RESEARCH ON FUTURES-COMMODITIES, MACROECONOMIC VOLATILITY AND FINANCIAL DEVELOPMENT

A thesis submitted for the degree of Doctor of Philosophy

by

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Abstract

This thesis consists of eight studies that cover topics in the increasingly influential field of futures-commodities, macroeconomic volatility and financial development. Chapter 2 considers the case of Argentina and provides a first thorough examination of the timing of the Argentine debacle. By applying a group of econometric tests for structural breaks on a range of GDP growth series over a period from 1886 to 2003 we conclude that there are two key dates in Argentina's economic history (1918 and 1948) that need to be inspected closely in order to further our understanding of the Argentine debacle.

Chapters 3 and 4 investigated the time-varying link between financial development and economic growth. By employing the logistic smooth transition framework to annual data for Brazil covering the period 1890-2003 we found that financial development has a mixed (either positive or negative) time-varying effect on growth, which depends on trade openness thresholds. We also find a positive impact of trade openness on growth while a mainly negative one for the various political instability measures.

Chapter 5 studied the convergence properties of inflation rates among the countries of the European Monetary Union over the period 1980-2013. By applying recently developed panel unit root/stationarity tests overall we are able to accept the stationarity hypothesis. Similarly, results from the univariate testing procedure indicated a mixed evidence in favour of convergence. Hence next we employ a clustering algorithm in the context of multivariate stationarity tests and we statistically detect three absolute convergence clubs in the pre-euro period, which consist of early accession countries. We also detect two separate clusters of early accession countries in the post-1997 period. For the rest of the countries/cases we find evidence of divergent behaviour. For robustness check we additionally employ a pairwise convergence Bayesian framework, which broadly confirms our findings. Finally, we show that in the presence of volatility spillovers and structural breaks time-varying persistence will be transmitted from the conditional variance to the conditional mean.

Chapter 6 focuses on the negative consequences that the five years of austerity (2010-2014) imposed on the Greek economy and the society in general. To achieve that goal we summarize the views of three renowned economists, namely Paul De Grauwe, Paul Krugman and Joseph Stiglitz on the eurozone crisis as well as the Greek case. In support of their claims we provide solid evidence of the dramatic effects that the restrictive policies had on Greece.

Chapter 7 analyzes the properties of inflation rates and their volatilities among five European countries over a period 1960-2003. Unlike to previous studies we investigate whether or not the inflation rate and its volatility of each individual country displayed time-varying characteristics. By applying various power ARCH processes with structural breaks and with or without in-mean effects the results indicated that the conditional means, variances as well as the in-mean effect displayed time-varying behaviour. We also show that for France, Italy and Netherlands the in-mean effect is positive, whereas that of Austria and Denmark is negative.

Chapter 8 examines the stochastic properties of different commodity time series during the recent financial and EU sovereign debt crisis (1997-2013). By employing the Bai-Perron method we detect five breaks for each of the commodity returns (both in the mean and in the variance). The majority of the breaks are closely associated with the two aforementioned crises. Having obtained the breaks we estimated the power ARCH models for each commodity allowing the conditional means and variances to switch across the breakpoints. The results indicate overall that there is a time-varying behaviour of the conditional mean and variance parameters in the case of grains, energies and softs. In contrast, metals and soya complex show time-varying characteristics only in the conditional variance. Finally, conducting a forecasting analysis using spectral techniques (in both mapped and unmapped data) we find that the prices of corn remained almost stable while for wheat, heating oil, wti and orange juice the prices decreased further, though slightly. In the case of natural gas, coffee and sugar overall the prices experienced significant deflationary pressures. As far as the prices of oats, platinum, rbob, cocoa, soybean, soymeal and soyoil is concerned, they showed an upward trend.

Chapter 9 examines the effect of health and military expenditures, trade openness and political instability on output growth. By employing a pooled generalised least squares method for 19 NATO countries from 1993 to 2010 we find that there is a negative impact of health and military expenditures, and political instability on economic growth whereas that of trade openness is positive.

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Publications

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Chapter 4 titled 'On the Time-Varying Link Between Financial Development, Political Instability and Economic Growth in Brazil, 1890-2003' is ready for submission (with Nauro F. Campos and Menelaos G. Karanasos).

Chapter 5 titled 'Inflation Convergence in the EMU and the Link Between Inflation Differentials and their Uncertainty' has been revised and resubmitted in the Journal of Empirical Finance (with Menelaos G. Karanasos, Karavias Y., and Arakelian V.).

Chapter 6 titled 'The Greek Dra(ch)ma: 5 Years of Austerity. The Three Economists' View and a Comment' is ready for submission (with Menelaos G. Karanasos).

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Introduction

In this thesis Chapters 2 to 4 focus on the main factors that drove economic growth in two developing countries, namely Argentina and Brazil. Chapters 5 to 7 investigated issues related to inflation convergence in the Economic and Monetary Union, inflation uncertainty itself and the impact of the austerity plans (imposed by the troika) on the Greek economy. Chapter 8 is based on modelling and forecasting commodities volatilities during the financial and European sovereign debt crisis whereas Chapter 9 examines the impact of health and military expenditures on economic growth in the NATO countries.

In particular, Chapter 2 focuses on Argentina. Argentina is the only country in the world that was developed in 1900 and developing in 2000. Although there is widespread consensus on the occurrence and uniqueness of this decline, an intense debate remains on its timing and underlying causes. This Chapter provides a first systematic investigation of the timing of the Argentine debacle. It uses an array of econometric tests for structural breaks and a range of GDP growth series covering 1886-2003. The main conclusion is the dating of two key structural breaks (in 1918 and 1948), which we argue support explanations for the debacle that highlight the slowdown of domestic financial development (after 1918) and of institutional development (after 1948).

Chapters 3 and 4 investigate the relationship between financial development and economic growth and how does it change over time in the case of Brazil. This Chapter revisits the growth-finance nexus using a new econometric approach and unique data set. More specifically, we apply the logistic smooth transition (LST) model to annual data for Brazil from 1890 to 2003. The main finding is that financial development has a mixed positive and negative time-varying impact on economic growth, which significantly depends on jointly estimated trade openness thresholds. We also show that there is a positive relation between trade openness and growth throughout the period while that of political instability is mainly negative.

In Chapter 5 we study the convergence properties of inflation rates among the countries of the European Monetary Union over the period 1980-2013. By applying recently developed panel unit root/stationarity tests overall we are able to accept the stationarity hypothesis. This means that some differentials are stationary and therefore there might be clubs of countries which have been in the process of converging absolutely or relatively. Thus next, having also obtained mixed evidence in favour of convergence using the univariate testing procedure, we use a clustering algorithm in the context of multivariate stationarity tests and we statistically detect three absolute convergence clubs in the pre-euro period, which comprise early accession countries. In particular, Luxembourg clusters with Austria and Belgium, while a second sub-group includes Germany and France and the third The Netherlands and Finland. We also detect two separate clusters of early accession countries in the post-1997 period: a sub-group with Germany, Austria, Belgium and Luxembourg, and one with France and Finland. For the rest of the countries/cases we find evidence of divergent behaviour. For robustness purposes we also employ a pairwise convergence Bayesian framework. The outcome broadly confirms our findings. We also show that in the presence of volatility spillovers and structural breaks time-varying persistence will be transmitted from the conditional variance to the conditional mean. If this transmission mechanism is ignored unit root tests will have poor power and size properties. For example, they might falsely indicate stationarity and, hence, in the case of inflation differentials falsely reject the null hypothesis of divergence.

Chapter 6 summarizes the opinion of three renowned economists, namely Paul De Grauwe, Paul Krugman and Joseph Stiglitz, on the eurozone crisis as well as the Greek case. In particular all three expressed in one way or another their reservations about the single currency. One one side De Grauwe and Stiglitz highlighted the design failures of the eurozone and on the other Krugman argued that the creation of the common currency was a terrible mistake. In support of their claims we provide evidence

of the negative consequences of the austerity measures that were implemented by the troika on the Greek economy for a period covering 2010-2014. After five years of austerity, Greece among others experienced significant deflationary dynamics, deep recession, high unemployment rates, that are among the highest in Europe and an increase of the percentage of the people at risk of poverty or social exclusion.

Chapter 7 investigates the properties of inflation rates and their volatilities among countries that belong to the Inner Six group, namely France, Italy and The Netherlands and countries being a part of the Outer Seven group namely Austria and Denmark. The first group adopted the European Economic Community (EEC) while the latter the European Free Trade Association (EFTA). Austria joined the EEC after the 1995 enlargement of the EU. Contrary to the studies examined so far we investigate whether or not the inflation rate and its volatility of each individual country displayed time-varying characteristics. For this purpose we employ quarterly inflation rates over a period 1960-2013.

Then by applying the Bai-Perron breakpoint technique we detect five breaks that reflected among others the oil crises of the early and late 1970s. The results from the various power ARCH processes with structural breaks and with or without in-mean effects indicated that both the conditional means and variances displayed time-varying characteristics. With respect to the relationship between inflation and its uncertainty, our results suggest that there is a time-varying link. In addition for the countries belonging to the Inner Six group (namely France, Italy and Netherlands) the in-mean effect is positive, whereas that of the countries belonging to the Outer Seven group (namely Austria and Denmark) is negative. Also we find negative and significant leverage effects for France and Italy whereas for Denmark (a country not a member of the common currency) positive asymmetric effects were displayed. Unlike the previous studies that model the conditional variance, we model the power transformed conditional variance. In particular, in the majority of the cases this is fixed and equal to 1.20. Perhaps it is on the same level among the countries, due to their participation in the EU, their common currency (apart from the case of Denmark) and the resulting monetary integration.

In Chapter 8 we analyze how the stochastic properties of different commodity time series have been impacted by the recent financial and EU sovereign debt crisis (2007-2013). By applying the Bai-Perron breakpoint technique we were able to identify five breaks for each series of futures returns and their volatilities, which were associated with previous economic events of great significance. The majority of the breaks (both in the mean and in the variance) reflected the financial and EU sovereign debt crisis respectively. Having obtained the breaks we estimated the power ARCH models for each commodity, allowing the conditional means and variances to switch across the breakpoints. The estimated models show overall that there is a time-varying behaviour of the conditional mean and variance parameters in the case of grains, energies and softs. In contrast, metals and soya complex show time-varying characteristics only in the conditional variance. Finally, conducting a forecasting analysis using spectral techniques (in both mapped and unmapped data) we find that the prices of corn remained almost stable while for wheat, heating oil, wti and orange juice the prices decreased further, though slightly. In the case of natural gas, coffee and sugar overall the prices experienced significant deflationary pressures. As far as the prices of oats, platinum, rbob, cocoa, soybean, soymeal and soyoil are concerned, they showed an upward trend.

In Chapter 9 we investigate the effect of health and military expenditures, trade openness and political instability on economic growth in the case of 19 NATO countries covering a period from 1993 to 2010. By employing a pooled generalised least squares method our results suggest first that there is a negative impact of health and military expenditures on economic growth. Second a positive link between trade openness and output growth while a negative one for political instability.

Chapter 10 provides conclusions and issues that the current work feels that future research should try to address.

Chapter 2

Apocalypse Now, Apocalypse When? Economic Growth and Structural Breaks in Argentina

2.1. Introduction

It is a well-known fact that Argentina is the only country in the world that was developed in 1900 and developing in 2000. From a long-run economic growth perspective, Argentina is truly unique. Per capita GDP levels and growth rates in Argentina (and nowhere else) declined over 1900-2000 vis-á-vis countries that were at similar levels of economic development in 1900. As a consequence, a rich debate ensued on the possible underlying causes and timing of such a debacle.

The debate on the timing of the relative decline of Argentina is intrinsically linked to the debate on its underlying causes. Taylor illustrates this point perfectly by asking 'Did Argentine economic decline begin with the First World War – an early retardation hypothesis that could implicate the prevailing liberal policy regime which adhered to openness in trade and maintained an outward orientation from 1913 to 1929? Or, conversely, did retardation begin with the Great Depression, a late-retardation hypothesis that could implicate the inward-looking import-substitution policies of populist and nationalist governments in the thirties, forties and fifties?' (1994, pp. 1-2).

The objective of this Chapter is to offer a comprehensive and systematic assessment of the timing of the Argentine debacle. In this Chapter we put forward such an econometric assessment by identifying structural breaks in GDP growth in Argentina since the 1880s. More specifically, we use an extensive battery of state-of-the-art parametric and non-parametric structural break tests on a dozen annual GDP growth series to identify the year(s) in which the Argentine relative decline may have started.

One may ask why so many tests and why so many different GDP series for Argentina? The reasons are simple. As far as the various structural breaks tests are concerned, here we want to complement the more standard or classical approach that is embodied in the Chow and Bai-Perron (1998) frameworks. These frameworks focus on structural breaks in the mean, while in many situations, breaks in the variance can also be of consequence[1]. In what follows we show that structural breaks are important in the mean of GDP growth rates in Argentina over the very long-run, but there are at least equally important structural breaks in the variance of those series and that these significantly contribute to the understanding of the Argentine debacle.

Regarding the various GDP series, we note that the United Nations system of National Accounts has existed only since the immediate post Second World War. Before the 1940s, GDP has to be estimated using various readily available components (such as imports and exports or government revenues). Hence, different series exist because they were constructed based on different components, periods, methodologies and deflators[2].

One last important caveat to be clarified at the outset is whether Argentina is actually the only country in the world that was developed in 1900 and developing in 2000. We claim this is the case. Maddison (2003) is arguably the most authoritative source for historical economic data series for data

[1] For example, breaks in the variance are at the root of the debate on the declining volatility of US growth rates since the 1980s (e.g. McConnell & Perez-Quiros, 2000).

[2] Another reason is that some authors have combined two or more series into a new series. We discuss these differences in detail below in section 3 and in the data appendix. Note that we contacted all the authors involved in this debate and they have kindly shared their data with us so that this potential source of variation can be accounted for here.

being comparable across countries. For year 1913, it reports per capita GDP data for 65 independent countries (bearing in mind that almost two-thirds of the countries that exist today were colonies at the time.) Argentina has the tenth largest per capita GDP, at precisely USD 3,797[3]. One concern is that other countries (chiefly Uruguay, but also to a lesser extent Chile) could be classified as 'developed' before World War I and, hence, liable to have undergone a similar rich-to-poor transition. According to Maddison's data, GDP per capita in Uruguay was about 10 per cent lower than Argentina's in 1913, and Chile's was substantially lower. Moreover, the gap between Argentina and Uruguay is not inconsiderable: In 1913 France, Austria and Germany had lower per capita GDP than Argentina's but larger than Uruguay's. Whether a country is considered developed or developing is arbitrary. If one takes the upper quintile as the cut-off point (which would be somewhat similar to today's split share of developed and developing) then the line for 1913 would be drawn at France or Germany on the eve of the First World War, ranked numbers 12 and 14 respectively (out of 65). On this basis, Argentina is unique: it is indeed the only country that was developed before the First World War and is now developing.

This Chapter contributes to the vast literature on the causes of economic growth. Durlauf et al. (2005) and Acemoglu (2008) provide recent, authoritative surveys which suggest that there is dissatisfaction with the empirical growth literature, while Sen (2013) and Spolaore and Wacziarg (2013) argue that within-country focus and historical quantitative research, respectively, may help to address such dissatisfaction. This Chapter contributes by focusing on the country that is one of the most undisputed outliers, as opposed to following the more standard practice of studying the 'average' or median country. In this Chapter we (a) study only one individual country over a very long period of time, (b) use the economic history literature to guide the identification of potential dates and reasons for the Argentine decline, and (c) utilize an econometric methodology that has seldom been used in the empirical growth literature despite the fact that it makes it possible to contrast the effects of various competing explanations directly. Another benefit of this choice of econometric framework is that it helps to shed light on the relation between mean growth rates and their volatility. While Ramey and Ramey (1995) show that growth rates are adversely affected by their volatility, Grier and Tullock (1989) argue that larger standard deviations of growth rates are associated with larger mean rates. Most papers focusing on the growth-volatility relationship seldom assess the effects of the structural breaks and how this information may be helpful in getting at the relative importance of contrasting theories by fully investigating structural breaks in both the mean and the variance.

The main findings of this Chapter are as follows. We detect one main structural break for a set of Argentinean GDP per capita growth series for the year 1918. This finding supports the early retardation hypothesis put forward by Taylor (1994, 1998). Yet a more nuanced picture emerges when we examine the ratio of Argentine GDP relative to other countries. Note the 1918 break is for the absolute per capita GDP series, not for the ratio of, say, Argentina's and the Western Offshoots or Western Europe series. For example, focusing on the ratio of per capita GDP in Argentina to per capita GDP in Western Europe, our estimation uncovers two structural breaks: one in 1914 and the other in 1948 (while the former supports the early retardation hypothesis, the latter is consistent with the explanations often associated with Conde, 2009). Relative to the Western Offshoots (United States, Canada, New Zealand and Australia), structural breaks are detected in years 1930 and 1947, with the former now supporting the 'late retardation hypothesis'. Finally, focusing on the ratio of per capita GDP in Argentina to per capita GDP in Latin America, 1948 once again emerges as the detected structural break.

In sum, considering both absolute and relative GDP growth series the main finding we offer is that of two significant structural breaks: one in year 1918 and the other in 1948.

The importance of these findings is that they shed further light on the debate on Argentina's unique decline. Previous research has offered a range of somewhat conflicting dates. As noted, disagreement is

[3]Maddison (2003) provides GDP and population data since at least 1800 for a large number of countries. There are nine countries with higher per capita GDP in 1913: Belgium, Denmark, the Netherlands, Switzerland, United Kingdom, Australia, New Zealand, Canada and the United States. France, Austria, Germany, Italy, Norway and Spain were all poorer than Argentina on the eve of the First World War.

seldom about whether the debacle occurred and mostly about the when, and of course the why. Some argue that the decline started with the Great Depression (for example, Diaz-Alejandro, 1985), Conde (2009) associates its beginning with WWII, Taylor (1992) argues for a turning point around 1913, and Villarroya (2005) detects an even earlier structural break in year 1899 (section 2 below discusses these various viewpoints in detail). Previous research sometimes, but far from always, based these proposed break dates on quantitative or econometric evidence. This Chapter is the first to use a range of historical annual GDP series for Argentina and extensive structural break tests to provide a full assessment of this dimension of the debacle. Our results highlight the important role played by the choice of comparator groups. If it is the Western Offshoots that are focused on, the Great Crash of 1929 looms large, as the break is detected for year 1930. However, focusing on Western Europe, 1930 is not a detected break, but 1918 is, in this case, suggesting that the events surrounding the First World War played a major role. Therefore, our results allow for a more nuanced understanding that paves the way to a reconciliation of this set of highly conflicting viewpoints.

The Chapter is organized as follows. The next section reviews the debate about the timing of the Argentine debacle, that is, of its relative long-term collapse in terms of GDP growth. Section 2.3 presents the various different Argentine GDP series we collected and use in this Chapter. Section 2.4 introduces our econometric methodology and Section 2.5 discusses our main results. Section 2.6 concludes.

2.2. Apocalypse When?

The objective of this section is to take stock of the debate about the timing of the Argentine debacle, that is, of the relative long-term decline of its GDP growth rates. There is a large debate in economic history about the timing of this relative decline (Taylor 2014), with at least five views that differ in their identification of the precise year in which the decline started. These are: 1913, 1929, 1913-1929, 1945 and 1899. We now turn to each of these views.

The view that 1913 is the main structural break (that is, that it marks the beginning of the Argentine debacle) is represented by the early retardation hypothesis put forward by among others Taylor (1992). The reasoning is as follows: Argentina adopted a very successful export-led growth strategy but it was heavily dependent on foreign markets, on foreign capital and on foreign labour. When the First World War starts in Europe in 1914, these flows are interrupted and Argentina suffers greatly. Foreign labour resumed after the War and export markets recovered to a lesser extent. There were, however, massive changes regarding foreign capital flows as the inter war years is the period in which the financial center of the world moves from London to New York. Another important element in this view of the debacle is the argument that by 1913 the agricultural frontier is starting to close down, with severe restrictions on the availability of high-quality agricultural land in the Pampas. This understanding also blames the relative decline of Argentina on the persistence of liberal policies in the period immediately following the First World War.

Diaz Alejandro is one of the main names associated with the notion that 1929 marks the beginning of the end for Argentina. The contrasts are starker than one would expect. The idea here is that the maintenance of liberal policies towards international trade, capital and labour after the First World War was actually a correct decision. This policy choice helped Argentina navigate the inter war years without any major noticeable relative decline in its international standing. This view proceeds by arguing that Argentina's *Belle Époque* does not end in 1913, but in 1930, the year in which a military coup puts an amalgam of conservative, agrarian, provincial and protectionist forces into power. This corresponds to a radical change in government policy, from extremely open to international trade and capital flows to a more closed stance. Diaz-Alejandro blames the Argentinean debacle on these post-1930 inward-looking policies. Spiller and Tommasi (2007) and Alston and Gallo (2010) also identify 1930 as the turning point, but blame the widespread use of corrupt methods to win political elections used by incumbent governments since, as one main factor in the debacle.

A third view is that offered by Taylor (1994). Although he argues that the Argentinean *Belle Époque* ends in 1913, he also notes that financial factors make the period between 1913 and 1930 a very difficult one for Argentina as foreign capital dries up, and domestic savings are incapable of filling the gap. Taylor's argument is that this is due to a very low domestic savings rate, which can be explained by a combination of high dependency ratios and a liberal immigration policy. Taylor also attaches blame to the inward-looking policies after 1930 as these aggravated price disincentives that channeled funds away from investment and deliberately supported high relative prices of imported capital goods.

A fourth view we discuss is that of Villarroya (2005, 2007). This differs from all others by being the first to offer an econometric answer to the question of when exactly the Argentinean debacle started. Villarroya uses cointegration analysis and the Bai-Perron methodology to tackle this question. She shows that the Argentinean per capita GDP series 'becomes stationary when modelling its trend with a set of structural breaks fixed at 1913, 1929, and 1974 (Villarroya, 2005, p. 443). She also finds that (a) Argentina started to fall behind Australia in 1899 and behind Canada in 1896, (b) Argentina did catch up to Canada over certain periods before 1900, and (c) Argentina stopped catching up with the OECD countries in 1913. Below we try to improve upon these results mainly in two ways: (a) by directly estimating the years in which the structural breaks occur (instead of setting them ex ante), (b) by examining the ratios between Argentinean GDP and various comparator groups in a more robust way, by checking both the individual series and the ratios themselves, and (c) by using a battery of structural breaks tests that go beyond the Bai-Perron framework and its emphasis on breaks in the means, also to take into account the potential importance of breaks in the variances. This is also done using a uniquely comprehensive set of historical GDP series (so that we can evaluate the relative roles of methodology and underlying data series in identifying differences in break points.)

In summary, this important debate about Argentinean economic history has been much less about whether a relative economic decline has indeed taken place and more about its timing. Differences in dating the relative decline are associated with different causal explanations. The views favoring 1913 and 1929 argue that these mark the exhaustion of the export-led growth that was so successful in Argentina at the turn of the last century. A third view is Taylor's, which can be interpreted as arguing for a double break in 1913 and 1929, and a fourth distinct view is Villarroya (2005), which places the start of the decline much earlier, in year 1899. Conde (2009) argues that the decline is well established and beyond debate after the end of the Second World War, but also that there are clear earlier signs of it, indeed as early as 1913. The earlier break identified for 1899 makes a lot of sense when we take into account that this is vis-á-vis the group of Western Offshoot countries, which were growing extremely rapidly at the turn of the century. The 1913 dating stresses the role of international integration (trade, capital flows and migration), the 1930 dating highlights some key domestic economic and political effects of the Great Depression, and the 1945 dating stresses the role of misguided populist political choices even more than misguided inward-looking economic policies. In light of this rich disparity of results and their attendant somewhat conflicting explanations, it is clear that a systematic assessment of structural breaks would be a welcome addition to this debate.

2.3. Data

One constraint hindering the identification of structural breaks in Argentina's economic history is reliable GDP data. A full set of national income account data for Argentina is only available from the mid-1930s. Previous researchers have tried to overcome this limitation by constructing proxy measures of economic activity for the earlier period. The quality of these constructs is, however, very uneven due to the lack and/or the very poor quality of output data for broad sectors of the economy. In particular, official output data in agriculture, manufacturing, construction, and services only become available from 1900 onwards and, even then, with gaps (Aiolfi et al., 2011, p. 9).

Our Chapter tries to address these data limitations by substantially broadening the number of GDP

variables from which one can derive valuable information on the Argentine debacle. The data were obtained from a number of Chapters and the compilation of both primary and secondary data sources. In most cases this resulted in new series being created; once combined with their counterparts from the later twentieth century, these series span the entire 1886-2003 period. Overall, we were able to put together a panel of nine individual GDP time series and three relative ones, which, as shown below, may provide an appropriate gauge of Argentine GDP growth. The Appendix provides a detailed discussion of measurement issues underlying the various series and the respective data sources.

Insofar as previous researchers tried to derive an aggregate measure of economic activity from averages of these production data (resorting to linear interpolation to fill gaps in some discontinuous annual series), the resulting indices are bound to be inaccurate. Della Paolera (1989) attempted to overcome these problems by backcasting Argentine GDP based on a handful of production and trade variables by means of linear OLS regressions (Della Paolera, 1989). In this Chapter we employ two Della Paolera series. The first one (DellapA) is taken from Della Paolera et al. (2003a) which is real GDP per capita at constant 1980 international prices. The second series (DellapB) has been employed in de la Escosura and Villarroya (2009). It is taken from Della Paolera et al. (2003b). They used real GDP per capita in current 1990 U.S. dollars. The next series (Bordo) is real GDP, used in Bordo et al. (2001). The fourth series (Maddison) is taken from Maddison (2003). We have used purchasing power parity adjusted GDP per capita expressed in 1995 US relative prices. The three relative series are also from Maddison (2003). There are the ratios of Argentina to (i) Latin America (Maddison, LA), (ii) Western offshoots (Maddison, US), and (iii) Western Europe (Maddison, WE).

Aiolfi et al. (2011) point out that while the work of Maddison (2003) has made important strides in filling some gaps and making long-run data more easily accessible, important deficiencies remain. For most developing countries, Maddison's pre-World War II data is either provided only for benchmark years or compiled directly from secondary sources relying on annual data from a very limited set of macroeconomic variables and often using disparate methodologies to build up GDP estimates. As discussed in detail in Aiolfi et al. (2011) for Argentina, this procedure can generate biased measures. Aiolfi et al. (2011) address these data limitations by substantially broadening the number of variables from which one can derive information on the pace of aggregate economic activity. They took into account not only production or foreign trade variables, but also monetary and financial indicators that economic theory suggests should be correlated with economic cycles. Thus the next series (Catão) is a real GDP index (2000=100), used in Catão et al. (2009) and Aiolfi et al. (2011). Aiolfi et al. (2011) point out that backcasting missing GDP data with information extracted from a wide and consistent set of indicators allows them not only to expand the data range, but also to increase the precision of inter-period comparisons of business cycle behaviour. They also emphasize that having such a measure of the evolution of economic fluctuations matters for issues related to the international transmission of real and financial shocks, the role of openness and international asset pricing (Aiolfi et al., 2011) and also also put forward predictions about volatility behaviour[4].

The sixth series (Kehoe) is another real GDP index (2000=100), used in Kehoe (2007). The next one (Kydland) is real GDP, in 1986 Argentinean pesos, used in Kydland and Zarazaga (2002/2007). In the next series (Moccero), real GDP was constructed by Moccero (2008). Finally, the ninth series (Prados) is real GDP per capita, in current 1990 U.S. dollars, used in de la Escosura and Villarroya (2009).

Figure 2.1 (see Appendix 1) plots these series over time and Appendix table A.2.1 presents details, sources and the sample period for each series.

Using the remaining three Maddison series (Maddison LA, Maddison US, Maddison WE), we also

[4] "Latin American volatility was high in the high openness regimes of the pre-1930 era, precisely during the formative years of key national institutions. It then dropped sharply during the four decades following the Great Depression. An apparent payoff of the inward-looking growth and highly interventionist policy regimes at a time of higher volatility in advanced countries. Cyclical instability in Latin America bounced back again in the 1970s and 1980s when these economies became again more open to international capital markets but then declined sharply since, amidst continuing financial and trade openness" (Aiolfi et al., 2011, p. 214).

construct a series of the relative output ratios of Argentina's GDP to each of these comparator groups. Figure 2.2 (see Appendix 1) shows these three relative output series over time.

2.4. Methodology

The objective of the section is to describe the statistical procedures we use to identify the regimes and/or segments of each series statistically and henceforth their underlying significant structural breaks (Hansen 2000, 2001). We divide the series into two types, which we call absolute and relative for convenience: (a) per capita GDP growth series for Argentina, and (b) the ratio of Argentine GDP to three different comparator groups (Western Europe, Western Offshoots, comprised of the USA, Canada, New Zealand and Australia, and the rest of Latin America). The methodology we use involves two main stages: first, we use a battery of parametric and non-parametric tests to identify or 'nominate' specific years for breakdates (note breakdate is the technical term used in the structural breaks literature) and, second, we use a set of statistical tests to 'award' the breakdate property to selected years.

The 'nominating breakdates' stage involves a specific procedure that can be based on one or more statistical test and/or on exogenous information to identify some dates as possible breakdates. In recent years, a number of statistical tests have been developed for this purpose, several of which are employed in this investigation[5]. Specifically, we use the following tests: (1) IT (Inclan and Tiao, 1994), (2) SAC1, the first test of Sansó, Aragó, and Carrion (2004), (3) SAC_2^{BT}, SAC_2^{QS}, SAC_2^{VH} which are three versions the second test of Sansó, Aragó, and Carrion (2004) with the Bartlett kernel, the Quadratic Spectral kernel, and the Vector Autoregressive HAC or VARHAC kernel of Den Haan and Levin (1998) respectively, (4) KL_{BT}, KL_{QS}, KL_{VH}, which correspond to the test refined by the Andreou and Ghysels (2002) version of the Kokoszka and Leipus (2000) test with the Bartlett kernel, the Quadratic Spectral kernel, and the VARHAC kernel respectively. Note we also report the more standard Bai-Perron test result so as to provide us with a common yardstick[6].

There are various reasons for selecting these tests to identify the structural changes in each of the Argentinean per capita GDP series presented above. First, although all of these tests are designed to detect structural changes in volatility dynamics, Karoglou (2006)[7] shows that many CUSUM-type tests (including all the above) do not discriminate between shifts in the mean and shifts in the variance. For present purposes, this is an important feature since all types of breaks need to be considered in order to determine if and to what extent the distributional properties change when moving from one regime to another. Figure 2.3 (see Appendix 1) plots the 'variances' (measured by the squared observations) of the nine absolute GDP series we use. A brief visual contrast of Figures 2.1 and 2.3 (see Appendix 1) suffices to suggest that frameworks focusing solely on breaks in the mean are likely to miss out on probably the most important parts of this story.

A second reason for selecting these CUSUM-type tests is that their properties for strongly dependent series have been extensively investigated (for example Andreou & Ghysels, 2002; Sansó, Aragó, & Carrion, 2004; Karoglou, 2006) and there is evidence that they perform satisfactorily under the most common ARCH-type processes. Thus, even when there is a break in a conditionally heteroskedastic process, these tests can detect it, that is, the tests do not exhibit size distortions and they have considerable power, even when the assumption of within-segment homoskedasticity is relaxed in order to include ARCH-type structures. In fact, (3) and (4) have some plausible properties even in the presence of IGARCH effects. Nevertheless, Karoglou (2006) shows that the relative performance of each of the above tests depends on the underlying data generating process (DGP)[8]. Consequently, since the true DGP is not known, it is

[5] Although we avoid doing this in this paper, it is relatively trivial to condition on observables, that is, in the simplest case by nominating the 'official' or 'widely accepted' breakdates for each series.

[6] A technical appendix briefly discussing each of these tests is available upon request.

[7] This work generalised the results of Bos and Hoontrakul (2002), who refer to the IT test.

[8] For example, the IT is found to be the most sensitive to the existence of volatility breaks for independent and identically

preferable to use all of them and select the break date according to an appropriate set of rules[9].

Another important advantage of this set of tests is that they can be used to identify multiple breaks in a series. This is achieved by incorporating the breaks in an iterative algorithm and applying these breaks to sub-samples of the series. In this Chapter, we propose the following algorithm (in six steps): in step 1 we calculate the test statistic under consideration using available data. In step 2, if the statistic is above the critical value, we split the particular sample into two parts at the date at which the value of a test statistic is maximised. In step 3 we repeat steps 1 and 2 for the first segment until no more (earlier) change-points are found. In step 4 we assign this point as an estimated change-point of the whole series. In step 5 we remove the observations that precede this point (that is those that constitute the first segment) and in step 6 we consider the remaining observations as the new sample and repeat steps 1 to 5 until no more change-points are found.

The above algorithm is implemented with each of the (single break date CUSUM-type) test statistics described above (that is IT, SAC_1, SAC_2^{BT}, SAC_2^{QS}, SAC_2^{VH}, KL_{BT}, KL_{QS}, KL_{VH}). The main feature of the algorithm (which differentiates it from a simple binary division procedure) is that it guarantees that the existing breaks are detected in a time-orderly fashion. In other words, the first break proposed by the algorithm is also the earliest break in the series, the second break proposed is the second earliest break, and so forth. This is important when transitional periods exist, in which case, a simple binary division procedure will probably produce more breaks in the interim period. In the absence of transitional periods the two procedures produce the same breaks. In conclusion, the nominated break dates for each series are all those which have been detected by any of the aforementioned tests at 5 per cent significance level and any other that is identified exogenously.

The 'awarding breakdates' stage involves applying a certain procedure to select, from the nominated breakdates, those dates that define a segment. A commonly used chronology in economic history is to separate four periods, one covering the Gold Standard (until around 1913), a second covering the interwar years (until about 1945), a third one for the Bretton Woods period (until 1973), and then a fourth period covering the years since the early 1970s to today. For example, Bordo et al. (2001) focus on the crisis problem (they consider currency crises, banking crises, and twin crises) and analyze a data set spanning 120 years of financial history. They distinguish the Bretton Woods period (1945-1971), the interwar years (1919-1939), and the gold standard era (1880-1913). For each of the GDP growth series we use, we calculate average GDP growth for the three aforementioned periods: gold standard era, 1919-1971 and post-Bretton Woods. We find that average GDP growth for all nine series (described above) is higher in the gold standard era than in the 1919-1971 period and it decreases even more in the post-Bretton Woods period. In particular, in the gold standard era the average growth for the Catão, Moccero and Bordo series is 6.4, 5.9 and 5.4 per cent respectively. In the 1919-1971 period it declines to 4.1, 3.6 and 4.1 per cent respectively. In the post-Bretton Woods period it declines further to 1.5, 2.3 and 1.8 per cent respectively. Similarly, the average growth for the Prados and the two Dellap series (A and B) in the gold standard era is 3.3, 2.6 and 1.8 per cent respectively. In the post-Bretton Woods period it falls to 0.5, 0.9 and 0.5 per cent respectively.

Kydland and Zarazaga (2002) point out that Argentina suffered a severe depression during the 1980s and that by the end of the 'lost decade', in 1990, Argentina's GDP per capita was a striking 33 per cent below trend. This is why the observed average growth during the period 1980-1989 is negative for all nine series: it ranges between -2.2 per cent (DellapB, Maddison and Prados) and -0.5 per cent (Catão).

distributed data, but suffers severe size distortions for strongly dependent data or for non-mesokurtic distributions. In contrast, the KL and the SAC2 variants do not exhibit size distortions in these cases but their power is smaller, while SAC1 does not exhibit size distortions for non-mesokurtic data and, although it does for strongly dependent data, its power is higher than KL and SAC_2. Sansó, Aragó, and Carrion (2004) derive some theoretical results on the properties of IT, SAC_1, and SAC_2 for data generating processes with different levels of kurtosis while Andreou and Ghyssels (2002) provide some simulation evidence for IT and KL.

[9] For example, a selection rule could suggest that a breakpoint can be considered only if two tests have identified it; or a breakpoint can be considered only if the resulting segments contain more than 10 observations.

Kehoe (2007) points out that in 1998-2002, after the boom in 1990-1997, Argentina experienced what the government described as 'our great depression'. It began in 1998 and deepened after 2001. A violent deepening of the recession occurred in the last two quarters of 2001 and the first of 2002. For this period, average quarterly falls of de-seasonalised GDP with respect to the previous quarter of 5 per cent took place.

It is important to point out that despite how illuminating these dates are they remain arbitrary and would clearly benefit from statistical support. Hence, we propose the use of time series techniques to estimate these points in time. The econometric analysis makes use of recent developments in the detection of structural breaks in univariate time series and in comparisons across time series.

The procedure we use involves uniting contiguous nominated segments (that is segments that are defined by the nominated breakdates) unless one of the following conditions is satisfied: (i) the means of the contiguous segments are statistically different (as suggested by the t-test and the Satterthwaite-Welch t-test, which is more robust when the contiguous segments do not have the same variance) or (ii) the variances of the contiguous segments are statistically different (as suggested by the battery of tests which is described below). This testing procedure is repeated until no more segments can be united, that is, until no condition of the two above is satisfied for any pair of contiguous segments.

With regards to the battery of tests discussed above, these involve several procedures designed to test for the homogeneity of variances of different samples and in this case these samples are two contiguous segments. These tests constitute a different approach to the CUSUM-type tests described previously in that they test for the homogeneity of variances of distinct samples, that is, without encompassing the time-series dimension of the data[10]. They include the standard F-test, the Siegel-Tukey test with continuity correction (Siegel & Tukey, 1960; Sheskin, 2003), the adjusted Bartlett test (see Sokal & Rohlf, 1995; Judge et al., 1985), the Levene test (1960) and the Brown-Forsythe (1974) test. The F-test requires equal sample sizes and is sensitive to departures from normality. The Siegel-Tukey test is based on the assumption that the samples are independent and have the same median. The Bartlett test is also robust when the sample sizes are not equal, despite still being sensitive to departures from normality. Its adjusted version makes use of a correction factor for the critical values and the arcsine-square root transformation of the data to conform to the normality assumption. The Levene test is an alternative to the Bartlett test which is less sensitive to departures from normality. Finally, the Brown-Forsythe test is a modified Levene test (substituting the group mean by the group median) which is superior in terms of robustness (when scores are skewed or samples relatively small) and power.

2.5. Econometric Results

For convenience of exposition, we divide the presentation of our results into absolute and relative series. We first report our findings regarding structural breaks for the individual Argentina GDP series, and then we report results using the same methodology and tests but referring to relative GDP series (in comparison to three selected groups of countries.)

2.5.1. Structural Breaks in Argentina GDP Growth Series

Table 2.1 (see Appendix 1) shows the structural break results in the mean and/or in the variance of each series that have been detected by each test. From the table we can see that there is strong support for a single break, namely in 1918 (detected in Maddison, DellapB and Prados). The IT test also suggests one more break (1963 for Bordo). However, the corresponding series are substantially leptokurtic and the

[10] Therefore, they provide the same value even if the observations of each segment are randomly ordered. In contrast, statistics that are based on sequential methods (such as the CUSUM tests) are influenced by the order of the observations.

IT test exhibits size distortions for leptokurtic data. Therefore, since this break is not detected by any other test, and only detected by the IT at 5 per cent significance level, we discount it. Also notice that the results from the Bai-Perron test are more extensive and also supportive of these results in the sense of suggesting an important structural break around year 1918 for 8 out of these 9 series. However, and in light of the discussion at the end of section 3 above, we decide to also include 1980 as an additional possible breakdate for the nominating stage below.

Consequently, in the 'nominating breaks' stage we suggest we can split each series into three contiguous segments. The first segment starts at the beginning of the sample of each series and ends in 1917; the second segment starts in 1918 and ends in 1979; and the third segment starts in 1980 and ends at the end of the sample of each series. Note that the end of the first period (1917) coincides with the closing of the Gold Standard Era, while the beginning of the third and last period (1980) coincides with the end of the Bretton Woods Era (see Eichengreen, 2008) and includes the lost decade and the great depression.

Table 2.2 (see Appendix 1) presents a detailed overview of the properties of each nominated segment. An interesting point that can be made involves the p-values of the Jacque-Bera normality test. In almost all series, the first and last segments appear to be statistically normally distributed. However, in about half series, the second segment is significantly positively skewed and leptokurtic. This, in conjunction with the fact that no growth series exhibits any (linear) dependence in the mean (based on the correlograms and the corresponding Q-statistics, not reported) suggests that each GDP series actually follows a normal random walk in each segment but with significantly different variances.

Figure 2.4 (see Appendix 1) depicts the sample mean and standard deviation of each series for each segment. Overall, most series seem to suggest that Segment 3 has the lowest mean. In other words, it appears that most series seem to agree that Argentina's GDP growth has been at its lowest levels after 1980. Three series (DellapA, DellapB and Maddison) suggest that Segment 2 has the highest mean. However, for all other series the average GDP growth in Segment 2 actually declined after 1918.

Table 2.3 (see Appendix 1) shows the results from comparing the means and variances of each pair of contiguous segments statistically for each series. We should note that this approach has clear parallels with the classical Chow framework. The results show an interesting pattern: in four growth series there is evidence supporting a statistically significant change in the mean of these series. In contrast, there is strong evidence that suggests significant changes in the variances. Therefore, the 'awarding breaks' stage confirms that the two nominated breaks can indeed be viewed as breaks for 3 series in the mean and for 5 series as breaks in the variance. In contrast, the evolution of the series volatility (as measured by the sample standard deviation) is less clear despite the fact that in most cases there is a substantial (and statistically significant) change of the standard deviation. In particular, two series (Kehoe and Kyndland) suggest that volatility has been continuously increasing; two series (DellapA and Prados) suggest that volatility has been continuously decreasing; four series (DellapB, Maddison, Moccero, and Catão) suggest that it reached its minimum level in Segment 2; one (Bordo) that it reached its maximum level in Segment 2; three (Kehoe, Kyndland, and Moccero) that Segment 3 has higher variability than Segment 1; and the remaining six the exact opposite. Therefore, it seems that Argentina's GDP growth volatility generally declined after 1918 and has remained roughly the same since then.

There seems to be considerable discrepancies in inference when focusing on different GDP measures, which clearly suggests that the substantially different properties of the underlying series constitute a major challenge to the validity of any analysis that does not involve meticulousness in explaining how closely its findings are related to the construction process of each of these series.

2.5.2. Structural Breaks in the Ratio of Argentina to Europe, US and LAC GDP Growth Series

Table 2.4 (see Appendix 1) shows the structural changes in the mean and/or in the variance of the weighted GDP growth series of other countries that have been detected by each test. From the table

we can derive one break for the Latin American (LA) economies, in 1948, two breaks for the Western offshoots (US), in 1930 and 1947, and two breaks for the Western European (WE) economies, in 1914 and 1948. Note that in the case of Western European economies, we do take into account the results of the IT test since we are dealing with leptokurtic series.

In order to analyse the relative properties of Argentina's GDP with respect to the other countries, we construct the ratios of Argentina's GDP (as measured by the MADDISON series) to the GDP of the other countries, which yields three ratio series. However, to study the statistical properties of these ratio series we need to take into account both the breaks that exist in Argentina's GDP series and the breaks that exist in the series of the other countries. Subsequently, we consider four segments in the ratio series of Argentina's GDP to the GDP of the Latin American countries (1900–1917, 1918–1947, 1948–1969, 1970–2003); five segments in the ratio series of Argentina's GDP to the GDP of the Western offshoots (1900–1917, 1918–1929, 1930–1946, 1947–1969, 1970–2003); and five segments in the ratio series of Argentina's GDP to the GDP of the Western European countries (1900–1913, 1914–1917, 1918–1947, 1948–1969, 1970–2003). These are shown in Figures 2.5, 2.6 and 2.7 (see Appendix 1) for each one of the three ratios or relative GDP series.

Table 2.5 (see Appendix 1) presents the results from comparing the means and variances of each pair of contiguous segments for each ratio series statistically. The ratio series of Argentina's GDP to the Latin American (LA) economies shows statistically significant changes in the mean of the ratios whenever we move to a neighboring segment up to Segment 3. The corresponding changes in the variance of the ratios are statistically significant only when moving from Segment 2 to Segment 3. In contrast, the ratio series of Argentina's GDP with the Western offshoots (US) economies show that the mean of the ratios changes only when we move from Segment 3 to Segment 4 and from Segment 4 to Segment 5, while the variance of the ratios is statistically different at each segment up to segment 4. The ratio series of Argentina's GDP with the Western European (WE) economies show changes in the mean of the series when moving from Segment 3 to Segment 4 and from Segment 4 to Segment 5 and very limited signs of changes in the variance of the ratios (mainly when moving from Segment 4 to Segment 5). Therefore, the 'awarding breakdates' stage in the ratio series justifies the selection of all segments apart from Segment 2 with the Western European economies – which is actually expected as it consists of only 3 observations.

2.5.3. Discussion

This Chapter provides a first systematic investigation of the timing of the Argentine debacle. We employ a vast array of econometric tests for structural breaks and a set of GDP growth series covering 1886-2003. Our main finding is that of support for two important structural breaks: one around year 1918 and one circa 1948.

We detect one main structural break for a set of various Argentinean GDP per capita growth series for the year 1918. Our interpretation is that this supports the early retardation hypothesis put forward by Taylor (1994). Yet a much more nuanced picture emerges when we examine the ratio of Argentina's GDP to other countries (what we call the relative series). For instance, focusing on the ratio of per capita GDP in Argentina to that in Western Europe, our estimation uncovers two structural breaks: one in 1914 and the other in 1948. While the former supports the early retardation hypothesis, the latter is consistent with the important explanations offered by among others Conde (2009). With respect to the Western Offshoots countries (United States, Canada, New Zealand and Australia), structural breaks are detected for years 1930 and 1947, with the former now supporting the 'late retardation hypothesis'. Finally, focusing on the ratio of per capita GDP in Argentina to per capita GDP in Latin America, 1948 again emerges as the detected structural break.

The importance of these findings is two-fold. Firstly, they throw further light on the main milestones of Argentina's unique decline and, secondly, they help in pointing future research to the importance of financial and institutional development as serious candidate explanations for the Argentine debacle.

Previous research has offered a range of somewhat conflicting dates for the start of Argentina's relative decline. This disagreement is seldom about whether the debacle occurred and mostly about the when, and of course about its multiple possible underlying reasons. Some authors argue that the decline started with the Great Depression (for example, Diaz-Alejandro, 1985), Conde (2009) associates its beginning with WWII, Taylor (1992) argues for a turning point around 1913, and Villarroya (2005) claims year 1899 as the beginning of the decline. Our results can reconcile these views by highlighting the important role played by the choice of comparator groups and type of series (relative or absolute). If one focuses on the Western Offshoots, the Great Crash of 1929 looms large as the break is detected for year 1930. However, focusing on Western Europe, 1930 is not a detected break, but 1918 in turn is, suggesting that the events surrounding the First World War played a major role instead. A similar conclusion can be reached by focusing on the absolute (not relative) Argentina GDP series. If more weight is given to comparisons to other New World countries (Latin America or the Western Offshoots) then the dating of WWII as the crucial breakdate can amass considerable support. Therefore, we would like to think our results allow for a deeper understanding and we believe they offer a way of reconciling this set of apparently highly conflicting findings.

In our view, our main finding is that of support for two significant structural breaks: one in year 1918 and the other in 1948. These breaks are consistent with explanations highlighting the slowdown of domestic financial development (which seems to have occurred principally after 1918) and the slowdown of institutional development, in general, and the onset of political populism (Peronism) and its attendant choice of inward-looking economic policies, which took place mostly after 1948. These two explanations for the relative decline of Argentina have been shown by Campos et al. (2012) to enjoy substantial econometric support.

2.6. Conclusions

In general, this Chapter provides a rather different and novel approach to why Argentina is the only country in the world that was developed in 1900 and developing in 2000. Using an extensive set of Argentinean per capita GDP (constructed by key scholars in this field) and a comprehensive econometric assessment of the number and timing of structural changes that could potentially exist in each of them, we conclude that there are two key dates in Argentina's economic history (1918 and 1948) that need to be inspected closely in order to further our understanding of the Argentine debacle.

The importance of establishing structural breaks in 1918 and 1948 is the possibility of thinking about the Argentina debacle in terms of both financial and institutional development, candidate explanations that have not received as much attention so far as some other more popular or prominent alternatives (such as macroeconomic instability or trade openness).

These findings are of interest in themselves but they also raise a number of new questions that we believe may be useful in motivating future research. We highlight two suggestions. As far as the role of finance in the process of economic development is concerned, our finding supports a large body of previous research in that we also show a positive impact of financial development on growth in the long-run. We also suggest that institutional development and different forms of political instability affect growth through different channels over different time windows, making up for a strong and resilient effect that proves rather powerful vis-á-vis the benefits brought by financial development. Future research should throw light on whether these two reasons play different roles in different countries over the long-run. A second suggestion for future research is that the interrelationship between finance and institutions should be further studied. Future research will surely benefit from investigating more intricate causal chains. This will help further qualify our results in that it will allow us to assess the possibility that we find, say, that a factor 'only' has a secondary effect because the method is not capturing the possibility of indirect effects through other variables.

The objective of this Chapter was to carry out a comprehensive assessment of the dating of the debacle that has not been tried previously. We hope our results showing the salience of 1918 and 1948 and the

related importance of finance and institutions contribute to discouraging mono-causal explanations and motivate future research that focuses on complex interactions and more nuanced inter-relationships among a full set of variables that have been identified as competing explanations for the Argentine puzzle.

Appendix 1

Figure 2.1. Argentina's GDP growth series over the XXth Century

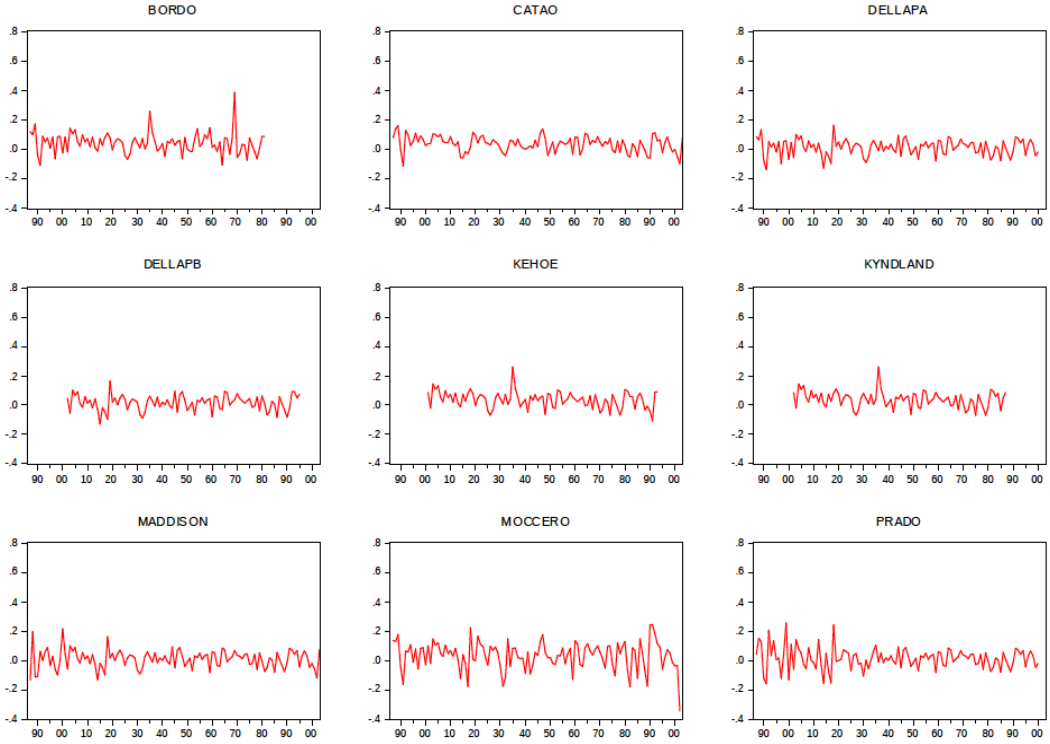


Figure 2.2. Argentina's GDP growth series relative to Western Europe, US et al., and Latin America

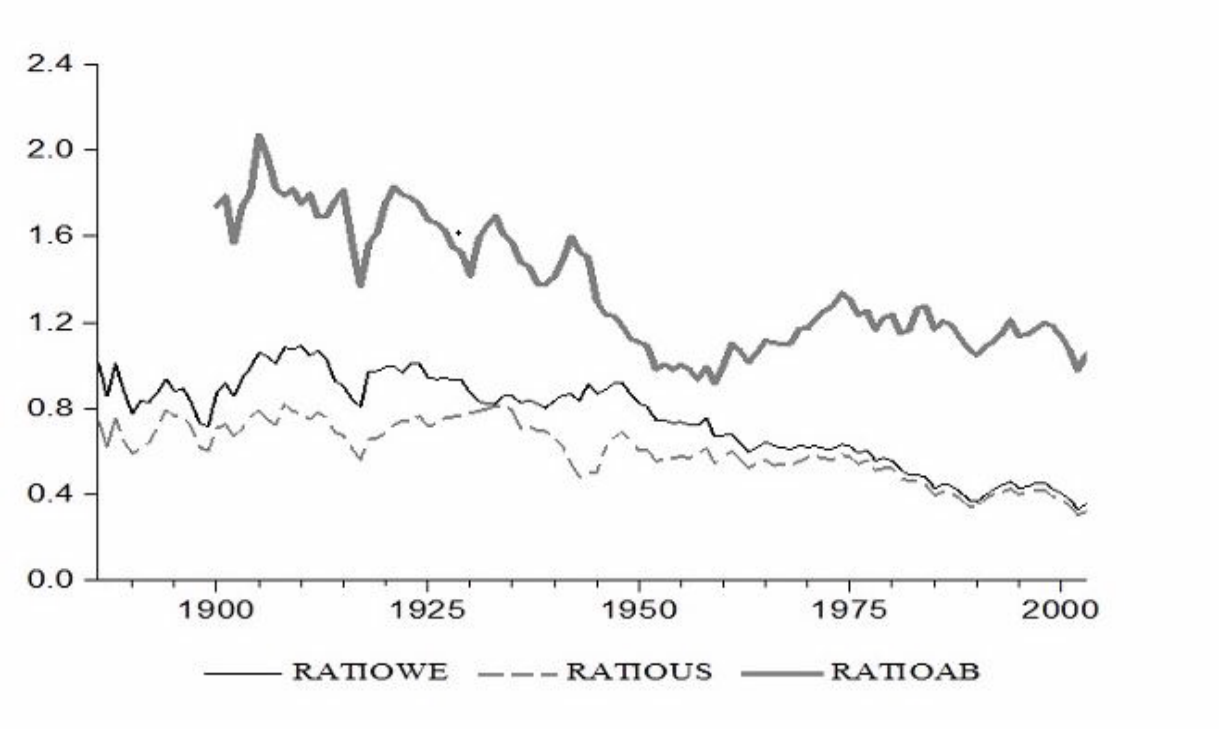


Figure 2.3. Variances of Argentina's GDP growth series over the XXth Century

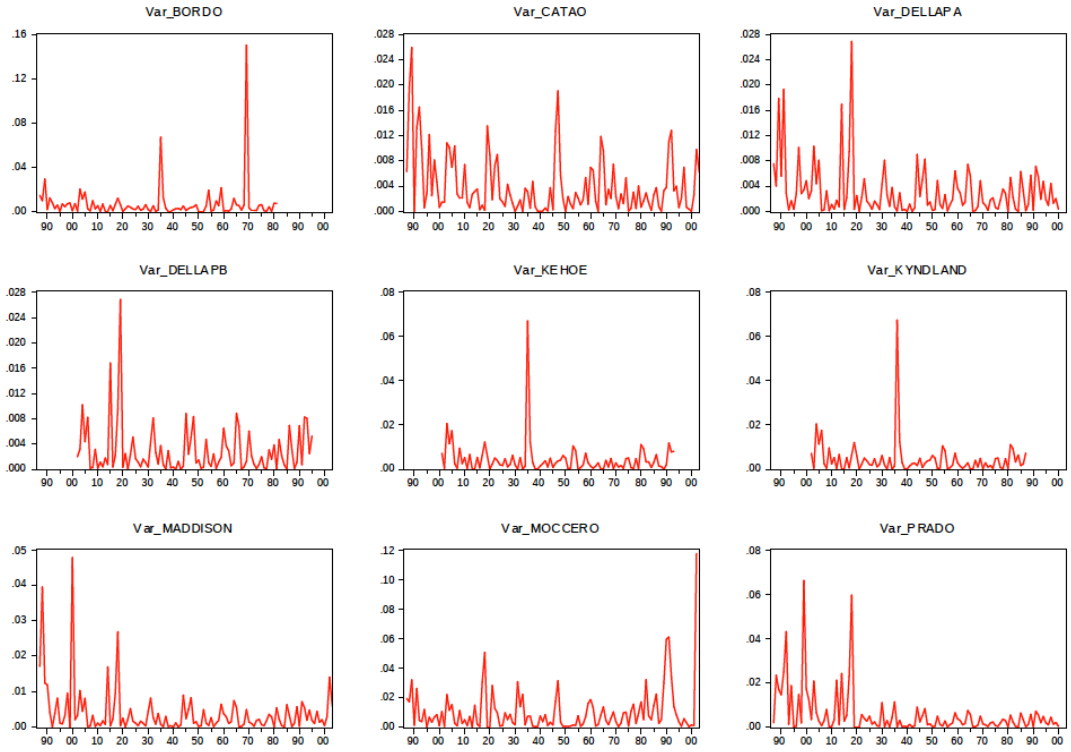


Figure 2.4. Sample mean and standard deviation of each pre-determined segment for each of Argentina's GDP growth series

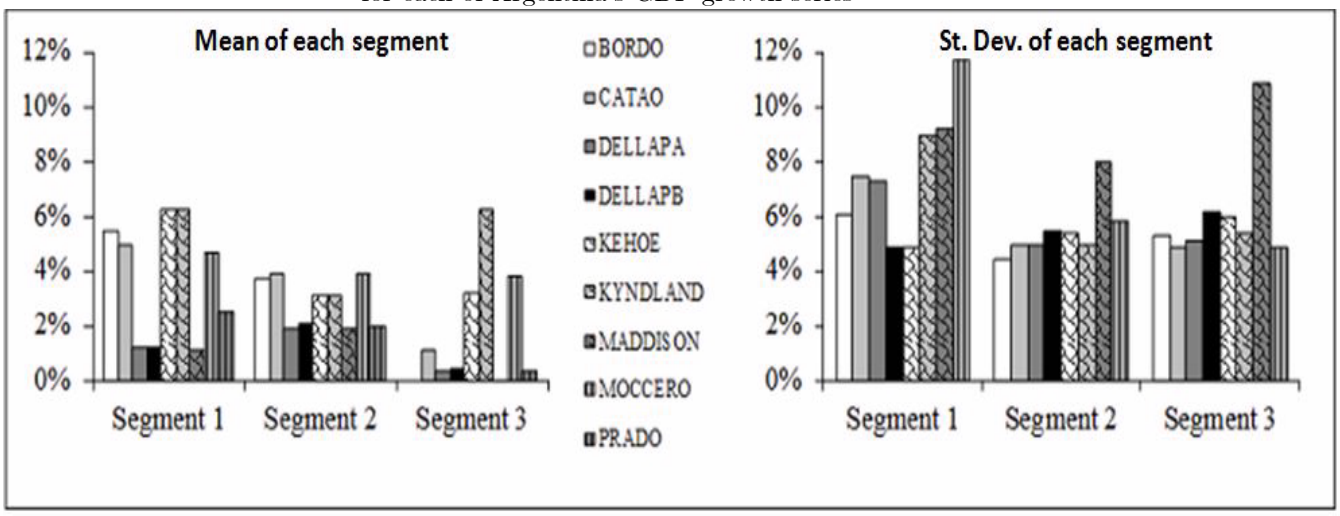


Figure 2.5. Sample mean (left axis, bold line) and standard deviation (right axis, dashed line) of the ratio of Argentina's GDP relative to the (population weighted) GDP of Latin American economies

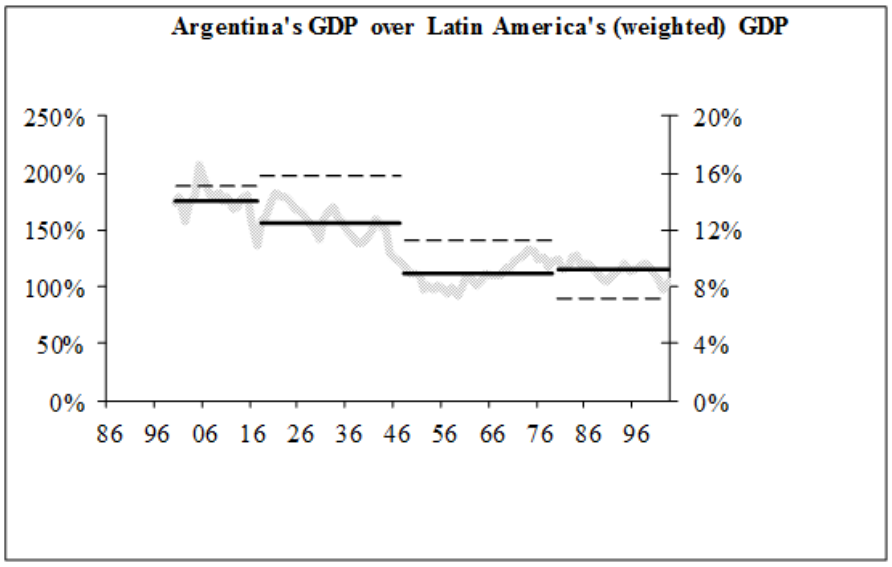


Figure 2.6. Sample mean (left axis, bold line) and standard deviation (right axis, dashed line) of the ratio of Argentina's GDP relative to the (population weighted) GDP of Western Off-shoots countries

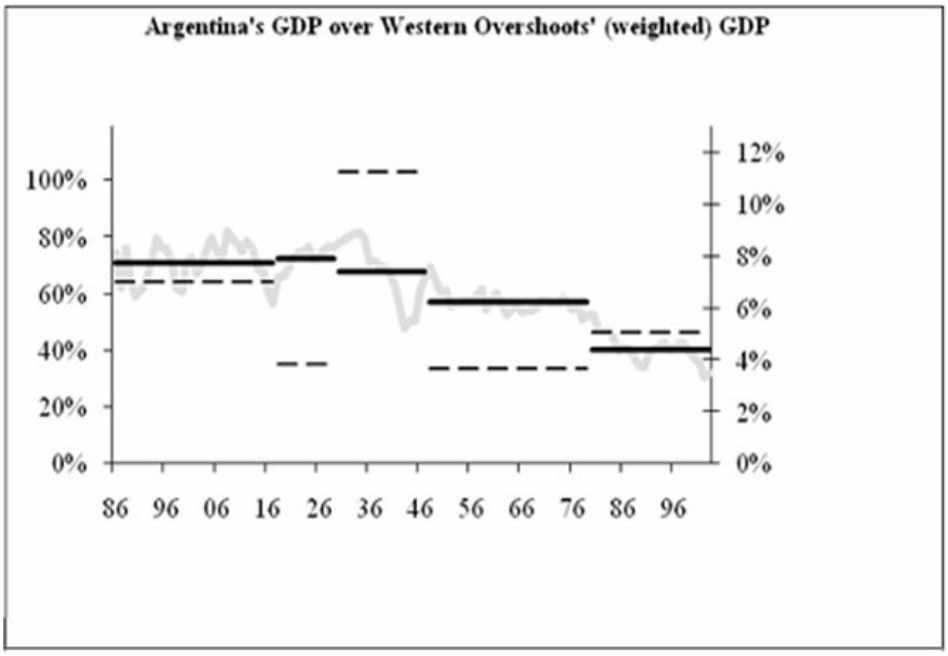


Figure 2.7. Sample mean (left axis, bold line) and standard deviation (right axis, dashed line) of the ratio of Argentina's GDP relative to the (population weighted) GDP of Western European countries

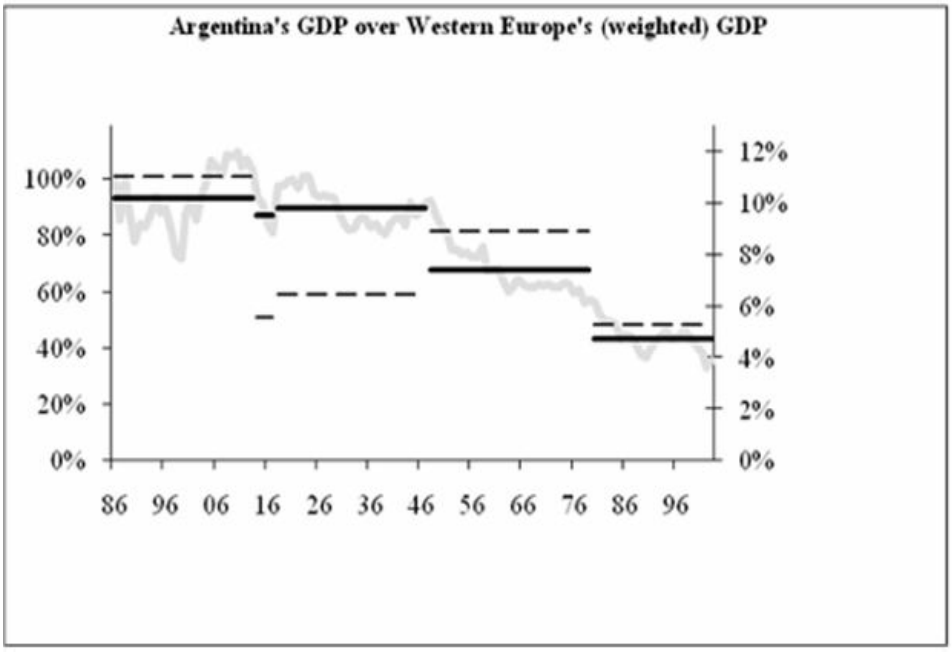


Table 2.1. Structural breaks detected by each test at 1% and 5% (shaded) statistical level in various Argentina GDP growth series

Series	*Bai-Perron*	*IT*	ASC_1	ASC_2 *Bartlett*	ASC_2 *QS*	ASC_2 *VARHAC*	*KL Bartlett*	*KL QS*	*KL VARHAC*	*LMT*
BORDO	**1919**:1934;1959	1963	-	-	-	-	-	-	-	-
CATÃO	1913;**1918**;1974	-	-	-	-	-	-	-	-	-
DELLAPA	1912;**1917**;1924	-	-	-	-	-	-	-	-	-
DELLAPB	1913;**1918**;1925	1918	1918	1918	1918	1918	1918	1918	1918	1918
KEHOE	1924;1931;1936	-	-	-	-	-	-	-	-	-
KYNDLAND	1925;1932;1937	-	-	-	-	-	-	-	-	-
MADDISON	1899;1912;**1917**	1918	1918	1918	1918	1918	1918	1918	1918	1918
MOCCERO	1980;1989;1994	-	-	-	-	-	-	-	-	-
PRADOS	1912;**1917**;1924	1918	1918	1918	1918	1918	1918	1918	1918	1918

Table 2.2. Descriptive statistics of the three segments of each series

		BORDO	CATAO	DELLAPA	DELLAPB	KEHOE	KYNDLAND	MADDISON	MOCCERO	PRADO
Segment 1	Mean	5.46%	4.94%	1.14%	1.16%	6.25%	6.24%	1.07%	4.65%	2.51%
	Std. Dev.	6.32%	6.06%	7.43%	7.23%	4.80%	4.79%	8.94%	9.14%	11.67%
	Skewness	-0.64	-0.64	-0.23	0.05	-0.12	-0.12	0.41	-0.66	0.16
	Kurtosis	3.07	3.43	2.50	2.81	2.06	2.06	2.82	3.30	2.20
	Jarque-Bera	2.20	2.45	0.62	0.03	0.71	0.71	0.95	2.44	0.99
	Probability	33.3%	29.3%	73.2%	98.3%	70.1%	70.1%	62.3%	29.5%	61.1%
	Observations	32	32	32	18	18	18	32	32	32
Segment 2	Mean	3.72%	3.88%	1.87%	2.04%	3.05%	3.05%	1.87%	3.89%	1.96%
	Std. Dev.	7.62%	4.24%	4.75%	4.70%	5.57%	5.57%	4.75%	7.86%	5.47%
	Skewness	1.73	-0.05	-0.06	-0.04	0.75	0.76	-0.06	-0.37	0.77
	Kurtosis	9.46	2.57	3.45	3.54	6.02	6.08	3.45	3.10	6.22
	Jarque-Bera	138.39	0.50	0.57	0.76	29.29	30.47	0.57	1.47	32.79
	Probability	0.0%	77.7%	75.3%	68.3%	0.0%	0.0%	75.3%	47.9%	0.0%
	Observations	62	62	62	62	62	62	62	62	62
Segment 3	Mean	8.65%	1.12%	0.31%	0.43%	3.19%	6.18%	-0.13%	3.79%	0.31%
	Std. Dev.	0.07%	5.86%	5.24%	5.99%	6.54%	4.94%	5.82%	12.28%	5.24%
	Skewness	0.00	-0.01	-0.06	-0.04	-0.74	-1.37	-0.17	-0.10	-0.06
	Kurtosis	1.00	1.98	1.78	1.77	2.43	3.72	1.95	2.24	1.78
	Jarque-Bera	0.33	1.04	1.31	0.95	1.47	2.34	1.22	0.53	1.31
	Probability	84.6%	59.5%	51.9%	62.2%	47.9%	31.0%	54.4%	76.5%	51.9%
	Observations	2	24	21	15	14	7	24	21	21

Table 2.3. Testing the equality of means and variances of contiguous segments

	testing the equality of means		testing the equality of variances				
	t-test	Satterthwaite-Welch	F-test	Siegel-Tukey	Bartlett	Levene	Brown-Forsythe
Bordo 1 & 2	1.11	1.18	1.23	1.38	1.45	1.76*	1.36
Bordo 2 & 3	-0.91	-5.08***	0.82	25.85***	1477.6***	1.22	6.25**
Catão 1 & 2	0.99	0.88	0.98	0.78	2.04**	1.07	5.5**
Catão 2 & 3	2.43**	2.11**	5.89**	4.44**	1.91*	1.94*	3.75*
DellapA 1 & 2	-0.58	-0.5	0.33	0.25	2.45***	2.86***	8.68***
DellapA 2 & 3	1.27	1.21	1.6	1.45	1.21	1.23	0.29
DellapB 1 & 2	-0.62	-0.49	0.38	0.24	2.36*	2.03**	5.56**
DellapB 2 & 3	1.13	0.97	1.27	0.94	1.62	1.67*	1.43
Kehoe 1 & 2	2.21**	2.4**	4.87**	5.75**	1.35	1.26	0.55
Kehoe 2 & 3	-0.09	-0.08	0.01	0.01	1.38	1.72*	0.57
Kyndland 1 & 2	2.21**	2.4**	4.87**	5.76**	1.35	1.3	0.56
Kyndland 2 & 3	-1.43	-1.57	2.03	2.46	1.27	1.42	0.14
Maddison 1 & 2	-0.57	-0.47	0.33	0.23	3.54***	3.12***	17.49***
Maddison 2 & 3	1.64	1.5	2.69	2.25	1.5	1.83*	1.43
Moccero 1 & 2	0.42	0.4	0.18	0.16	1.35	0.5	0.96
Moccero 2 & 3	0.04	0.03	0	0	2.44**	1.98**	6.7***
Prado 1 & 2	0.31	0.25	0.1	0.06	4.55***	4.07***	25.09***
Prado 2 & 3	1.21	1.23	1.46	1.52	1.09	0.85	0.06

Note: * 10%, ** 5% and *** 1% significance level.

Table 2.4. Structural breaks detected by each test at 1% and 5% (shaded) statistical level in various ratios of Argentina GDP growth series

Series	*Bai-Perron*	*IT*	ASC_1	ASC_2 *Bartlett*	ASC_2 *QS*	ASC_2 *VARHAC*	*KL Bartlett*	*KL QS*	*KL VARHAC*	*LMT*
Latin America	1914 1940,1980	1948	1948	1948	1948	1948	1948	1948	1948	1948
Western Offshoots	1914	1930	1930	-	1930	-	-	1930	-	1930
	1940,1980	1947	1947	-	1947	-	-	1947	-	1947
Western Europe		1914	-	-	-	-	-	-	-	-
	1951,1958,1980	1948	-	-	-	-	-	-	-	-

Table 2.5. Testing the equality of means and variances of contiguous segments

	testing the equality of means		*testing the equality of variances*				
	t-test	*Satterthwaite-Welch t-test*	*F-test*	*Siegel-Tukey*	*Bartlett*	*Levene*	*Brown-Forsythe*
Ratio with LA 1 & 2	4.28***	4.33***	1.09	1.16	0.04	0.71	0.69
Ratio with LA 2 & 3	12.76***	12.62***	1.97*	0.46	3.35*	2.83*	2.66
Ratio with LA 3 & 4	-1.35	-1.44	2.53**	2.18**	5.17**	6.19**	5.81**
Ratio with US 1 & 2	-0.89	-1.15	3.41***	1.94*	4.73**	6.48**	5.27**
Ratio with US 2 & 3	1.44	1.69	8.73***	2.48**	11.43***	11.04***	8.81***
Ratio with US 3 & 4	4.96***	3.92***	9.42***	4.25***	27.54***	28.36***	23.53***
Ratio with US 4 & 5	14.4***	13.76***	1.91	1.5	2.73*	2.13	2.19
Ratio with WE 1 & 2	1.09	1.78	3.94**	1.11	1.61	3.14*	3.1*
Ratio with WE 2 & 3	-0.78	-0.88	1.36	0.61	0.1	0.6	0.36
Ratio with WE 3 & 4	11.19***	11.31***	1.89*	0.39	2.9*	1.99	0.55
Ratio with WE 4 & 5	11.94***	12.81***	2.85***	1.58	6.49**	7.52***	3.16*

Note: * 10%, ** 5% and *** 1% significance level.

Appendix 2

Data Description

In this section we describe (in alphabetical order) the GDP series used in this Chapter and how they are constructed:

Bordo (Bordo et al., 2001)

The real GDP in Bordo et al. (2001) was constructed from three different sources: 1884-1913, Gerardo della Paollera (1989); 1914-1988, International Historical Statistics: The Americas, 1750-2000, (B. R. Mitchell, 2003); 1989-1997, International Financial Statistics (IFS) (1998) (see Bordo et al., 2001).

References:

- Bordo, M., Eichengreen, B., Klingebiel, D., & Martinez-Peria, M. S. (2001). Is the Crisis Problem Growing more Severe?. Economic Policy, 16(32), 51-82.
- International Financial Statistics Yearbooks various issues.
- Mitchell, B. R. (2003). International Historical Statistics: The Americas, 1750-2000 5h Eds.. London : Palgrave MacMillan.
- della Paolera, G. (1989). How the Argentine Economy Performed During the International Gold Standard: A Reexamination. Doctoral dissertation, University of Chicago, Department of Economics.

Catão (Aiolfi, Catão & Timmermann, 2011)

This real GDP index (2000=100) is used in Catão, Fostel and Kapur (2009). It is based on Aiolfi, Catão and Timmerman's (2011) estimates of the output gap superimposed onto the HP-filtered trend growth rate of output figures from Della Paolera, Taylor and Bózolli (2003b).

References:

- Aiolfi, M., Catão, L. A., & Timmermann, A. (2011). Common Factors in Latin America's Business Cycles. Journal of Development Economics, 95(2), 212-228.
- Catão, L. A., Fostel, A., & Kapur, S. (2009). Persistent Gaps and Default Traps. Journal of Development Economics, 89(2), 271-284.
- della Paolera, G., Taylor, A. M., & Bózolli, C. G. (2003b). Historical statistics. In della Paolera, G., & Taylor, A. M. (Eds.). A New Economic History of Argentina. Cambridge: Cambridge University Press, 376-385 (plus CD).

DellapA (della Paolera, Taylor 2003a)

This series is taken from Della Paolera and Taylor (2003a). They have used real GDP pc, Hofman estimate, at constant 1980 international prices.

Reference:

- della Paolera, G., & Taylor, A. M. (2003a). A New Economic History of Argentina. Cambridge: Cambridge University Press.

DellapB (Della Paolera, Taylor and Bózolli, 2003b)

This series has been employed in de la Escosura and Snaz-Villarroya (2009). It is taken from Della Paolera, Taylor and Bózolli (2003b). They have used real GDP pc, at current 1990 U.S. dollars.

References:

- della Paolera, G., Taylor, A. M., & Bózolli, C. G. (2003b). Historical statistics. In della Paolera, G., & Taylor, A. M. (Eds.). A New Economic History of Argentina. Cambridge: Cambridge University Press, 376-385 (plus CD).

- de la Escosura, L. P., & Villarroya, I. (2009). Contract Enforcement, Capital Accumulation, and Argentina's Long-Run Decline. Cliometrica 3(1), 1-26.

Kehoe (Kehoe, 2007)

Kehoe (2007) used a real GDP index (2000=100). The description of the original data used in Kehoe (2007) is: O.1) GDP, Argentina (millions of 1990 Geary-Khamis Dollars); O.2) GDP, Argentina (1986 pesos); O.3) GDP Volume Index, Argentina (2000 = 100). The sources are: O.1) Maddison (2003), Levels of GDP; O.2) Kydland and Zarazaga (2002, 2007), originally from Meloni (1999); O.3) IFS, 21399BVPZF... The construction of the series is as follows: O.3 spliced with O.2 and O.1.

References:

- Kehoe, T. (2007). What Can We Learn From the 1998-2002 Depression in Argentina?. In Kehoe, T., & Prescott, E. C. (Eds.). Great Depressions of the Twentieth Century. Mineapolis: Federal Reserve Bank of Mineapolis, 373-402. Retreived from http://www.greatdepressionsbook.com/datasets.cfm

- Kydland, F., & Zarazaga, C. (2002). Argentina's Lost Decade. Review of Economic Dynamics, 5(1), 152-165.

- Kydland, F., & Zarazaga, C. (2007). Argentina's Lost Decade and Subsequent Recovery: Hits and Misses of the Neoclassical Growth Model. In Kehoe, T. & Prescott E. C. (eds). Great Depressions of the Twentieth Century, Minneapolis: Federal Reserve Bank of Minneapolis, 191-216.

- Maddison, A. (2003). The World Economy: Historical Statistics, Paris: OECD.

- Meloni, O. (1999). Crecimiento potencial y productividad en Argentina. Secretaría de Programación Económica y Regional, Buenos Aires.

Kydland (Kydland & Zarazaga, 2002)

The real GDP series, in 1986 pesos, used in Kydland and Zarazaga (2002, 2007) is from Meloni (1999). The description of the original data used in Kydland and Zarazaga (2002) is: O.1) Real GDP 1900-50 at market prices, million pesos moneda nacional, in 1950 prices; O.2) Real GDP 1950-70 at market prices, australes, 1960 prices; O.3) Real GDP 1970-80 at market prices, australes, 1970 prices; O.4) Real GDP 1980-97 at market prices, thousand pesos, 1986 prices. The sources are: O.1) ECLAC-CEPAL (1958). Data from this source are also posted on the following Website page of the Ministry of the Economy of Argentina: http://www.mecon.gov.ar/secpro/dir_cn/series_historicas/series_pbireal.xls; O.2) ECLAC-CEPAL (1988). Cuadro 1, p. 205; O.3) ECLAC-CEPAL (1988). Cuadro 1, p. 245; O.4) Heymann (2000). Cuadro 1, p. 156. As mentioned above the constructed series is real GDP at market prices, thousand pesos, 1986 prices. The construction of the series is as follows: Period 1980-97: series O.4. Period 1900-79: spliced by applying the annual growth rates of original series O.1, O.2, and O.3 to 1980 level in series O.4.

References:

- ECLAC-CEPAL (Economic Commission for Latin America-Comisión Económica para América Latina) (1958): "El desarrollo económico de la Argentina". Santiago de Chile. Chile.

- ECLAC-CEPAL (Economic Commission for Latin America-Comisión Económica para América Latina) (1988): "Estadísticas de corto plazo de la Argentina: cuentas nacionales, industria manufacturera y sector agropecuario pampeano." Documento de Trabajo 28.

- Heymann, D. (2000). Políticas de Reforma y Comportamiento Macroeconómico, in Heymann, D. and Kosacoff, B. (Eds.). Desempeno económico en un contexto de reformas. Editorial Universitaria de Buenos Aires (EUDEBA), Buenos Aires, Argentina.
- Kydland, F., & Zarazaga, C. (2002). Argentina's Lost Decade. Review of Economic Dynamics, 5(1), 152-165.
- Kydland, F., & Zarazaga, C. (2007). Argentina's Lost Decade and Subsequent Recovery: Hits and Misses of the Neoclassical Growth Model. In Kehoe, T. & Prescott E. C. (eds). Great Depressions of the Twentieth Century, Minneapolis: Federal Reserve Bank of Minneapolis, 191-216.
- Meloni, O. 1999. Crecimiento potencial y productividad en Argentina. Secretaría de Programación Económica y Regional, Buenos Aires.

Maddison (Maddison, 2003)

This series is taken from Maddison (2003). We have used purchasing power parity adjusted GDP per capita expressed in 1995 US relative prices.

References:

- Maddison, A. (2003). The World Economy: Historical Statistics, Paris: OECD. Retrieved from http://www.ggdc.net/maddison/Historial_Statistics/BackgroundHistoricalStatistics_10-2009.pdf

Moccero (Moccero, 2008)

To construct nominal GDP, Moccero (2008) used the nominal National Accounts presented in IEERAL (1986) for the period 1914-1980. He then extended this series over the future using data from INDEC (nominal National Accounts, methodologies 1986 and 1993). The extension over the past (1885-1913) was based on information from Taylor (1998). Nominal GDP was deflated using the wholesale price index (in australes of 1985). In constructing the wholesale price index three data sources were mixed: Della Paolera and Taylor (2003a) for 1885-1900, Véganzonès and Winograd (1997) for 1901-1993, and the National Institute of Statistics and Censuses of Argentina (INDEC) for the remaining period.

References:

- della Paolera, G., & Taylor, A. M. (2003a). A New Economic History of Argentina. Cambridge: Cambridge University Press.
- IEERAL, (1986). Estadísticas de la Evolución Económica Argentina: 1913-1984. Revista Estudios 39.
- INDEC, (1993). Anuario Estadístico de la República Argentina. Buenos Aires, Instituto Nacional de Estadística y Censos.
- Moccero, D. N. (2008). The Intertemporal Approach to the Current Account: Evidence for Argentina. Journal of Applied Economics, 11(2), 327-353.
- Taylor, A. (1998). Argentina and the World Capital Market: Saving, Investment, and International Capital Mobility in the Twentieth Century. Journal of Development Economics, 57(1), 147–184.
- Véganzonès, M., & Winograd, C. 1997. L'Argentine au XXe Siécle : Chronique d'une croissance annoncé. OCDE publishing.

Prados (de la Escosura & Villarroya, 2009)

de la Escosura and Villarroya (2009) have used purchasing power parity adjusted GDP per capita estimated by Maddison (2003) expressed in 1990 International Dollars. For Argentina up to 1935 they used Cortes Conde GDP reconstruction (1997).

References:

- de la Escosura, L. P., & Villarroya, I. S. (2009). Contract Enforcement, Capital Accumulation, and Argentina's Long-Run Decline. Cliometrica, 3(1), 1-26.
- Cortes Conde, R. (1997). La Economía Argentina en el Largo Plazo (Siglos XIX y XX), Editorial Sudamericana, Universidad de San Andrés.
- Maddison, A. (2003). The World Economy: Historical Statistics, Paris: OECD.

Table A.2.1. Sample sizes

Series name:	**Data span:**	**Found in:**
Bordo	1896-2001	Bordo et al., 2000
Catão	1886-2003	Aiolfi, Catão and Timmermann, 2011
DellapA	1901-1994	Della Paolera, Taylor and Bózolli, 2003
DellapB	1896-2000	Della Paolera, Taylor and Bózolli, 2003
Kehoe	1900-2003	Kehoe, 2007
Kydland	1900-1997	Kydland and Zarazaga, 2002
Maddison	1886-2003	Maddison, 2003
Maddison, LA	1900-2003	Maddison, 2003
Maddison, US	1886-2003	Maddison, 2003
Maddison, WE	1886-2003	Maddison, 2003
Moccero	1896-2002	Moccero, 2008
Prados	1896-2000	Prados and Sanz-Villarroya, 2009

Chapter 3

On the Time-Varying Link Between Finance and Growth: A Smooth Transition Approach for Brazil, 1890-2003

3.1. Introduction

In 2001, Goldman Sachs published an influential report. It was responsible for popularizing the BRICS acronym in business and economics. BRICS, of course, stands for Brazil, Russia, India, China and South Africa. The time of the report also marks the start of a shift in relative weights in the world economy towards the so-called emerging market countries. Although many analysts questioned whether Brazil should be included in such a distinguished group, few questioned that the country has undergone a most remarkable transformation in the last 100 years or so. From a poor, unsophisticated, primary exporter economy about one hundred years ago it became one of the largest and richest emerging markets of today. Economists have gone to great lengths to try to understand this important transformation. One class of potential explanations that has received considerable attention is related to finance. Various hypotheses have been put forward to explain this process of deep structural transformation but attention has focused on the roles of financial development, public finances and international financial integration. Few previous studies have tried to evaluate how the explanatory power of these factors has changed over time and this is one of the main contributions of this Chapter. We apply the logistic transition (LST) model and use annual time series data for Brazil covering the period from 1890 to 2003.

We focus our study on the relationship between financial development and economic growth. An authoritative review of the state of play in this regard is Zingales (2015), which highlights an important yet under researched finding in this literature regarding divergent short and long-run effects of finance on growth. For example, Gavin and Hausmann (1996) argue that financial liberalization and expansion without constraints could cause banking crises and economic collapse. Kaminsky and Schmukler (2003) argue that financial development being robustly associated with economic growth, it has also often been found to be the main predictor of financial crises. That is, while the long-run effect of finance on growth is positive, in the short-run it is negative. Loayza and Ranciere (2006) report panel evidence that the size of the effects is similar but the negative short-run effect is often larger than the positive long-run effect. Focusing on time-series for a single country, Argentina, Campos et al. (2012) show that the short-run effect of finance on growth was likely to be negative, but smaller than the positive long-run effect. The depth and extent of the debate surrounding substantial differences in the effect of finance on growth depending on whether one focuses on the shorter- (negative) or the (positive) longer-run suggests that further research examining this time-varying relationship would be valuable. This is the aim of this Chapter.

This Chapter contributes to this literature by further investigating this time-varying link basically between finance and economic growth. It uses the smooth transition framework and annual time series data for Brazil covering the period from a very long time window covering 1890 to 2003. The Chapter chiefly addresses the following questions: What is the relationship between economic growth, on the one hand, and financial development, trade openness and political instability, on the other? Does the intensity and sign of these effects vary over time?

We may add that this Chapter also contributes to the literature on economic growth. Regarding the body of scholarly research on the main causes of economic growth, Durlauf et al. (2005) and Acemoglu (2008) provide recent, authoritative surveys that support the view that there seems to be dissatisfaction with the empirical growth literature. This Chapter tries to improve matters in this regard by focusing

on a single country as opposed to following the common practice of trying to learn something about growth by focusing on the mean or median country. We believe this study can further our understanding of economic growth mainly because of two main considerations. Firstly, we study only one individual country over a very long period of time with annual frequency data. Various papers allow analysis of Brazil's performance from a cross-country perspective (among others, Loyaza and Ranciere, 2005), while those focusing solely on Brazil tend to cover the period from the 1930s onwards (e.g. de Paiva Abreu and Verner, 1997). Secondly, we employ an econometric methodology that has been seldom used in the empirical growth literature.

Our main finding is that financial development has a mixed (positive and negative) time-varying impact on economic growth; trade openness has a positive effect, whereas the effect of political instability, both formal and informal, on growth is unambiguously negative. Moreover, the positive time-varying effect of financial development on economic growth significantly depends on jointly estimated trade openness thresholds.

The Chapter is organized as follows. Section 3.2 provides details and justification for our econometric methodology. Section 3.3 describes the data. Section 3.4 discusses our baseline econometric results. Section 3.5 concludes and suggests directions for future research.

3.2. Econometric Framework

Non-linear models have attracted the interest of more and more researchers in recent years. Teräsvirta (1994) suggested a specification technique of three stages, assuming that if the process is not linear, then the alternative might be a smooth transition (ST) autoregressive model, which captures regime-switching behaviour. The first stage of the estimation procedure is to identify a linear autoregressive model. The second focuses on testing linearity for different values of d, the delay parameter, and the third one on choosing between an exponential ST (EST) or a logistic ST (LST) model by testing a sequence of three hypotheses (see Teräsvirta, 1994 and Appendix 3 below). Nevertheless, initial estimation of both EST and LST models and the usage of postestimation information criteria could provide us with the final choice between models, Teräsvirta (1994). The ST model for the economic growth series y_t is given by

$$y_t = \boldsymbol{\phi}_1' \mathbf{x}_{t-l} + \boldsymbol{\phi}_2' \mathbf{x}_{t-l} G(s_{t-d}) + \epsilon_t \tag{3.1}$$

where $\mathbf{x}_{t-l} = (1,\, x_{2,t-l}, \ldots, x_{k,t-l})'$ is the $k \times 1$ vector of the explanatory variables, $\boldsymbol{\phi}_i = (\phi_1^{(i)}, ..., \phi_k^{(i)})'$, $i = 1, 2$, are the $k \times 1$ vectors of coefficients and $G(s_{t-d})$ is the transition function (see eq. 3.2 below), which changes smoothly from 0 to 1 as the transition variable s_{t-d} increases. The term d determines the lag-length of the transition variable and $\{\varepsilon_t\}$ are independently and identically distributed *(i.i.d)* random variables. Here we use the first order logistic function, which is defined as:

$$G(s_{t-d}) = \frac{1}{1 + e^{-\gamma(s_{t-d} - c)}}, \tag{3.2}$$

where γ determines how smooth the change in the value of the logistic function is (and hence the transition from one regime to another) and the intercept c is the threshold between regimes. In eq. 3.2, when the smoothness parameter becomes very large, $\gamma \to \infty$, then the transition is said to be abrupt. When $\gamma \to 0$ the logistic function approaches a constant. Thus when $\gamma = 0$ the LST model reduces to the linear model. The advantage of an ST against a threshold autoregressive (TAR) model is that the conditional mean function is differentiable (Tsay, 2010). However, previous research shows that the transition parameters γ and c are quite difficult to estimate (see Teräsvirta, 1994). Following Teräsvirta (1994) we test whether the non-linear model is preferred and if the use of the logistic function is warranted.

3.3. Data

Our data set contains annual data for economic growth, financial development, trade openness and political instability for Brazil between 1890 and 2003, excluding the World War years. The main data source for the first three is Mitchell (2003), see Figure 3.1. Economic growth is measured as annual growth rates of gross domestic product (GDP). Our measure of financial development is commercial bank deposits over GDP (CBD) defined as the sum of time deposits in commercial banks and deposits at the end of the period in commercial banks and it tries to capture the efficiency of the financial sector. Data have been reported by Mitchell (2003) but due to missing values we follow the approach of Pelaez and Suzigan (1976) to reconstruct the series. As far as trade openness is concerned we use the ratio of exports plus imports as a share of GDP (TO). Among others, Krueger (1978) and Wacziarg and Welch (2008) argued that trade openness leads to higher growth rates. International Monetary Fund (IMF, 1997) stated that policies favoring international trade are among the most significant elements in promoting economic expansion and convergence in developing countries. In addition, a report from OECD (1998) suggested that more open and outward oriented economies tend to surpass countries with restrictive and more isolated trade policies. Finally, Fischer (2000) during a lecture (see also Rodriguez and Rodrick, 2001) noted that the optimal way for a nation to grow is to harmonise its policies with the global economy. However, these arguments were lacking general approval especially after the Great War in developing countries and in particular Latin America, which very often adopted so-called Import Substitution Industrialization policies (ISI), which imposed barriers on international trade. The outbreak of World War II turned Latin America back to protectionism and to high tariff policies and it was not until the 1990s when liberal policies took effect (Edwards, 1994). This Chapter tries to capture these changes in trade policies by using trade openness as the transition variable in the case of Brazil for the following reasons. Brazil is the most advanced industrial economy in South America (Pereira et al., 1993). According to the United Nations' statistical agency[11] it is a major exporter of iron ore and concentrates, petroleum oil, soya beans, coffee and processed meat, as it is involved in the manufacture of small aircraft. Finally, the importance of trade policies for successive Brazilian governments is apparent from: the fact that its patent law dates back to 1809 (in contrast to Germany, where it only appeared 70 years later); their participation in every international conference associated with intellectual property rights since that time; and their signing of GATT in 1947 (General Agreement on Tariffs and Trade) founding declaration (Lattimore and Kowalski, 2009).

The new data we use in this Chapter is for political instability. We use a taxonomy of political instability divided into two categories, informal and formal (Campos et al., 2012). Formal political instability originates from within the political system, informal from outside. Our starting point as the source of historical annual data for various types of political instability is Arthur Banks's Cross National Time Series Data Archive (CNTS). The informal political instability measures consist of the number of demonstrations (DEM), defined as peaceful public gatherings of at least 100 people and the number of strikes (STR) of 1000 or more workers involving multiple employers and aimed at government policies (see Figure 3.2). Formal political instability is measured by legislative selection (LS) and legislative elections (LE). The latter is defined as the number of elections for the lower house each year. The former takes the value 0 when no legislature exists, the value 1 in the case of nonelective legislature and 2 when legislators or members of the lower house in a bicameral system are selected by means of either direct or indirect popular election (Figure 3.3). For these formal and informal political instability variables, Banks data (2005) do not exist for the pre-1918 period. In order to generate this new political instability series, all relevant political events from years 1890 to 1939 were catalogued and classified into different types of political instability (see Campos et al., 2014). We then took advantage of an intentional overlap between the series during the period 1919 to 1939 to assess the reliability of the new information. We find that there are a few circumstances where there is mild disagreement between the two series and thus argue

[11] For further information regarding Brazil's profile please check the: http://comtrade.un.org

that the new data series is as reliable as the more standard CNTS data.

Results from the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests are presented in Table 3.1 below. Both suggest that either the level of the series or their first differences are stationary. In addition, unit root tests with breaks provided by Zivot and Andrews (1992) have been conducted (Table A3.1 in the Appendix). In all cases the unit root hypothesis is rejected at 1% and 10% level respectively (with the exception of le that fails to reject the unit root hypothesis when we allow for a break in the trend: see Table A3.1 in the Appendix, third column).

Figure 3.1. Growth rate, Financial Development and Trade Openness

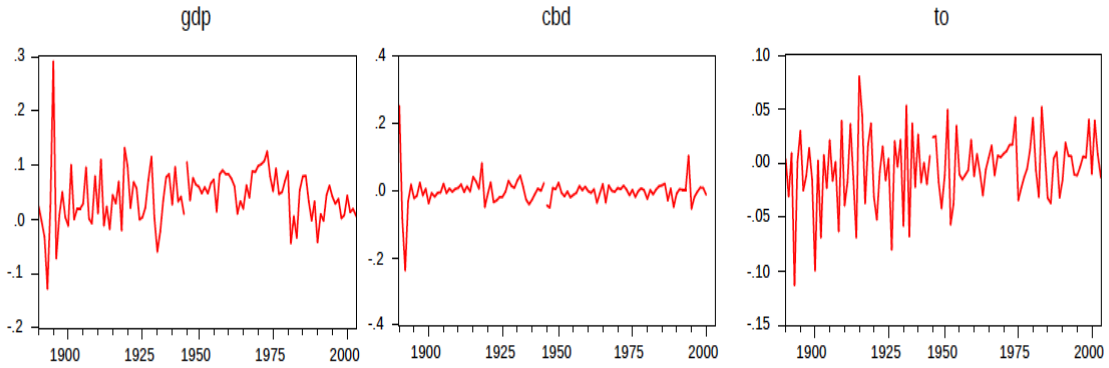


Figure 3.2. Informal Political Instability measures

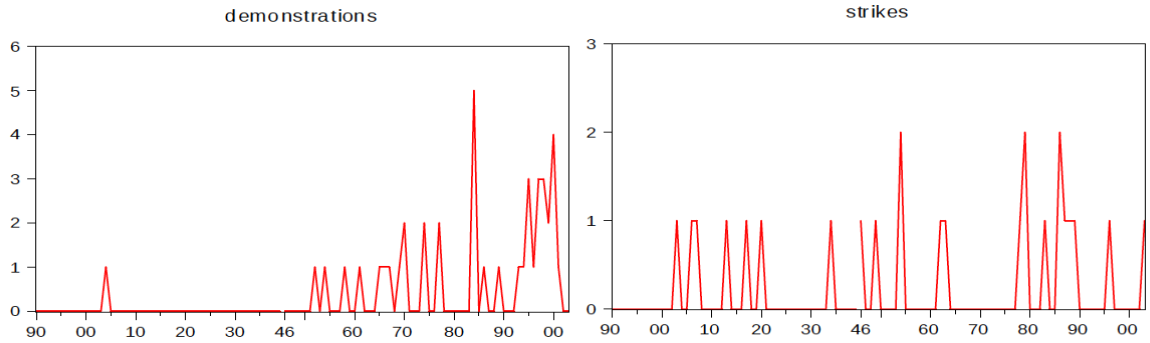


Figure 3.3. Formal Political Instability measures

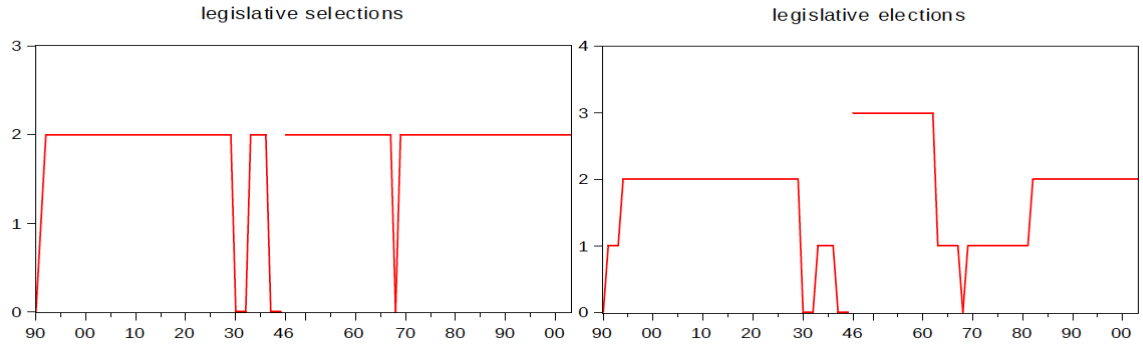


Table 3.1. Augmented Dickey Fuller (ADF) and Phillips Perron (PP) Unit Root Tests.

Variable	ADF at level	ADF at first difference	PP at level	PP at difference
GDP	-9.29^{***}		-9.29^{***}	
CBD		-12.35^{***}		-11.94^{***}
TO		-13.00^{***}		-13.00^{***}
DEM	-4.54^{***}		-7.37^{***}	
STR	-8.99^{***}		-8.99^{***}	
LS	-6.29^{***}		-6.37^{***}	
LE	-3.63^{***}		-3.69^{***}	

Notes: *** indicate significance at 1% level. Numbers represent the estimated ADF and PP t-statistics respectively. Both tests suggest that either the level of the series or their first difference are stationary at 1% level.

3.4. Empirical Results

In this section we use the smooth transition model to investigate the relationship between economic growth, financial development and political instability with the level of trade openness in the economy as the transition variable. The economic history of Brazil demonstrates the close relation between trade openness and economic growth (Baer, 2013), so trade openness is clearly the most intuitive choice for our transition variable. The reasons for the choice of trade openness as our transition variable are not just easily found in economic history but this choice is also fully supported econometrically by standard linearity tests. In particular, when financial development is used as the transition variable they fail to reject the linearity hypothesis (from now on LM_2) in two cases (demonstrations and legislative elections) while for the other two (strikes and legislative selections) the p-values of LM_2 are weaker than those when trade openness is the transition variable[12]. The reason why we do not test linearity using political instability as the transition variable is simply because our measures contain many 0 values. When $s_{t-d} = 0$, then the transition function (see equation 2 above) becomes 0 and hence the model, in equation 1, reduces to a linear one. A range of linearity tests suggests the use of LST instead of the EST model (see Table 3.2 below). The only case in which an ESTAR is the preferred choice is when legislative elections serve as the political instability measure. However, based on Teräsvirta (1994) the choice between an

[12]results not reported.

EST or an LST model could be postponed until both types of models are estimated and evaluated using postestimation criteria. In our case, an LSTAR model seemed more suitable[13]. We use the RATS software to estimate equations (3.1) and (3.2) above. As mentioned in Section 2, Teräsvirta (1994) argues that specifying a linear autoregressive model constitutes the first stage of the estimation procedure. We select the optimal lag length that rejects stronger linearity, that is, for financial development $l = 3$, while for demonstrations $l = 4$.[14]

Table 3.2. Linearity testing, Determining the Delay Parameter and Selection Between LSTAR and ESTAR. Trade Openness is Used as a Threshold.

Variable	Linearity LM_2	p-value H01	p-value H02	p-value H03	d-delay parameter	TP choice
DEM	0.02	0.01	0.84	0.03	4	LSTAR
STR	0.01	0.02	0.16	0.13	4	LSTAR
LS	0.01	0.27	0.13	0.01	4	LSTAR
LE	0.01	0.25	0.02	0.03	4	ESTAR*

Notes: Column 2 represents the p-value (strength) of the linearity rejection. Based on the Teräsvirta (1994) selection process, columns 3 to 5 suggest an LSTAR model except from *le*. However, the use of the LSTAR model fits better in our data. Column 6 represents the delay parameter, which in our case is 4, since the power of linearity rejection is stronger relative to other values of d. The usage of LM_2, H01, H02 and H03 follows Teräsvirta (1994).

For trade openness and legislative selections the selection of $l = 4$ is made on the basis of the minimum value of LBQ and the General to Simple (GS) information criterion (see Table A3.2 in the Appendix). Finally, a portmanteau test of Ljung and Box was conducted to control for residual autocorrelation in our model and hence possible misspecification. The results indicated no residual serial correlation (results, not reported, are available upon request). The choice of the delay parameter is determined by the strongest linearity rejection relative to different values of d. Accordingly, we set $d = 4$. The vector of explanatory variables contains the drift, the third lag of commercial bank deposits (CBD) and the fourth lags of the various measures of political instability (PI), and trade openness (TO). That is, $\mathbf{x}_{t-l} = (1, CBD_{t-3}, PI_{t-4}, TO_{t-4})$. The preferred model was the one with $\phi_4^{(2)} = 0$ and where the regime indicator variable s_{t-d} was chosen to be TO_{t-4}.

Table 3.3 reports our baseline results when the various measures of political instability are used as expalanatory variables. In order to estimate the time-varying effects of trade openness, political instability and financial development on growth we use the following three equations[15]:

[13] This choice was derived from postestimation Ljung and Box statistic for residual autocorrelation (LBQ) and on the basis of the minimum value of Akaike information criterion (AIC).

[14] A common way would be the usage of the AIC or the Schwarz information criterion (SBIC) in order to select the appropriate lag structure of the model. However, a choice based on SBIC could lead to too parsimonious models since the estimated residuals derived from the selected model may not be free from serial correlation. Hence, models suggested by any information criteria should be followed by a test of residual serial correlation, for instance the Ljung and Box portmanteau test. In addition, Luukkonen et al. (1990) stressed that in the case of US unemployment, the linearity might be rejected when the lag length is increased, which indicates on one side the significance of longer lags in explaining nonlinearity and the weakness of shorter ones on the other side.

[15] Equations 3.3 to 3.5 below are the first derivative of GDP_t with respect to TO_{t-4}, the vector of PI measurers and CBD_{t-3} in equation 3.1 respectively.

$$\frac{\vartheta(GDP_t)}{\vartheta(TO_{t-4})} = \phi_4^{(1)} + \gamma(\phi_1^{(2)} + \phi_2^{(2)} CBD_{t-3} + \phi_3^{(2)} PI_{t-4}) \exp\left[-\gamma(TO_{t-4} - c)\right](1 + \exp\left[-\gamma(TO_{t-4} - c)\right])^{-2}, \tag{3.3}$$

$$\frac{\vartheta(GDP_t)}{\vartheta(PI_{t-4})} = \phi_3^{(1)} + \phi_3^{(2)}(1 + \exp\left[-\gamma(TO_{t-4} - c)\right])^{-1}, \text{ and} \tag{3.4}$$

$$\frac{\vartheta(GDP_t)}{\vartheta(CBD_{t-3})} = \phi_2^{(1)} + \phi_2^{(2)}(1 + \exp\left[-\gamma(TO_{t-4} - c)\right])^{-1}. \tag{3.5}$$

Table 3.3. Logistic Smooth Transition Model

	$\phi_1^{(1)}$	$\phi_2^{(1)}$	$\phi_3^{(1)}$	$\phi_4^{(1)}$	$\phi_1^{(2)}$	$\phi_2^{(2)}$	$\phi_3^{(2)}$	γ	c
DEM	0.08^{***}	-0.86^{***}	-0.04^{***}	0.58^{**}	-0.04	1.16^{***}	0.04^{**}	5.54	-0.008
	(0.02)	(0.18)	(0.02)	(0.28)	(0.02)	(0.38)	(0.02)	(5.07)	(0.00)
STR	0.09^{***}	-0.86^{***}	-0.03^{**}	0.76^{*}	-0.06	1.21^{***}	0.03	3.52	-0.007
	(0.03)	(0.25)	(0.01)	(0.41)	(0.05)	(0.51)	(0.02)	(2.84)	(0.00)
LS	0.14^{***}	-0.78^{***}	-0.04^{***}	0.69^{**}	-0.12^{*}	1.18^{***}	0.04^{*}	3.94	-0.005
	(0.03)	(0.21)	(0.01)	(0.34)	(0.06)	(0.46)	(0.02)	(3.11)	(0.00)
LE	0.13^{**}	-1.02^{**}	-0.02^{**}	0.91	-0.14	1.62^{*}	0.03	2.02	-0.005
	(0.06)	(0.46)	(0.01)	(0.60)	(0.11)	(0.88)	(0.02)	(1.50)	(0.00)

Notes: Table reports parameter estimates for the following model:
$GDP_t = \phi_1^{(1)} + \phi_2^{(1)} CBD_{t-3} + \phi_3^{(1)} PI_{t-4} + \phi_4^{(1)} TO_{t-4}$
$+(\phi_1^{(2)} + \phi_2^{(2)} CBD_{t-3} + \phi_3^{(2)} PI_{t-4})(1 + \exp\left[-\gamma(TO_{t-4} - c)\right])^{-1} + \epsilon_t.$
The numbers in parentheses represent standard errors.
***, **, * indicates significance at the 1%, 5% and 10% level respectively.

First, notice that there is a positive and statistically significant time-varying relationship between trade openness and economic growth (see equation 3.3 above, Figure 3.4 below and Section 4.5.1.1 for a more detailed description of the results on trade openness). The lowest effects of trade openness are observed in five periods. The first one is between 1908-1910, which shows the consequences of the Taubate Convention, signed in 1906, in which it was proposed that the government should buy the excess coffee production at a minimum preestablished price and that it should also restrict the production of low-quality coffee, stimulate internal consumption, and promote the product abroad (Luna and Klein, 2014). The second period in which low trade openness effects were observed covers the period from 1929 to 1933 (Great Depression), the third one from 1951 to 1954 (adoption of Import Substitution Policies, Korean War), the fourth from 1982 to 1989 (hyperinflation, low net capital inflows as a share of GDP, Edwards 1994) and the final one during 1993, where slow down of the world economy and of productivity gains, and real exchange rate appreciation in Latin America occurred. Regarding the time-varying impact of political instability (either informal or formal) on economic growth the results show that they are negative throughout (see equation 3.4 above and Section 4.5.1.2 for a more detailed description of the results on political instability)).

Our principal findings refer to financial development: Figure 3.4 shows our estimates for this mixed time-varying relationship. Notwithstanding the annual frequency, we estimate a negative effect in 56 cases (years) out of 104 (see equation 3.5 above). For example, in three periods financial development has a clearly positive effect on economic growth, namely 1968-1974, 1991-1993 and 1997-1999 (see Section 4.5.1.3 for a more detailed discussion of the results on CBD). The first period is the one known as the "Brazilian Miracle", when average annual growth rates were high following a number of important financial sector reforms that underpinned a massive increase in infrastructure investment (Goldsmith et al., 1986). During the 1990s there were various attempts to develop non-inflationary sources of finance

and to diminish Brazil's dependency on foreign savings. Despite the political turmoil that marked the early 1990s, 1991 saw law changes allowing foreign institutions to trade domestically issued bonds and securities (Studart, 2000). From 1992 onwards capital flows rose rapidly. One main source of this capital was repatriation of the capital that fled in the 1980s after the interest rate shocks of 1979. The third period covers the late 1990s and this might be explained as the consequences of the successful implementation of the '1994 Real Plan' and the expansion of the PROER programme from 1997 onwards, which supported a wave of mergers and acquisitions in the financial sector (Folkerts-Landau et al., 1997). Moreover, the opening of the Brazilian market to new financial institutions led to the liberalization of the financial system (Bittencourt, 2011).

As far as the level of γ (γ determines how smooth the change in the value of the logistic function is, cf eq. 3.2) is concerned the change between the two regimes is not so smooth, with the exception of legislative elections, where the transition is smoother (see Figure 3.5 below).

Figure 3.4. Time-varying Effects of Financial Development and Trade Openness on Growth Using Various Political Instability Measures.

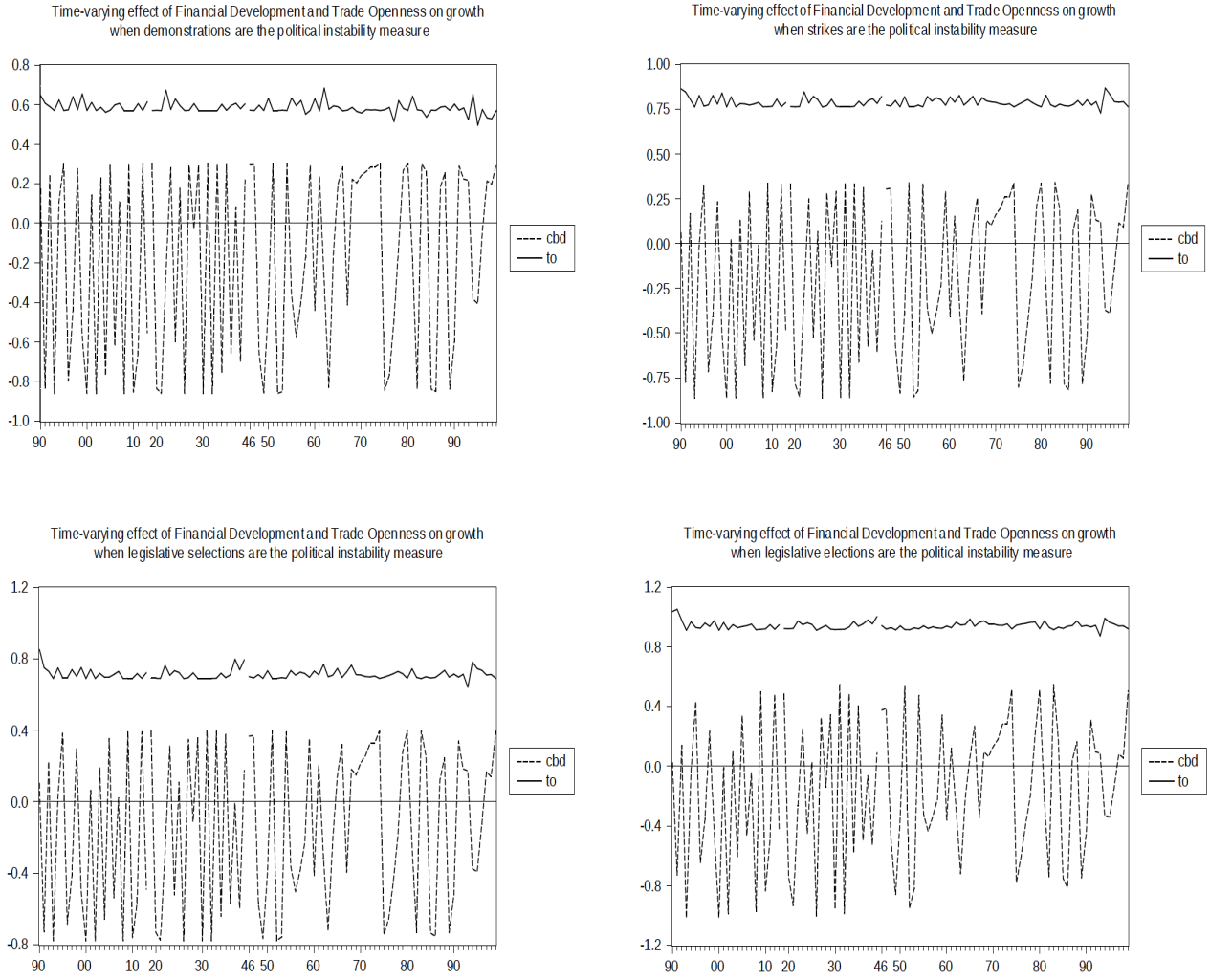
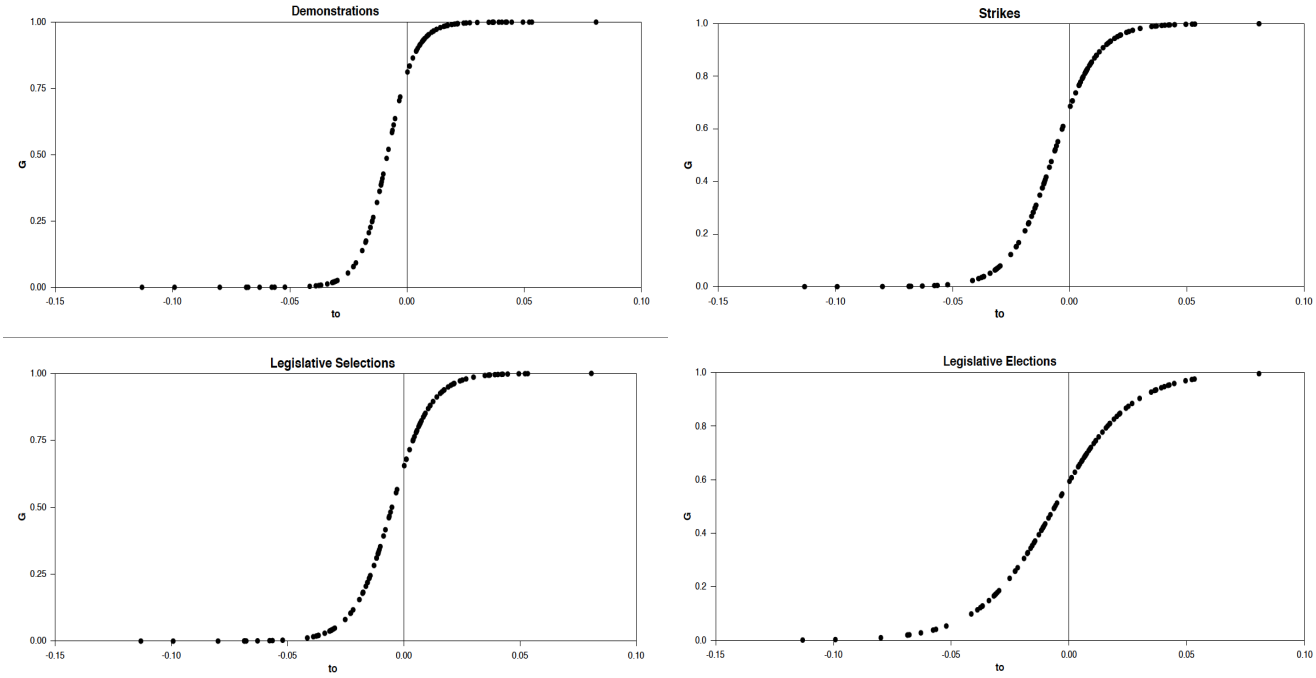


Figure 3.5. Smooth Transition Function ($G(s_{t-d})$) vs Transition Variable (TO_{t-4}).



3.5. Conclusions

The objective of this paper was to further our understanding of the dynamics of relationship between economic growth and financial development. This paper revisits the growth-finance nexus using a new econometric approach and new and unique data set. The econometric approach we use, and that has been seldom used in this literature so far, is the logistic smooth transition model (LST). Our unique data set contains annual data for Brazil from 1890 to 2003. The logistic smooth transition framework allows us to study the dynamics of this relationship over the long-run, to evaluate the intensity and direction of its main drivers over time, and to assess how smooth (or not) was the transitions we estimate.

Our main finding is that financial development has a time-varying effect on economic growth, which significantly depends on jointly estimated trade openness thresholds, whereas the effect of political instability (both formal and informal) is unambiguously negative. We show that the finance-growth nexus in Brazil intrinsically depends on political institutions and on the regime-switching factor, which we estimate to be trade openness. Differently from most of the previous literature, which reports a negative short-run relation between financial development and growth, we argue in favour of a mixed time-varying effect (in the short-run). As far as the time-varying results are concerned we detect at least three periods, where financial development has a clearly positive and large effect on economic growth, interestingly all towards the end of our time window. Our estimates also show that a positive impact of trade openness on growth but with interesting variation regarding their size and power. For example, we estimate weaker (although still positive) effects between 1929 and 1933 which correspond to the Great Depression. Finally, our parameter estimates suggest that the change between the regimes tends not to be smooth.

Regarding possible directions for future research, two that we believe deserve high priority are a comprehensive breakpoint analysis (which could well be conducted by employing structural change models)

and the implementation of an LST econometric framework that more fully takes into account the estimated breaks. This would allow further comparisons of the episodes of regime switch and a deeper understanding of the abruptness (or lack of smoothness) of the transitions we identify that drive the dynamics of growth rates of per capita GDP in Brazil over the very long-run.

Appendix 3

LM-type Linearity Tests and Choosing Between a Logisitc and an Exponential STAR models

The second stage of the LST estimation procedure focuses on testing linearity for different values of the delay parameter d. In particular Teräsvirta (1994) argued that there are many ways of defining linearity of the equation (3.1) in Section 3.2 above. For example, in the case that $H01 : \gamma = 0$ holds then the model in (3.1) reduces to a linear AR(p) model. Teräsvirta (1994) in his paper considered the Lagrange multiplier (LM)-type tests for the aforementioned $H01$. However, due to the fact that (3.1) are not identified under these null hypothesis, Teräsvirta (1994) followed the suggestion of Davies (1977) and he firstly derived the test statistic maintaining the unknown values fixed [see the paper of Teräsvirta (1994) for more details]. More specifically, he adopted the solution proposed in Luukkonen et al. (1988) with an appropriate Taylor series approximation. Under the null hypothesis of linearity, the LM test (LM_2) displayed the usual χ^2 distribution asymptotically.

After rejecting the linearity by LM_2 someone could consider the usage of the STAR models as a non-linear alternative. At this point it worths mentioning that the alternative hypothesis of the linearity test includes models other than the STAR models. In Chapter 3 and 4 we follow the selection procedure that Teräsvirta (1994) suggested. In particular this procedure consists of a sequence of nested F-tests. Based on these tests Teräsvirta's rule is based on checking which hypothesis are rejected and then examining in contrast the relative strength of rejections. If the model is an LSTAR then hypothesis $H01$ and $H03$ are rejected more strongly than the $H02$ hypothesis. Hence, Teräsvirta (1994) suggested that an ESTAR model is more preferable if the p-value of the $H02$ is the smallest among the $H01, H02, H03$ alternatively the LSTAR model is preferred (see Table 3.2 in Section 3.4 above for more details).

Table A.3.1. Zivot and Andrews (1992) Unit Root Tests with Breaks

	Type of Break		
Variable	With Intercept	With trend	Both
GDP	-10.77^{***} (1981)	-10.37^{***} (1973)	-10.72^{***} (1981)
CBD	-12.94^{***} (1906)	-13.87^{***} (1906)	-14.34^{***} (1919)
TO	-13.85^{***} (1909)	-13.81^{***} (1916)	-14.09^{***} (1920)
DEM	-9.76^{***} (1984)	-9.58^{***} (1981)	-9.66^{***} (1984)
STR	-9.41^{***} (1978)	-9.15^{***} (1988)	-9.82^{***} (1978)
LS	-7.09^{***} (1930)	-6.75^{***} (1933)	-7.58^{***} (1946)
LE	-4.78^{*} (1940)	-3.72 (1971)	-4.80^{*} (1940)

Notes: $^{***},^{*}$ indicate significance at 1% and 10% level respectively. Columns 2, 3 and 4 report estimated t-statistics when we allow for breaks in the intercept, in the trend and in both respectively. Numbers in parentheses represent break points. Only the case of LE is unit root when we allow for a break in the trend.

Table A.3.2. Lag Specification

Variables	Information Criteria				
	AIC	SBIC	LBQ	LM	GS
CBD	0	0	1	0	2
TO	5	1	1	1	**4**
DEM	**3**	2	2	2	2
STR	0	0	0	0	0
LS	7	1	**4**	1	3
LE	8	1	1	1	8

Notes: The Table reports the maximum lag-length on the basis of minimum information criteria*. For the cases of *TO* and *LS* we choose four lags (numbers in bold). For *CBD*, DEM the optimal lag-length is two for *STR* zero and for LE eight. However, for linearity rejection purposes we use three lags for *CBD* and four for *DEM, STR* and *LE* respectively. *LM stands for Lagrange multiplier test for residual serial correlation.

Figure A.3.1. 3D Graphs political instability vs GDP per capita % and time

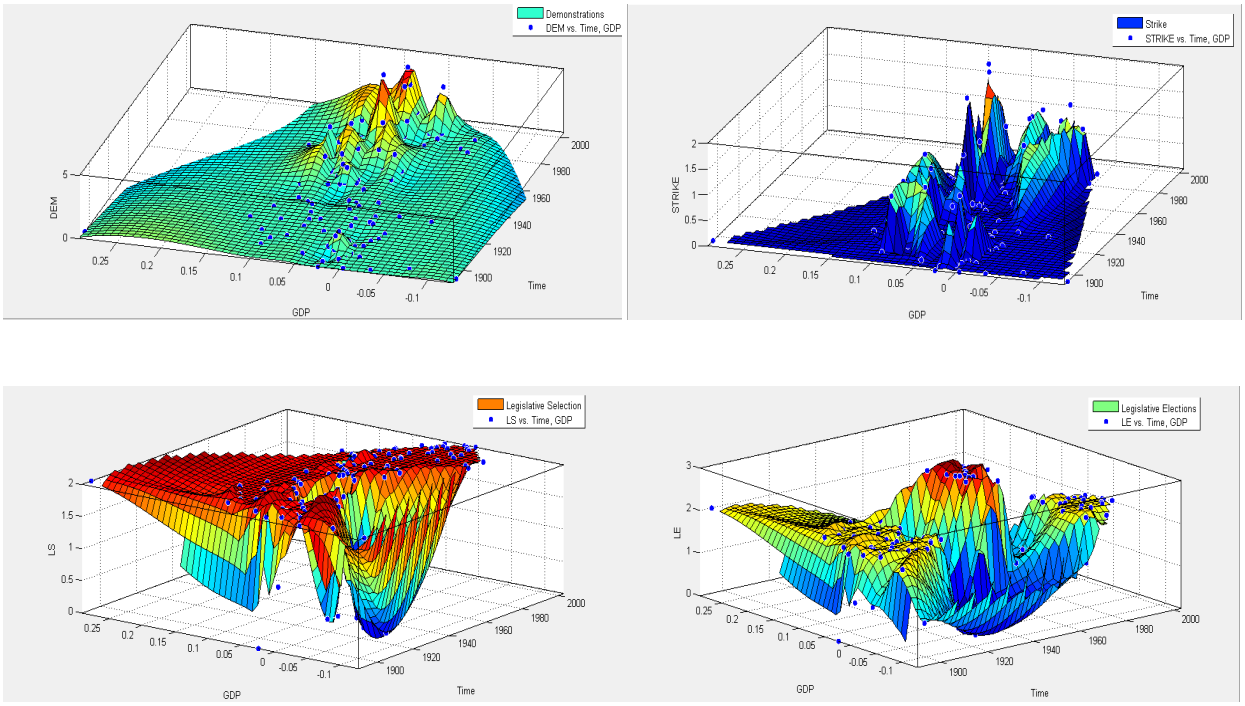
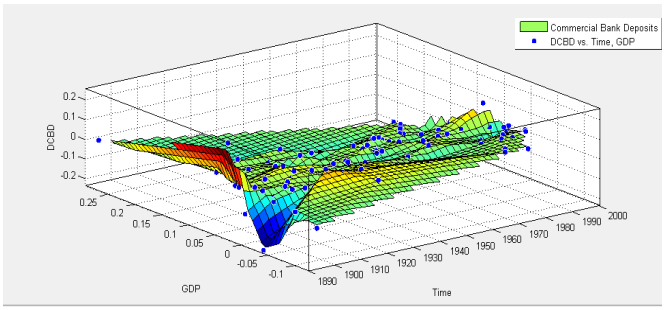


Figure A3.2. 3D Graph financial development (CBD) vs GDP per capita% and time



Chapter 4

On the Time-Varying Link Between Financial Development, Political Instability and Economic Growth in Brazil, 1890-2003

4.1. Introduction

O'Neil (2001) introduced the term BRIC. By the end of 2000 these countries were experiencing an impressive increase in equity markets: Brazil's increased by 369%, India's by 499%, Russia's by 630% and China's by 201% using the A-share market. But why are these four countries so important? Simply because by the end of 2000 the gross domestic product (GDP in US$) of the BRICs in both Purchase Power Parity terms (PPP) and current prices accounted for the 23.3% and 8% of the world's total GDP respectively. According to Goldman Sachs in 40 years time the BRICs as a whole could be larger than G6 in US$ terms. In the same report it is stated that Brazil's economy will overtake that of Italy by 2025, France by 2031 and Germany and UK by 2036. In addition Brazil with a GDP of about US$ 2.253 trillion in 2012 (according to World Bank) is the world's seventh most wealthy economy and the largest country in area and population in Latin America. In the last 100 years from a destitute and far from sophisticated economy, Brazil became one of the largest and richest emerging markets hosting the World Cup in 2014 and the Olympic Games in 2016, events that demanded huge amounts of investments among others in transport infrastructure and social development. In our opinion this remarkable transition from a poor to a prosperous economy is worth further further examination.

This Chapter contributes to this literature by further investigating this time-varying link between finance, political instability, trade openness and economic growth since little research has been conducted related to these three factors jointly. It uses the smooth transition framework and annual time series data for Brazil covering the period for a very long period of time (1890-2003). The study will try to address the following questions: What is the relationship between economic growth, on the one hand, and financial development, trade openness, and political instability on the other? Does the intensity and the sign of these effects vary over time? Is the transition from one regime to the other smooth or not?

We may also add that this Chapter contributes to the literature on economic growth by providing further evidence on the incongruity that seems to exist in the empirical growth-financial development literature. For Schumpeter (1934), Gurley and Shaw (1955) and Goldsmith (1969) financial development is the workforce of economic growth. Hicks (1969) argued that financial development was momentous in boosting industrialization in England by encouraging the flow of capital towards boundless work. In general, endogenous growth theories that developed recently concluded that the financial sector has a positive role in the economy and its expansion (Bencivenga & Smith, 1991). In particular financially developed economies provide efficient allocation of resources, reduce transaction costs and promote a more rapid capital accumulation and technological advancement (Roubini & Sala-I-Martin, 1992; King & Levine, 1993; Greenwood & Smith, 1997; Levine, 1997; Levine, 2005). In contrast, research papers such as Gavin and Hausmann (1996), Loayza and Ranciere (2006) argued that financial liberalization and expansion without any constraints could cause banking crises and thus economic collapse. Kar et al. (2011) drew the conclusion that the exact relationship between economic growth and financial development is inconclusive and there is no clear evidence on the direction of the causality between them. Robinson (1952) argued that economic expansion creates demands for new types of financial arrangements, hence the financial system responds automatically to these requirements. According to Lucas (1988) economists tend to overvalue the impact and the role of the financial sector in economic growth. Finally Stern's work (1989) on development economics does not make any reference to finance.

An additional contribution of our Chapter is that unlike the vast amount of literature that tries to examine the link between economic growth and financial development using cross-country analysis we focus on one individual country, Brazil, over a very long period of time with annual frequency data. For example, various papers allow analysis of Brazil's performance from a cross-country perspective (among others, Loyaza and Ranciere, 2006), while those focusing solely on Brazil tend to cover the period from the 1930s onwards (e.g. de Paiva Abreu and Verner, 1997). Hence we believe that this Chapter could expand knowledge regarding economic growth since we study one individual country for a long period of time, 1890-2003. The third intended contribution is that by employing an econometric methodology that has been seldom used in the empirical growth literature we try to shed light on a country's economic and political behaviour, since according to Wilson (2003) Brazil belongs to the fastest growing economies in the world. From a small agricultural economy Brazil managed to become, only in 100 years, one of the richest and largest emerging economies of our days. The fourth and the final planned contribution is that depending on an estimated threshold the effect of financial development could be either negative or positive.

One of the most influential studies of the long-run Brazilian economic growth is a study conducted by de Paiva Abreu and Verner (1997). Covering a period from 1930 to 1990 they tried to analyze the effects of various factors such as financial development, trade openness and education policies on economic growth. Their results suggested that there was no evidence that financial development boosted economic growth. In contrast Bittencourt (2011) argued that financial development played a significant role in promoting growth in Latin America. Moreover, previous literature such as Pinheiro and Bonelli (2005), Stefani (2007), Muinhos and Nakane (2006) and Vale (2005) examined the relationship between financial development and economic growth in Brazil and they found that a strong positive link exists between financial development and output growth.

However, using an alternative approach, and in particular the smooth transition framework, which allows us to examine positive and negative effects, we find that financial development has a mixed positive and negative time-varying impact on economic growth, which significantly depends on jointly estimated trade openness thresholds. As far as the trade openness is concerned there is a positive effect on growth throughout the period, although there are periods where the aforementioned impact is either high or relatively low. Finally, with respect to the impact of political instability, both informal and formal, on output growth, this is mainly negative, with the exception of the revolutions, where a mixed time-varying relation was detected.

This Chapter is organized as follows. Section 4.2 presents a brief early economic and political history, which explains the economic performance of Brazil from 1890 to 2003. Section 4.3 provides details and justification for our econometric methodology and Section 4.4 describes the data. Section 4.5 presents our results and finally Section 4.6 concludes and suggests directions for further research.

4.2. Early Economic and Political History of Brazil

In this Section, we will record briefly the early economic and political history of Brazil. Although this study focuses on the period 1890-2003, we will start our analysis well in advance, since we believe that this period (early and middle 19^{th} century) will help us to understand the background of Brazil in terms of trade openness, political instability and financial development.

The recorded history of Brazil (the name stands for brazilwood, source of red dye) began with the arrival of Portuguese sailors. Brazil was 'discovered' on April 21^{st} 1500 by Portuguese commander Pedro Alvares Cabral, who was appointed by Manuel I (King of Portugal and Algarves). The treaty of Tordesilhas of 1494 divided the discovered South American continent between Portugal and Spain and assigned to the first a considerable part of modern Brazil (which in 1494 was still undiscovered). Modern Brazil is the world's fifth largest country. However, during the first 200 years after its discovery, Brazil was not so crucial for the economic and strategic interests of the Portuguese empire and the crown. Nevertheless, Amazonian drugs, gold, diamonds, sugar and the slave trade were some of the

most important commodities that the young colony offered to the Old World. The discovery of gold and diamonds in 1695 and 1729 accordingly in the area called Minas Gerais was a nodal point, since the Portuguese changed the capital from Salvador to Rio de Janeiro, which was closer to the gold and diamond mines and had a port and a bay, which were easier to defend. The transition from sugar to gold resulted in a smooth change in domestic elites (from sugar to gold based ones).

Early 19^{th} Century

Throughout the 19^{th} century approximately 80% of the world's gold supply was provided by Brazil. The effects of the discovery of gold and diamonds were tremendous both for the colony and the metropolis (Portugal). The aforementioned discovery of precious stones came at the precise moment when Portugal's economy was in decline and appeared seemingly to revitalize the economy. However, despite these promising signs the gold and diamond mines never provided more than a facade of wealth. The reason why this happened was that all this wealthiness went to the hands of northern Europeans and especially the English, who sold manufactured commodities to the Portuguese. Hence the sector of agriculture did more to improve and to accelerate the Brazilian economy since at a corresponding stage the average per capita income from the sugar industry was significantly higher than that provided by gold and diamonds. The nineteenth-century economic decline of Portugal can be attributed among others to the negative effects of the Napoleonic Wars, which forced the royal family to move to Brazil and to transfer the crown from Lisbon to Rio de Janeiro. Thus, Brazil might be the only colonial place in the world that became the Imperial center. The events described above and the opening of all the Brazilian ports to other nations, such as England (with the royal decree of 1808), concluded with Brazilian independence in 1822. The following period (meaning the next couple of decades) is marked by high political, economic and social unrest. It is worth mentioning that the aforementioned period (1820-1840) in Brazil coincides with an event of great importance, The Industrial Revolution.

Mid 19^{th} Century

There is little dispute in the literature that the years from 1830 to 1930 was a period during which the Brazilian economy flourished, despite the fact that its economy passed from difficulties and constraints during the World War I and the Great Depression of 1929. The age of sugar, which was the dominant export commodity of the colonial economy, faded rapidly in the nineteenth century. In around 1830 sugar fell to the second place behind coffee (see Burns, 1970) and never again recovered. The Coffee Economic Cycle would be the horsepower of the Brazilian economy for almost a century (1830-1930). In particular the importance of coffee (which was greater than that of gold, diamonds and sugar) for the Brazilian economy lies in the fact that coffee exports accounted for about a fifth of the total Brazilian exports by the period of independence, a figure which rose by two thirds until the collapse of the monarchy in 1889. Moreover the value of coffee sold during these years was equal to that of all exports during the entire colonial period. The decade of the 1860s gave the opportunity to Brazil to develop other factors of prosperity than coffee. The Civil War in the United States of America reduced the world's cotton reserves, hence European textile manufacturers started to seek other sources to buy cotton. Brazil as a response to that increased the production of cotton to meet the high demand. More specifically during the 1860s cotton accounted 18.3% of the total exports, a threefold increase over the previous decade. However, coffee remained the main export product since apart from the boost that coffee offered to the Brazilian economy, it influenced Brazil's relations with the outside world and helped the country to transform internally. The abolition of slavery[16] in 1822, the introduction of the wage salary in 1888 and the end of the monarchy in 1889 marked the beginning of a new socioeconomic and political era in Brazil. During the late 1920s, Brazil was a major coffee exporter, covering 80% of the world's demand for coffee, while

[16] In particular in 1822 the new nation counted approximately 4 million inhabitants (Burns, 1970) of whom probably half were slaves of African origin. When Princess Isabel signed the Golden Law in 1888 roughly 600,000 slaves gained their freedom.

they (coffee exports) constituted 12.5% of the country's gross national product (gnp). Baer (2013) argued that coffee exports were the engine of growth during most of the 19^{th} century. Nevertheless, an economic expansion of such an extent requires financial backing. One of the main objectives of this Chapter is to understand the interplay between trade openness and financial development and the resulting effect of this on economic growth.

In the period from 1864 to 1870 a war between Brazil (and its allies Argentina and Uruguay) and Paraguay took place culminating in victory for Brazil and its allies. The military of Brazil as an institution appeared to have a significant role from that period and onwards. Five years of conflicts increased both its significance and its size. The army from 17,000 soldiers in 1864 rose to 100,000 by the end of 1870. After finishing their military actions in 1870, officers focused their attention on politics. The Duque de Caxias held the military under constant audit. However, his death in 1880 gave the military a more significant political role. Hence, there were now two classes in parliament: on the one side, the landed aristocracy with their traditional way of thinking and political acting, and on the other military officers, who represented the middle classes of the society.

Up to this point we have described briefly the early and mid 19^{th} century background of Brazil, which is mainly linked to trade openness. In the following paragraphs we will cover the period 1890-2003 from an economic and political point of view as well.

Late 19^{th} and Early 20^{th} Century

The military started to express its opinion publicly and to debate government policies in 1879. More specifically the latter supported education, industrialization, abolition of slavery, regeneration of the nation and guarding of the fatherland, the so-called *solider citizen*, by proclaiming them as agents of social change. Under Deodoro's orders, on November 15^{th} 1889, the army captured the Royal Palace, the main government building and silenced Rio de Janeiro. Using a strict authoritarian tone the Marshal of the general order announced to the surprised nation that from then on the empire belonged to the past. The day after November 15^{th}, Deodoro declared Brazil a federal republic. The period that followed, the First Republic (1889-1930), was characterized by political unrest as well as the politics of coffee with milk (known as *cafe com leite*), a combination of the Sao Paulo coffee and the Minas Gerais milk political elites. The main target of the First Republic was to balance the power between the two oligarchic elites (that of coffee and milk) and the army. However, the problems of the oligarchic system developed further. More specifically the "Tenent Revolt" of 1922 and 1924 rocked the interior of Brazil.

1930s and 1940s

During the Great Depression of 1929, coffee exports were brought to a deadlock, while the Paulista regime hooked up to power, resulting in the end of the politics of coffee with milk. In 1930, the situation got out of control, where gun assassinations and revolutions took place (for example the Revolta da Princesa outburst in the Northeastern state of Paraiba and the assassination of João Pessoa, governor of Paraiba occurred. Shorty after Pessoa's death, more riots followed, including the Revolution of 1930, on October 24^{th} 1930).

Getulio Vargas, after failing to be elected as president in 1930, led a revolt that placed him in power. From 1930 until 1934 he ruled Brazil as a dictator, from 1934 to 1937 he was elected as president and then again as a dictator from 1937 to 1945. Under the Estado Novo (1937-1945), among others, state autonomy ended, all political parties were dissolved and governors were replaced until 1944 (see Hudson, 1998). After 1945, Vargas still served as a senator until 1951, when, after general elections, he was elected president, a position which was held by him until 1954. Hence Getulio Vargas played a central political role in Brazil for nearly 24 years. According to Maddison (1995), during the Vargas era (and up to 1980) the economic growth of Brazil was among the highest in the world. The Vargas years had a significant impact on national politics and economics. Even in the 1990s, the local political leaders were still called *colonels*. During his era, reorganization of the armed forces, the economy, international trade and foreign

relations took place. The average annual GDP growth rate during that period was 4%. Finally, the 1930-1945 period added a new term to the Brazilian political lexicon, that of corporatism[17]. Vargas committed suicide on August 24, 1954. However, his influence in Brazilian politics remained indelible for decades (Hudson, 1998). Thus during the 1930s and 1940s Brazil was characterized by significant political unrest.

1950s and 1960s

If corporatism was the benchmark of the 30s and 40s period, populism, nationalism and developmentalism dominated the two following decades (50s and 60s). Each of these terms contributed to the crisis that occurred in Brazil, which resulted in the authoritarian regime that occurred after 1964. By the early 1960s, Brazilian society was boiling. Labor classes became more and more active seeking a better future, and the population continued to grow beyond the state's capability to increase educational and social services. As a consequence, the conservative elites alongside the middle classes, which tended to follow the elites' vision considering the lower classes as a threat, feared that they were going to lose control of politics and of the state. It was the same elites that opposed Vargas due to his intention to use the state for a fairer distribution of resources. During the period 1956-1961 Juscelino Kubitschek (who was the only post Vargas elected president to serve a full term) promoted the establishment of an automotive industry, which could help Brazil to overcome the economic stagnation. The new factories produced 321,000 vehicles in 1960. Among his legacies are the world's eighth largest automobile production and a great highway network of the late twentieth century. Constant motorized advancement in farm equipment and changes in transportation transformed the vast countryside areas of Mato Grosso and Goias, making Brazil the world's number two food exporter. All these led the overall economy to grow by 8.3% a year. Hence there might be some truth in Kubitschek's motto *Fifty Years' of Progress in Five* (Hudson, 1998).

Brazil of 1960 was completely different from that of 1930. The population reached 70 million from 34 million in 1930, with 44% residing in urban areas. Life expectancy increased as well. The number of workers increased from 1.6 million in 1940 to 2.9 million in 1960, an approximate 100% increase in 20 years. The share of industrial productivity as a percentage of GDP was higher (25.2%) than of agriculture (22.5%). From the other side the annual rate of inflation kept rising from 12% in 1949 to 26% in 1959 and to the shocking 39.5% in 1960. Savings depreciated, lenders' unwillingness to offer long term loans that are essential for investments, high interest rates and the government's refusal to comply with the International Monetary Fund (IMF) conditions created a negative environment among the people. The high differences between poor and rich remained, with 40% of the national income to be enjoyed by 10% of the population, 36% going to the next 30% and the remaining 24% distributed to the remaining 60% of the population. Struggling to maintain control, the government of João Goulart[18] in a huge rally in Rio de Janeiro on March 13^{th} 1964 attempted to promote reforms. An opposition rally held six days later in Sao Paulo put 500,000 people on the streets. Rio de Janeiro's Correio da Manha (a daily newspaper of Rio de Janeiro) published an unusual front cover with the headline Enough whereas the next day's front cover had the title Out. In the next few days the military intervened to secure the country and Goulart fled to Uruguay. The period of the military republic (1964-1985) had begun. Summarizing, the 1950s and 1960s periods were marked by high political instability, which in turn affected the level of the trade openness of the Brazilian economy in different ways .

[17] The term developed mostly in Italy under Benito Mussolini. Corporatism is a concept opposite to that of Marxism and Liberal Democratic political philosophies.

[18] Vice President, a populist and a minister of labor under Vargas, he won the presidency on the 7^{th} of September 1961 until the 1^{st} of April 1964 when he left power.

1980s and 1990s

As with the previous regime changes of 1889, 1930 and 1945, the coup of 1964 divided the military into two groups. The first one included those who believed that they should focus on their professional duties and the second group, the hard-liners, who believed that politicians were betrayers that would deliver Brazil to communism. The dominance of the hard liners' opinion led Brazil into what a political scientist (named Juan J. Linz) defined as *an authoritarian situation*. In 1983 the economy was running with average GDP growth of 5.4%, but the importance of this was diminished by the rising inflation and the weak and disheartening political leadership. Millions of Brazilians went out to the streets in all major cities demanding a direct vote (diretas ja). In April 1984, Congress failed to achieve the necessary numbers in order to grant the people's wish and the choice was left to an electoral college. On January 15^{th} 1985, the electoral college elected Tancredo Neves of Minas Gerais. Similarly to the regime changes of the previous years (namely that of 1822, 1889, 1930, 1946 and 1964) the 1985 change would prove to be full of obstacles as well. Some years later it was Fernando Collor de Mello's turn to rule the country (in office from 1990 to 1992). Mello was the first Brazilian president elected directly by the people. During his term in office he attempted to control hyperinflation and started a massive program of privatization of state-owned firms. His tenure ended in 1992 with the presidency of Itamar Franco, who stayed in power until 1995. The last five years of the 20^{th} century found Fernando Henrique Cardoso in office, whose administration was characterized by the promotion of human rights in Brazil.

To sum up, the period since 1890 is a significant era for Brazilian history since the country experienced significant economic and political expansion, being transformed to an emerging market and forming one of the BRIC countries. However, there is an ongoing debate which tries to identify the key factors that are responsible for this astonishing route. Financial development, trade openness, financial integration and macroeconomic stability are the main factors that most of the previous literature pays attention to. This Chapter will attempt to shed light on the main causes of economic growth since there seems to be a dissatisfaction within the empirical growth literature. Using data that cover a period from 1890 to 2003 we will try to explain (under a smooth transition approach) the role that financial development, trade openness and political instability played in economic growth and the transformation of Brazil in general (for a brief review of the main political events\periods in the history of Brazil see Table B1 in the Appendix).

4.3. Econometric Framework

Non-linear models have attracted the interest of more and more researchers in recent years. Chan and Tong (1986) introduced the threshold autoregressive models (TAR). Then Teräsvirta (1994) suggested a specification technique of three stages, assuming that if the process is not linear, then the alternative might be a smooth transition autoregressive model (ST), which captures regime-switching behaviour. The first stage of the estimation procedure is to identify a linear autoregressive model. The second focuses on testing linearity for different values of d, the delay parameter, and the third one on choosing between an exponential ST (EST) or a logistic ST (LST) model by testing a sequence of three hypotheses (see Teräsvirta, 1994). Nevertheless, initial estimation of both EST and LST models and the usage of post-estimation information criteria could provide us with the final choice between the models, Teräsvirta (1994). The ST model for the economic growth series y_t is given by

$$y_t = \boldsymbol{\phi}_1' \mathbf{x}_{t-l} + \boldsymbol{\phi}_2' \mathbf{x}_{t-l} G(s_{t-d}) + \epsilon_t \tag{4.1}$$

where $\mathbf{x}_{t-l} = (1,\, x_{2,t-l}, \ldots, x_{k,t-l})'$ is the $k \times 1$ vector of the explanatory variables, $\boldsymbol{\phi}_i = (\phi_1^{(i)}, ..., \phi_k^{(i)})'$, $i = 1, 2$, are the $k \times 1$ vectors of coefficients and $G(s_{t-d})$ is the transition function (see eq. 4.2 below), which changes smoothly from 0 to 1 as the transition variable s_{t-d} increases; the term d determines the lag-length of the transition variable and $\{\varepsilon_t\}$ are independently and identically distributed *(i.i.d)* random variables. Here we use the first order logistic function of $G(s_{t-d})$, which is defined as:

$$G(s_{t-d}) = \frac{1}{1 + e^{-\gamma(s_{t-d}-c)}}, \tag{4.2}$$

where γ determines how smooth the change in the value of the logistic function is (and hence the transition from one regime to another) and the intercept c is the threshold between regimes. In eq. 4.2, when the smoothness parameter becomes very large ($\gamma \to \infty$) then the transition is abrupt. When $\gamma \to 0$ the logistic function approaches a constant. Thus when $\gamma = 0$ the LST model reduces to a linear one. The advantage of an ST against a TAR model is that the conditional mean function is differentiable (see Tsay, 2010). However, previous research shows that the transition parameters γ and c are quite difficult to estimate (see Teräsvirta, 1994). Following Teräsvirta (1994) we test whether the non-linear model is preferred and if the use of the logistic function is warranted.

4.4. Data

Our data set contains annual data of economic growth, financial development, trade openness and political instability for Brazil between 1890 and 2003, excluding the World War years. The main data source for the first three is Mitchell (2003), (see Figure 4.1 below and Figure A.4.1 in the Appendix). Economic growth is measured as annual growth rates of gross domestic product (GDP). Our three measures of financial development consist of commercial bank deposits (CBD), money supply (M1) and deposits at Banco do Brasil (DBB). Commercial bank deposits is defined as the sum of time deposits in commercial banks and deposits at the end of the period in commercial banks over GDP and alongside DBB it tries to capture the efficiency of the financial sector and not its relative size. Data have been reported by Mitchell (2003) but due to missing values we follow the approach of Pelaez and Suzigan (1976) to reconstruct the series. The second financial development indicator is the ratio M1 over GDP (retrieved from Mitchell, 2003). One potential drawback of this measure is that the ratio reflects the depth or the relative size of the financial system and not its efficiency. The third and final one, (DBB), is measured by the added value of time deposits and deposits at the end of the period in the central bank over GDP. Given M1's and DBB's more restrictive nature we use both of them as a robustness check of our results and thereby we attach greater weight to commercial bank deposits.

As far as trade openness is concerned we use the standard ratio of exports plus imports as a share of GDP. The idea that trade liberalization is the horsepower of growth has its roots back in Adam Smith. Among others Krueger (1978) and Wacziarg and Welch (2008) argued that trade openness does indeed lead to higher growth rates. The IMF (1997) has stated that policies favoring international trade are among the most significant elements in promoting economic expansion and convergence in developing countries. In addition, a report from the OECD (1998) concluded that more open and outward oriented economies tend to surpass countries with restrictive and more isolated trade policies. Finally, Fischer (2000) during a lecture (for further information see Rodriguez et al., 2001), argued that the optimal way for a nation to grow is to harmonise its policies with the global economy. However, these arguments were lacking general approval especially after the Great War in developing countries and in particular Latin America, which very often adopted the so-called Import Substitution Industrialization policies (ISI), which imposed barriers on international trade. The outbreak of World War II turned Latin America back to protectionism and to high tariff policies and it was not until the 1990s when liberal policies took effect (Edwards, 1994). This Chapter tries to capture these changes in trade policies by using trade openness as the transition variable in the case of Brazil for the following reasons. Brazil is the most advanced industrial economy in South America (Pereira et al., 1993). According to the United Nations' statistical agency[19] it is a major exporter of iron ore and concentrates, petroleum oil, soya beans, coffee and processed meat, and it is involved in the manufacture of small aircraft. Finally, the importance of trade policies for successive Brazilian governments is apparent from: the fact that its patent law dates

[19] For further information regarding Brazil's profile please check the: http://comtrade.un.org

back to 1809 (in contrast to Germany, where it only appeared 70 years later); their participation in every international conference associated with intellectual property rights since that time; and the signing of the founding declaration of GATT (General Agreement on Tariffs and Trade) in 1947 (Lattimore and Kowalski, 2009).

The data we use for political instability measures constitutes one of the main contributions of this Chapter. We use a taxonomy of political instability divided into two categories, informal and formal (Campos et al., 2012). Formal political instability originates from within the political system, informal from outside. Arthur Banks' Cross National Time Series Data Archive (CNTS) consists of our starting point as the source of historical annual data for the various types of political instability. The informal political instability measures consist of**:** the number of demonstrations (dem), defined as peaceful public gatherings of at least 100 people**;** revolutions (rev), representing illegal or forced change in the top governmental elite, attempts at, or successful or unsuccessful armed rebellion**;** the number of strikes (str) of 1000 or more workers involving multiple employers and aimed at government policies**;** and coups d'etat (coup) measuring the number of overthrows/sudden and forced seizure of the government (see Figure 4.2 below and Figure A.4.2 in the Appendix).

Formal political instability is measured by**:** purges (pur) including any systematic elimination by jailing or execution of political opposition within the ranks of the regime or the opposition**;** the number of constitutional changes (cc) including governmental crises**;** legislative selections (LS) taking the value 0 when no legislature exists, the value 1 in the case of nonelective legislature[20] and 2 when legislators or members of the lower house in a bicameral system are selected by means of either direct or indirect popular election**;** and legislative elections (le) defined as the number of elections for the lower house each year (see Figure 4.3 below and Figure A.4.3 in the Appendix).

For these formal and informal political instability variables, Banks data (2005) do not exist for the pre-1918 period. For the creation of this new data set of political instability measures, all suitable political events from years 1890 to 1939 were recorded and grouped into different forms of political instability (see Campos et al., 2014). We then took advantage of the intentional overlap between the series during the period 1919 to 1939 to assess whether or not the new dataset was reliable. We find that there are a few cases where there is little difference between the two series and hence argue that the new data set is as reliable as the CNTS data.

Results from the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests are presented in Table 4.1 below. Both suggest that either the level of the series or their first differences are stationary. In addition, unit root tests with breaks provided by Zivot and Andrews (1992) and Lumsdaine-Papell (1997) have been conducted (see Tables A.4.1 and A.4.2 in the Appendix). For GDP and informal and formal political instability the unit root hypothesis is rejected at either the 1%, 5% or 10% level in all cases (with the exception of le, which fails to reject the unit root hypothesis when we allow for a break in the trend: see Table A.4.1 in the Appendix). Regarding the two financial development measures CBD and dbb, the results fail to reject the unit root hypothesis in the case of the ADF tests, while they rejected the unit root in the case of the PP tests (see Table 4.1 below). Due to the aforementioned incongruity we use the first difference of the series where the results from both the ADF and the PP tests reject the unit root hypothesis (see Table 4.1 below). As far as the M1 and TO are concerned the ADF and the PP tests do not reject the unit root hypothesis for the level while both tests rejected it when the first differences of the series were considered (see Table 4.1 below). Therefore for all the three measures of financial development (CBD, DBB, M1) and for TO we employ first differences.

[20] An example could be the selection of legislators by the effective executive, or by means of heredity or ascription.

Figure 4.1. Growth rate, Financial Development and Trade Openness

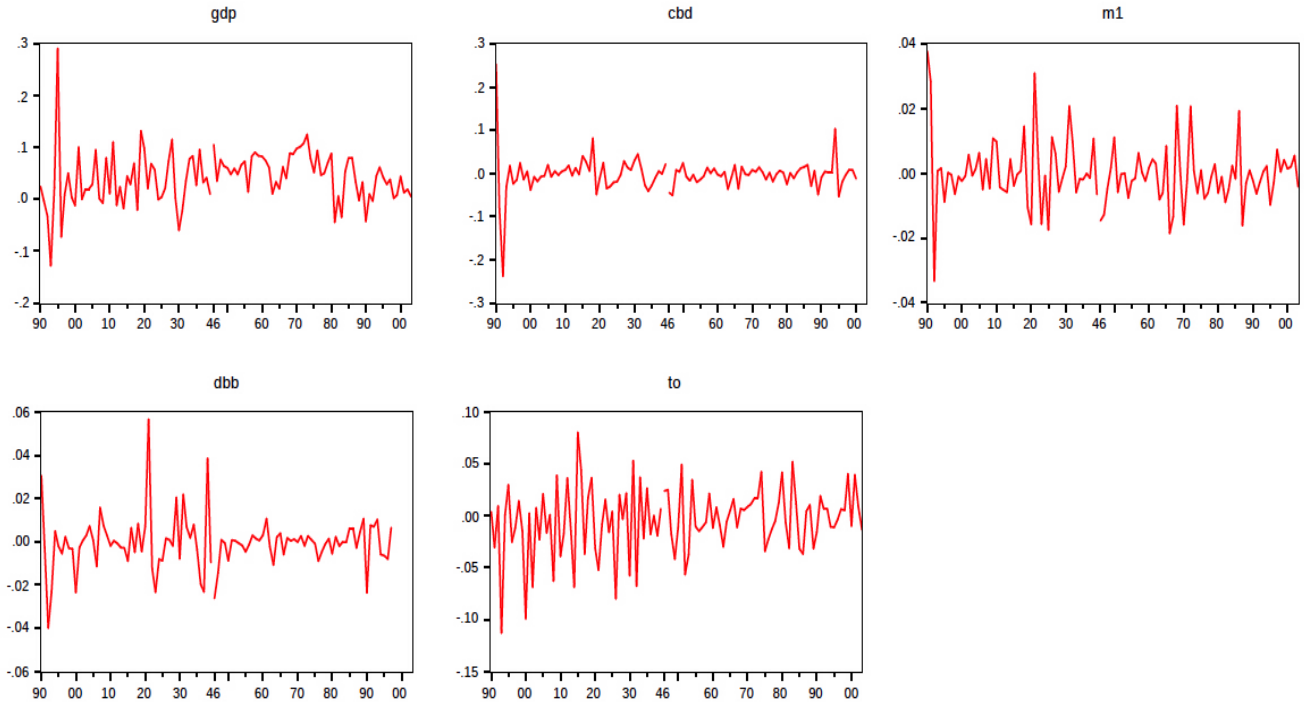


Figure 4.2. Informal Political Instability Measures

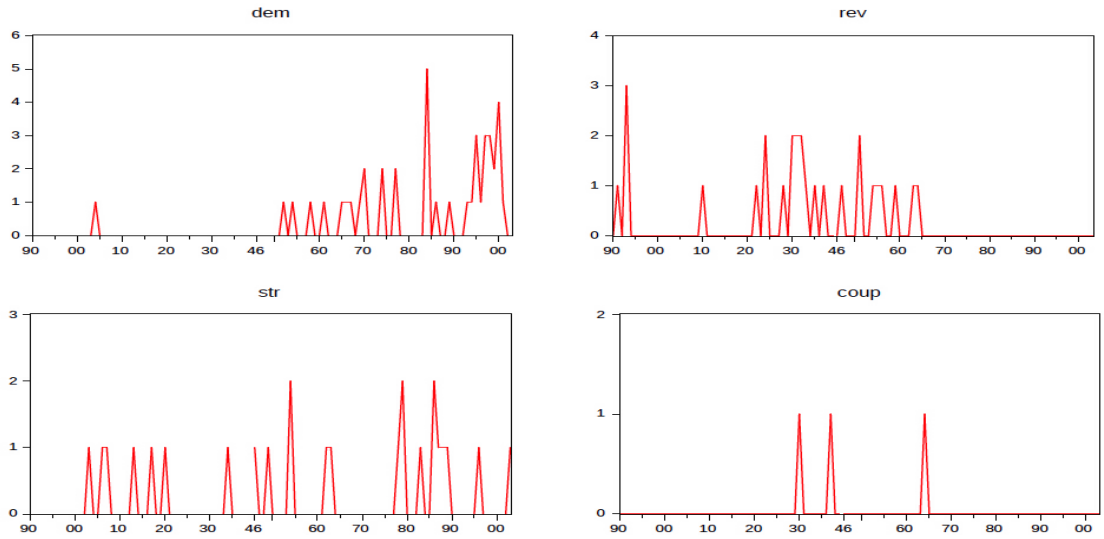


Figure 4.3. Formal Political Instability Measures

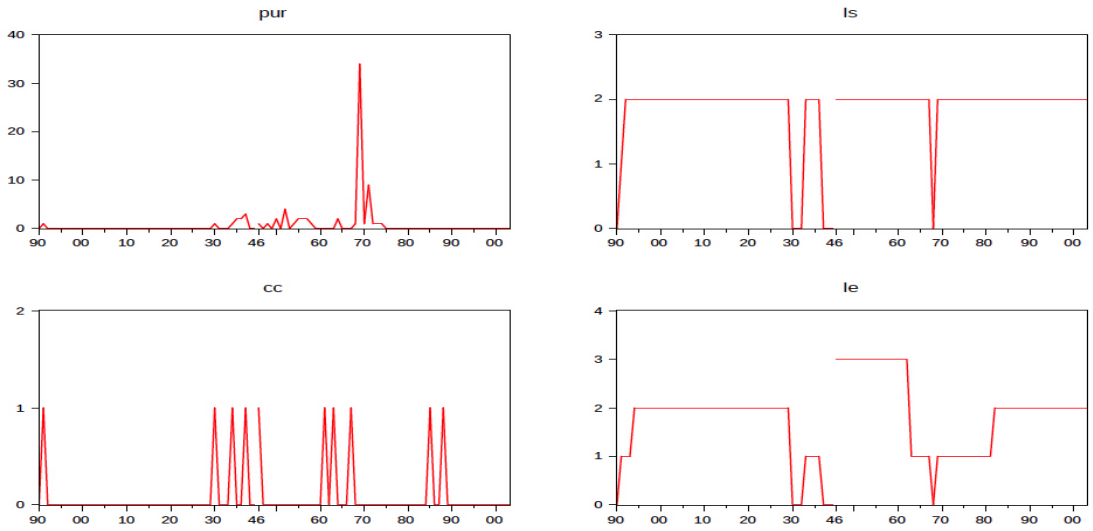


Table 4.1. Augmented Dickey Fuller (ADF) and Phillips Perron (PP) Unit Root Tests.

Variable	ADF at level	ADF at first difference	PP at level	PP at difference
GDP	-9.29^{***}		-9.29^{***}	
CBD	-1.09	-12.35^{***}	-3.35^{***}	-11.94^{***}
M1	-0.95	-13.39^{***}	-0.94	-14.79^{***}
DBB	-1.35	-9.23^{***}	-4.37^{**}	-10.11^{***}
TO	-1.67	-13.00^{***}	-1.31	-13.00^{***}
DEM	-4.54^{***}		-7.37^{***}	
REV	-3.98^{***}		-9.09^{***}	
STR	-8.99^{***}		-8.99^{***}	
COUP	-10.55^{***}		-10.56^{***}	
PUR	-5.51^{***}		-9.91^{***}	
LS	-6.29^{***}		-6.37^{***}	
CC	-3.48^{***}		-11.39^{***}	
LE	-3.63^{***}		-3.69^{***}	

Notes: ***,** indicate significance at 1% and 5% level respectively. Numbers represent the estimated ADF and PP t-statistics respectively. ADF tests suggest that either the level of the series or their first difference are stationary at the 1% level. PP tests suggest that all the series are stationary either at level or their first difference at the 1% or 5% level, with one exception of CBD and DBB, which are stationary both at level and at first difference.

4.5. Empirical Results

The Transition Model

In this section we use the smooth transition approach to investigate the relationship between economic growth, financial development and political instability with the level of trade openness in the economy as the transition variable. The economic history of Brazil demonstrates the close relation between trade openness and economic growth (Baer, 2013), so this is clearly the most intuitive choice for our transition variable. The reasons for the choice of trade openness as our transition variable are not just easily found in economic history but this choice is also fully supported econometrically by standard linearity tests. In particular, when CBD and dbb are used as the transition variable the rejection of the linearity hypothesis fails (from now on LM_2) to occur in the majority of the cases, 9 out of 12 (see Tables 4.3 below and A.4.5 in the Appendix). When *CBD* is used as the transition variable, linearity rejection exists in the case of demonstrations, constitutional changes and legislative elections while for revolutions, strikes and legislative selections the p-values of LM_2 are weaker than those when trade openness is the transition variable (see Table 4.2 and Table 4.3 below). When dbb represents the transition variable linearity is rejected in all cases (see Tables A.4.5 and A.4.6 in the Appendix). Only when M1 is used as the transition variable does rejection of the linearity hypothesis take place in all cases (see Table A.4.3 and A.4.4 in the Appendix). The reason why we do not test linearity using political instability as the transition variable is simply because our measures contain many 0 values. When $s_{t-d} = 0$, then the transition function (see equation 2 above) becomes 0 and hence the model, in equation 1, reduces to a linear one. Hence we could say that linearity rejection shows homogenous behaviour only when we use trade openness as the transition variable (where linearity rejection occurs in all models).

Logarithmic versus Exponential

A range of linearity tests suggest the use of LST instead of the EST model (see Table 4.2 below and Table A.4.4 and A.4.6 in the Appendix). The only case in which an ESTAR is the preferred choice is when legislative elections serve as the political instability measure (see Tables 4.2 below and A.4.4 in the Appendix). However, based on Teräsvirta (1994) the choice between an EST or an LST model could be postponed until after both types of models are estimated and evaluated using post-estimation criteria. In our case an LSTAR model seemed more appropriate[21]. We use the RATS software to estimate equations (1) and (2) above.

The Lag Order

As noted in Section 4.3, Teräsvirta (1994) argued that specifying a linear autoregressive model constitutes the first stage of the estimation procedure. A common way would be the usage of the AIC or the Schwarz information criterion (SBIC) in order to select the appropriate lag structure of the model. However, a choice based on SBIC could lead to too parsimonious models since the estimated residuals derived from the selected model are not free from serial correlation. Hence, models suggested by any information criteria should be followed by a test of residual serial correlation, for instance the Ljung and Box portmanteau test. In addition, Luukkonen and Teräsvirta (1990) stressed that in the case of US unemployment the linearity might be rejected when the lag length is increased, which indicates on one side the significance of longer lags in explaining nonlinearity and the weakness of shorter ones on the other side. We select the optimal lag length that rejects stronger linearity, that is, for financial development measures $l = 3$, while for demonstrations, strikes, coups, purges and legislative elections $l = 4$. For trade openness, revolutions, constitutional changes and legislative selections the selection of $l = 4$ was made on the basis of the minimum value of LBQ and the General to Simple (GS) information criterion (see Table A.4.7 in the Appendix). Finally, a portmanteau test of Ljung and Box was conducted to control for residual autocorrelation in our model and hence possible misspecification. The results indicated no residual serial correlation (results not reported are available upon request).

The Delay Parameter

The choice of the delay parameter is determined by the strongest linearity rejection relative to different values of d. Accordingly, we set $d = 4$. The vector of explanatory variables, for the models of Tables 4.4, 4.5 and 4.6 below, contains the drift, the third lag of the three financial development measures (FD) and the fourth lags of the various measures of political instability (PI), and trade openness (TO). That is, $\mathbf{x}_{t-l} = (1, FD_{t-3}, PI_{t-4}, TO_{t-4})$. The preferred model was the one with $\phi_4^{(2)} = 0$ and where the regime indicator variable s_{t-d} was chosen to be TO_{t-4}.

[21] This choice was derived from postestimation Ljung and Box statistic for residual autocorrelation (LBQ) and on the basis of the minimum value of Akaike information criterion (AIC).

Table 4.2. Linearity testing, determining the delay parameter and selection between LSTAR and ESTAR. Results when CBD is the financial development measure and trade openness is used as a threshold.

Variable	Linearity LM_2	p-value H01	p-value H02	p-value H03	d-delay parameter	TP choice
DEM	0.02	0.01	0.84	0.03	4	LSTAR
REV	0.02	0.02	0.80	0.02	4	LSTAR
STR	0.01	0.02	0.16	0.13	4	LSTAR
LS	0.01	0.27	0.13	0.01	4	LSTAR
CC	0.06	0.01	0.34	0.43	4	LSTAR
LE	0.01	0.25	0.02	0.03	4	ESTAR*

Notes: Column 2 represents the p-value (strength) of the linearity rejection. Based on Teräsvirta (1994) selection process, columns 3 to 5 suggest an LSTAR model except from *le*. However the use of the LSTAR model fits better in our data. Column 6 represents the delay parameter, which in our case is 4, since the power of linearity rejection is stronger relative to other values of d. The usage of LM_2, H01, H02 and H03 follows Teräsvirta (1994).

Table 4.3. Linearity testing, using commercial bank deposits (CBD) as the transition variable.

Variable	Linearity LM_2	d-delay parameter
dem	0.25	4
rev	0.03	4
str	0.03	4
ls	0.07	4
cc	0.39	4
le	0.20	4

Notes: Column 2 represents p-values of the linearity rejection. Based on Teräsvirta (1994) *dem, cc* and *le* fail to reject linearity while *rev, str* and *ls* reject it. However, this rejection is weaker compared to the case when trade openness is used as the transition variable (see Table 2 above).

Table 4.4, 4.5 and 4.6 (below) report the baseline results. In order to calculate the time-varying effects of trade openness, political instability and financial development on growth we use the following three equations:

$$\frac{\vartheta(GDP_t)}{\vartheta(TO_{t-4})} = \phi_4^{(1)} + \gamma(\phi_1^{(2)} + \phi_2^{(2)} FD_{t-3} + \phi_3^{(2)} PI_{t-4}) \exp[-\gamma(TO_{t-4} - c)](1 + \exp[-\gamma(TO_{t-4} - c)])^{-2}, \quad (4.3)$$

$$\frac{\vartheta(GDP_t)}{\vartheta(PI_{t-4})} = \phi_3^{(1)} + \phi_3^{(2)}(1 + \exp[-\gamma(TO_{t-4} - c)])^{-1}, \text{ and} \quad (4.4)$$

$$\frac{\vartheta(GDP_t)}{\vartheta(FD_{t-3})} = \phi_2^{(1)} + \phi_2^{(2)}(1 + \exp[-\gamma(TO_{t-4} - c)])^{-1}. \quad (4.5)$$

4.5.1. Commercial Bank Deposits

4.5.1.1. The Impact of Trade Openness

First notice that there is a positive and statistically significant time-varying relationship between trade openness and economic growth in all models of Table 4.4 except in the case when le is the political instability measure, where the link is positive but statistically insignificant (see: equation 4.3 above on how we calculate this effect, the parameter estimates of Table 4.4, the summary Table 4.7 and Figure 4.4 below). Notice from Figure 4.4 that there are periods where the size of the effect of trade openness on growth (though positive in all cases) is high and some periods where it is relatively low (though positive in all cases). In the analysis below we will focus on the dates\periods where trade liberalization displayed low values, which in turn might explain the low size effect of trade openness on growth (see Figure 4.4 below).

From our results it follows that the first period where the low size effects of trade openness on growth took place was during 1893. Political instability and violence during the first years of the First Brazilian Republic created a negative macroeconomic environment for the Brazilian economy, which might explain low levels of trade openness. The main source was the fight for power between different elite groups that had contrasting visions regarding the government model and the role of the military in society. After the adoption of the new constitution of 1891 (which established the Republic of the United States of Brazil and adopted the US system of governance) Deodoro da Fonseca and Floriano Peixoto were elected president and vice president respectively, with the former receiving 123 votes and the latter 153[22]. However, after difficulties that the president (Deodoro da Fonseca) faced in sharing power with the Congress, he dissolved it in November 1891, simultaneously encouraging revolts in the navy and in the Rio Grande do Sul (a state in the southern part of Brazil, which is the ninth largest by area and the fifth most populous region). One of the most cruel revolts was the one that broke out in Rio de Janeiro in September 1893, the well known Revoltas da Armada (Brazilian Naval Revolts), which could constitute an extra cause of low trade liberalization levels. One point worth mentioning is that during this specific rebellion we have the first documented intervention in Brazil's internal affairs by the United States of America. The Brazilian-US relationships have gone through various stages during the last 200 years: from indifference to close alignment (see Hirst, 2005). In particular during the last decade of the 19^{th} century from the one side Brazilian diplomacy tried to borrow features of the US political behaviour while from the other the US opened its market to coffee, Brazil's main export. Proof of that was the signing of the Treaty of Commercial Reciprocity of 1891 between the two countries. However, the panic of 1893 in the United States created a significant economic depression in that country, which was the worst at that time. It was not until 1897 that the US economy recovered and began steadily to expand. Hence the aforementioned economic crisis might be an additional reason for reduced trade openness and hence low size effects of the latter on growth during 1893.

The second period of reduced trade openness size effects on growth occurred from 1908 to 1910 (see Figure 4.4 below). Events that might explain low trade openness during that period might be the following. In 1906, the Taubate Convention was signed, in which it was proposed that the government should buy the excess coffee production at a price which would be at a minimum pre established level, and that it should restrict the production of low-quality coffee, stimulate internal consumption, and promote the product abroad. It was the first trade intervention policy following the coffee crisis of 1902 (Luna and Klein, 2014). The aim of this Treaty was to mitigate the problems caused by the excess stock of Brazilian coffee. By 1906 Brazil was producing alone all the quantity that the whole world was consuming in a year. The significance of the coffee economy can be seen by the fact that it represented more than half of Brazilian exports, defining it as the main economic activity of the country. Although the government politics until that time were in favor of free trade, they were forced to implement policies that had a negative impact on trade liberalization during the period 1908 to 1910.

[22] The numbers of votes that the president and the vice president received deserve mentioning.

The third period covered the years from 1929 to 1933, namely the Great Depression. The US stock market collapse of 1929 affected Latin America severely. Specifically in the case of Brazil the political repercussions of the revolution of 1930 (under Getulio Vargas) put an end to the Old Republic. In the field of the economy, the Depression had a severely negative impact on Brazil's exports, whose value fell from US$ 444.9 million in 1929 to US$ 180.6 million in 1932 (Baer, 2013). This fall in export earnings combined with the large amount of foreign exchange that the country needed in order to serve its external debt forced the government to take actions. Accordingly, after a devaluation of the currency, the cost of imports increased and hence the value fell from US$ 416.6 million to US$ 108.1 million (or by 75%). The combination of the aforementioned events (reduction in exports and imports) caused a drop in the level of trade openness that may explain the low levels of the size effect of trade liberalization on growth. Moreover, in August of 1931, Brazil temporarily stopped partial repayments of foreign debt and started negotiations towards a new agreement related to debt. In addition the crisis harmed the backbone of the Brazilian economy, which was the coffee industry. The low levels of demand due to the shock of 1929 (resulting in low market prices) and the overproduction of coffee because of the planting in the 1920s led to protectionist policies in the following years, which decreased the openness of the economy. In particular, the coffee support program was centralized and transferred from the states to the federal government. The Conselho Nacional do Cafe (National Coffee Council) was established in May 1931. It was assigned to buy all the quantities of coffee and to destroy whatever could not be sold or stored.

The fourth period where trade liberalization size effects on growth were low covers the period from 1947 to 1954 (with the exception of 1948 and 1950, see Figure 4.4 below). The years after the second war and up to 1962 were marked by severe Import Substitution Policies (ISP). From 1947 exchange controls were introduced that lasted up to 1953. The overvalued cruzeiro[23] encouraged imports, which were boosted by the outbreak of the Korean war as well (Baer, 2003). Hence ISPs were considered to be an antidote to the aforementioned exchange controls by keeping the economy protected and relatively closed. Notably our results suggested a significant drop in the effect of trade openness on growth from 1951 to 1954 (when the ISP's launched). An additional occasion that might have kept trade liberalization at low levels might be when Getulio Vargas, the Brazilian president as of 1951 tried to re-boost the weak economy[24]. In particular during the early 1950s the government introduced a multi-level exchange rate system (the tariff law designed in 1957 with some minor changes was in force up to 1990) whose main purpose was not only to rationalize the scarcities in foreign exchange but also to offer insurance for a range of import-competing business activities (see Braga and Tyler, 1990). The main effect of these inward-looking trade policies (alternatively less extrovert trade policies) was to allocate capital to import-subsitution activities and to provide protection for the domestic industry.

An exception to the rule was the period from 1969 to 1973, where, despite the fact that we detect low size trade openness effects on growth, the history suggests that the aforementioned period was characterized by spectacular growth as well as by the increased levels of trade openness. In particular only in that period was the average annual growth of GDP around 11%, with that of industry reaching 13%. After years of ISPs, timid openings in trade policies occurred from 1967 to 1973 (Braga and Tyler, 1990). Policy makers realized that growth without opening in trade cannot be sustainable. Among these measures were included modifications in the exchange rates policies, the introduction of export incentives and the relaxation of the import obstacles. Following GDP's upward trend, exports increased from US$ 1.4 billion in 1963 to 6.2 US$ billion in 1973 while imports in the same period rose from US$ 1.3 billion to US$ 4.4 billion (Hudson, 1998).

The year 1974 and the period from 1978 to 1980 consist of the sixth period where low size trade openness effects (on growth) were observed (see Figure 4.4 below). This might be attributed to events that reduced the level of the trade liberalization such as the oil shock of 1973, which might have resulted in

[23] the currency of Brazil from 1942 to 1986 and from 1990 to 1993.

[24] It was 3^{rd} of October of 1953 when Petrobas was established. Petrobas is a multinational energy company with headquarters in Rio de Janeiro of Brazil.

reductions of terms of trade (this period covers from 1974 to 1980 and it is known as the period of growth with debt). In addition, during the early 1970s Brazil's exports were limited by an overvalued currency. Furthermore, the fall of inflation during 1968 to 1974 was reversed by a remarkable increase during 1973 to 1980. It is notable that the growth rate of the general price index from 16.2% a year in 1973 increased to 110.2% a year by 1980 (Hudson, 1998). However, instead of undertaking measures of devaluation of the domestic currency and growth reducing policies the government chose the opposite way, that of high growth and import protectionism (which imposed constraints\tariffs on imports). This strategy from one side reduced the trade openness of the Brazilian economy while from the other maintained its growth.

The penultimate period of low size trade liberalization effects was from 1982 to 1989 (with the exception of 1988, when the new constitution institutionalized the first presidential election directly from the people since 1960). While the economy tried to cope with the first oil shock in 1973 a second one in 1979 doubled the price of imported oil in Brazil and worsened the balance of terms of trade even more. The debt crisis and the Lost Decade (1979-1989) had just started. The reaction was the same as with the first oil shock of 1973. The policy makers increased borrowing from abroad and further import tariffs were imposed (which worsened the trade openness). For instance trade barriers related to extensive import restrictions and import financing requirements were introduced, foreign exchange controls were established by the Central Bank[25] and finally negotiations between individual importing companies and the CACEX[26] were conducted every year in order to determine the annual import levels. However, borrowing from outside increased the debt and trade surpluses policies employed in order to deal with that problem. The arrival of IMF in the economic life of Brazil and the austerity program imposed as a result in late 1979 lasted until 1984. During that period the Mexican debt crisis (of 1982) limited Brazil's access to international financial markets. In addition, the program of IMF, while it facilitated the interest payments on the debt, also worsened the economy and increased the inflation rates. All these events, namely the general economic crisis, the import tariffs that were imposed, hyperinflation, low net capital inflows as a share of GDP (Edwards, 1994), the Cruzado Plan in 1986, the Bresser Plan in 1987, and the Summer Plan in 1989 (for more information regarding the Cruzado, Bresser and Summer Plan see Hudson, 1998) lessened trade liberalization levels, which in turn might explain the low size trade openness effects (on growth) that were indicated by our results during 1982-1989.

Finally, the last period of constraint size effects of trade openness on output growth was during 1993 and from 1996 to 1999 (see Figure 4 below). The series of events and policies listed below might be responsible for low trade liberalization levels and possibly, therefore, for the low size effects of trade openness on growth. In particular, after the constitution of 1988, the first presidential election since 1960 was held in 1989 appointing Fernando Collor de Mello[27] as the first president elected by the people after 30 years of military regimes. Collor de Mello was considered the solution to Brazil's economic difficulties. Despite the government's efforts to control hyperinflation and to heal the almost bankrupted public sector, inflation continued to run with rates higher than 30% a month, the levels of productivity gains were relatively low and real exchange rate appreciation, which lowered the degree of competitiveness, was observed in Latin America during 1993 (where our results indicate low trade openness size effects), Edwards (1994). In the following year (1994) the implementation of the Real Plan (Plano Real), despite its successful attempts to maintain inflation rates at lower levels, could not do much in terms of the real exchange rate appreciation that occurred. Hence the Brazilian products became more expensive and less competitive, which in turn contributed to higher current account deficits. The situation became worse when the policy of overvalued inflation rate as a stabilization tool between 1994 and 1998 was

[25] following the foreign exchange deficit in 1982 and 1983 (see Braga et al. 1990).

[26] CACEX stands for Carteira de Comêrcio Exterior do Banco do Brasil S.A. or Portfolio Foreign Trade Bank of Brazil S.A.. It was an agency established by the government of Getulio Vargas in 1953. Some of the main roles of this agency included exports and imports licensing, funding of foreign trade as well as keeping records of statistical data on exports and imports. The agency paused its activities in 1990 under the government of Collor.

[27] a former governor of Alagoas, located in the Northeast region and member of National Reconstruction Party (NRP) at that time.

implemented by the government. The burden of these deficits became even heavier when the Asian financial crisis in 1997 and the default of Russian bonds in late summer of 1998 broke out. It was a blow to investors' confidence in emerging markets (where Brazil's exports to Eastern Europe and Asia fell by 11.4% and 27.4% respectively, while globally they shrank by 3.5% between 1997 and 1998, see Averbug report). As an answer to the financial crisis in Asia, in 1997 all the members of MERCOSUR[28] agreed to increase the Common External Tariff (CET) by 3% points. In addition, tariffs were imposed on imported consumer goods (from 0% to 5%). Therefore, the reduction of the average import tariffs (which constitutes the main trade instrument of Brazil according to the World Trade Organization) of the previous years (namely 1990-1995), was replaced by a slight rise in import tariffs in 1996 and in 1997 and a bigger one in 1998 (see Averbug report) lowering the openness of the Brazilian economy.

4.5.1.2. The Effects of Political Instability

Regarding the time-varying impact of political instability (either informal or formal) on economic growth the results show that it is mainly negative throughout (see: equation 4.4 above on how we calculate this effect, the parameter estimates of Table 4.4 and the summary Table 4.7 below). The only exception are revolutions, where the impact on growth seems to be mixed (positive effect in 60 out of 104 cases\years) whereas that of cc is statistically insignificant. According to Stokes (1952) since 1900 and up to 1950 Latin American governments were overthrown by revolts seventy six times, and nobody knows how many unsuccessful attempts occurred during those years. In the analysis below we will focus on the most important periods when revolutions displayed a positive effect on economic growth.

The first period with a positive effect of revolutions on economic growth was from 1899 to 1902. During that period events of great political and economic importance took place, which might explain this positive effect. More specifically, the last decade of the 19^{th} century was marked by countless political rebellions (two naval revolts in 1891 and 1893-1894, the Federalist Riograndense Revolution of 1893-95 and the war of Canudos in 1896-97) and a major economic bubble called Encilhamento. The devastated economy was in the hands of Manuel Ferraz de Campos Sales (the Old Republic's first civilian government), ex minister of Justice in Deodoro's provisional government, where he fulfilled his duties successfully (Bello, 1959). Campos Sales's non inflationary policies and drastic but harsh measures at the financial level allowed the Brazilian economy to recover and to avoid the danger of bankruptcy. Notably even the Rothschilds (a well known international banking family) were applauding Campos Sales's efforts in the field of the economy at the end of his term of office (Bello, 1959).

The second period covers the years from 1920 to 1926 (with the exception of 1923). After the end of the first War and the signing of the Treaty of Versailles in 1919, Brazil was faced with events of great importance (which might explain this positive link) such as the Bolshevik Revolution in Russia in 1917, which was welcomed very enthusiastically by the Brazilian elite of the labor movement (Alexander and Parker, 2003) and considered by many as the harbinger of subsequent changes. Furthermore, during 1922 and later from 1924 to 1927 the Revoltas Tenentistas (Tenente Revolt) outbreak took place. The revolt was orchestrated by low rank officers demanding, among others, significant reforms in the agricultural sector, nationalization of the mines and modernization of the society. Despite the fact that it was unsuccessful it opened the way for the Revolucao de 1930 (Revolution of 1930), which ended the era of the Old Republic and paved the foundations of the reinvention of the Brazilian economy (with the Constitution of 1937). At the economic level the Brazilian economy during the 1920s performed well, with an average growth rate of 4.8%[29]. The expansion in the economy was driven more by the flourishing

[28] MERCOSUR stands for Mercado Comum do Sul (Southern Common Market) comprising Argentina, Brazil, Paraguay, Uruguay and Venezuela. Its associate countries are Chile, Bolivia, Colombia, Ecuador and Peru. Observer countries are New Zealand and Mexico. Its main purpose is to promote free trade and the fluid movement of goods, people, and currency. The Treaty of Asuncion was signed by the member states in March of 1991. It could be said that MERCOSUR was Latin America's attempt to form its own Union like the one that Europeans established initially in 1951. For more information about MERCOSUR follow the link: http://www.mercosur.int/msweb/portal%20intermediario/.

[29] Source http://www.ipeadata.gov.br/.

coffee economy and less by the growth in the industrial sector (Baer, 2003). However, there were some industrial sub-sectors such as chemicals, metallurgy and tobacco, which achieved significant growth rates that were above the average, showing the trend and the diversification that the Brazilian economy started to exhibit.

The next nine years (1930-1938) marked the end of the Old Republic and the beginning of the Vargas Era. During most of that period (excluding the years 1931, 1933 and 1935) our results indicate a positive link between revolutions and economic growth. This might be explained by the fact that the leader of the country (at that period) Getulio Dornelles Vargas was to leave his footprint on Brazilian political and economic life for the next 15 consecutive years. More specifically he attempted to stimulate the middle class by converging the interests between the Paulista coffee oligarchy and the bourgeoisie, using his populist rhetoric to do. With his policies, especially from 1930 to 1934, he favoured Brazilian manufacturers, since the traditional elites had little interest in promoting the interests of the former (industrial/manufacturers interests) during the previous years. Influenced by the Revoltas Tenentistas mentioned before, he implemented a program of social welfare and reforms that were in parallel with the New Deal (a series of reforms over the period 1933-1938, which were focused on the 3 Rs, Relief, Recovery and Reform. These reforms were the response of the American government under Franklin D. Roosevelt to the Great Depression) in the United States of America, promoting a benign macroeconomic environment that boosted growth. Sharing the dream of the New Deal, Vargas attempted to mitigate the differences between capital and labor. Nevertheless, the rise of Nationalism and Fascism in Europe led him to adopt a hybrid system of political thought between Mussolini's in Italy and Salazar's Estado Novo in Portugal. The inevitable consequence was the abolition of the policies that the provisional government (1930-1934) had carved out. However, the Constitution of 1934 and the unsuccessful revolt of the Communists to gain control of the government left Vargas the only considerable force in the country. The importance and the effects of the new constitution (from 1934 to 1937) and the Estado Novo (New State 1937-1945) were reflected by transferring the institutional powers of coffee elites to the central government and by creating a more centralized authority in Rio de Janeiro. Moreover, the federal government activities were meant to become more rational and fixed, freed from the tactics of the Old Republic and especially the Coronelismo (Rule of Coronels), promoting the expansion of the economy. Hence after the Constitution of 1934 there was a more direct mechanism of exercising the power of the federal government in the economy. Public and mixed companies dominated the important heavy and infrastructure industries, while the private sector established its rule in the manufacturing activities. In addition, positive effects of the 1930 revolution on the Brazilian economy include among others the increase in foreign direct investments (FDI)[30] and the more than double rise of industrial production (Baer, 2003). Furthermore, 1934 was the turning point for the external consolidated debt, which started to de-escalate after almost 40 years of upward trend (see Figures A.4.4, A.4.5 and A.4.6 in the Appendix) while the average growth rate only for the period from 1936 to 1938 (which are the main years that when results indicated a positive effect of revolutions on economic growth) was around 7.06% (source, ipeadata).

The fourth period when revolutions had a constructive effect on growth was during 1948-1958 (excluding 1951 and 1954). Following the resignation of Vargas in 1945 the second Brazilian Republic (1946-1964) begun. History shows that during that period a series of constructive events took place (among others Dutra's and Kubitschek's presidency). In particular it all started when Eurico Gaspar Dutra (1946-1951) took control of the country. Dutra's period of administration was marked by a sequence of significant reforms and actions that favoured economic growth, such as the establishment of the 5^{th} Constitution[31], the strengthening of the relations between US and Brazil, the breaking of diplomatic relations with the USSR and the implementation of the Salte Plan, which incorporated reforms in basic economic sectors

[30] Ipea-data show a boom in the investment rate especially after 1933. In particular during the period 1936 to 1938 investments ran at an average rate of 12.85%.

[31] The first constitution that provided full political freedom, even for the banned Communist Party and the last one that officially used the name Estados Unidos do Brasil (United States of Brazil). One of the key points of the new constitution referred to postal privacy and the prohibition of entering houses by the police without permission.

such as transportation, energy, food and health. Among others more than 4,000 new schools in rural areas were founded, railways were expanded and improved as were roads connecting Rio de Janeiro with Salvador and Sao Paolo (Hudson, 1998). Finally, the average growth rate during his term was around 7.20% (according to ipeadata) and 8.06% from 1948 to 1950 (where our results report positive impact of revolutions on GDP growth). In the following years (1952-1953) Brazil continued to experience high growth rates as a consequence of the political reforms that Dutra established. The economic success of the country continued as well during the presidency of Juscelino Kubitschek de Oliveira (1956-1958), who was the only post-Vargas era president that managed to remain in office for a full term of five years. His term was characterized by political stability and respect for democratic principles. Kubitschek's political legacy was represented by the Plano de metas *(Goals'* Plan) comprising 31 goals. The further opening of the economy to foreign capital, the exemption of the taxes of all machinery and industrial equipment imports (under the condition that the foreign capital was linked with national income) boosted the economy. In addition the promotion of the automotive industry, which was able to transform the economy and Brazilian life within 30 years (a generation), the construction of a remarkable highway network and the transfer of the capital from Rio de Janeiro to Brasilia were some of his achievements as president. Because of the transportation system and the accessibility of agricultural machinery, Brazil was transformed into the second largest food exporter in the world during the next decades (Hudson, 1998). Hence, (as mentioned before) from one point of view Kubitschek's government motto *Fifty years of progress in five* could sound reasonable.

The penultimate period where the political instability measure (REV) seems to have had a positive influence on economic expansion was from 1975 to 1978, during the Brazilian (economic) Miracle. In particular, at that time Ernesto Beckmann Geisel came to the presidency with Medici's approval. He was the second president appointed by the military junta of 1969. Despite the oil shock of 1973 he sought ways to sustain the high economic growth rates of the previous years. In particular during Emilio Garrastazu Medici's term the economy was growing at an average of 11%. This period is well known as The Brazilian Miracle. His actions consisted of three axes. The first one under the name distensao allowed the consolidation of the democratic norms. The second axis included investments in infrastructure such as, highways, telecommunications, hydroelectric dams, mineral extraction, factories, and atomic energy (Hudson, 1998). Furthermore, he allowed foreign firms to search for oil in Brazilian soil for the first time after almost 25 years. Finally the third axis introduced a new more realistic foreign policy, so-called Responsible Pragmatism. Despite his anti-communist feelings his government recognized Angola, China and Mozambique and started building closer bonds with Europe, Japan and Hispanic America. The final report of his tenure (1974-1979) was an economy with growth rates around 6%. Therefore, all the aforementioned occasions might explain why revolutions had a positive link with output growth during that period.

Concluding with our analysis related to political instability, the final period when revolutions contributed towards growth was from 1994 to 1995 during Itamar Augusto Cautiero Franco's leadership (who was the last non-elected president of Brazil and the one that restored political stability). During his term a series of actions (for example, the free trade zone in South America could be credited to his administration) and policies led to the economic recovery of Brazil, hence possibly explaining why the revolutions displayed a positive link with economic growth during the aforementioned period. More specifically after the exhausting economic crisis of the previous years (1981-93) with inflation rates of 1,100% in 1992 and 2,400% in 1993 the implementation of the *Plano Real* (Real Plan) in 1994 started stabilizing the crumbling economy and deflating the prices. The new currency introduced (Real) gained value over the US dollar, keeping inflation under control while the economic recession of the previous 3 years was now replaced by growth of almost 5%.

4.5.1.3. The Impact of Commercial Bank Deposits

Our principal findings refer to financial development, (Figure 4.4 shows our estimates for this mixed

time-varying relationship); notwithstanding the annual frequency, we estimate a negative effect in 56 cases (years) out of 104 (see: formula 5 above on how we calculate this effect, the parameter estimates of Table 4.4, the summary Table 4.7 and Figure 4.4 below). While previous research argues in favor of a negative relationship between financial development and growth in the short-run and a positive one in the long-run, we argue the case for a mixed (negative and positive) time-varying link between financial development and output growth (in the short-run), which is robust. The aforementioned finding constitutes one of the contributions of this Chapter.

In particular in three periods financial development has a clearly positive effect on economic growth, namely 1968-1974, 1991-1993 and 1997-1999. Levine (1996) argued that Goldsmith's cross country work in 1969 provided evidence that rapid economic growth was accompanied by above the average financial development. Similarly Haber (1991, 1996) suggested that capital market development had a significant impact on economic growth. He justified this view by using the case of Brazil, Mexico and the United states. In Brazil the liberalization of the capital markets after the fall of the monarchy in 1889 provided the Brazilian firms with easier access to foreign capital. While Mexico followed the example of Brazil, the opening of the financial policies was much more subdued. Consequently economic growth in Mexico was weaker and slower than that of Brazil. Finally McKinnon (1973) studied the link between financial systems and economic expansion among others in Argentina and Brazil after the end of the 2^{nd} War. His findings strongly indicated the beneficial nature of well functioning financial systems for economic growth.

The first of the three periods indicating positive financial development effects (1968-1974) is the one known as the Milagre economico (Brazilian Miracle), when average annual growth rates were extremely high following a number of important financial sector reforms that underpinned a massive increase in infrastructure investment, Goldsmith et al. (1986).

The second period of positive CBD impact on growth occurred during the period 1991-1993. Among the reasons that could explain the positive link between CBD and GDP growth during that period might be the fact that from the early 1990s there were various attempts to develop non-inflationary sources of finance and to diminish Brazil's dependency on foreign savings. More specifically, despite the political turmoil that marked the early 1990s, 1991 saw law changes allowing foreign institutions to trade domestically issued bonds and securities, Studart (2000). From 1992 onwards capital flows rose rapidly due to the repatriation of the capital that fled in the 1980s after the interest rate shocks of 1979.

The third and final period of constructive impact of CBD on output growth covers the late 1990s (1997-1999, see Figure 4.4 below). This could be attributed to the successful implementation of the 1994 Real Plan and the expansion of the PROER programme from 1997 onwards, which supported a wave of mergers and acquisitions in the financial sector (see Folkerts-Landau et al., 1997). Moreover, the opening of the Brazilian market to new financial institutions contributed towards liberalization of the financial system, Bittencourt (2011). An interesting point in our results is the fact that when the financial development effect was positive (and at relatively high levels) trade openness levels were either stagnant (1969-1974) or on a downward slope (1993, 1995-1999). This could potentially show us the changes in the priorities of the Brazilian government after 1969.

Finally, as far as the level of γ is concerned, the change between the two regimes is not so smooth, with the exception of legislative elections, where the transition is smoother (see the parameter estimates of Table 4.4 and Figure 4.5 below). The value of c represents the point when the transition between the two regimes happens (see the parameter estimates of Table 4.4 below).

Table 4.4. Logistic Smooth Transition Model (CBD as the Financial Development Measure)

	$\phi_1^{(1)}$	$\phi_2^{(1)}$	$\phi_3^{(1)}$	$\phi_4^{(1)}$	$\phi_1^{(2)}$	$\phi_2^{(2)}$	$\phi_3^{(2)}$	γ	c
DEM	0.08^{***}	-0.86^{***}	-0.04^{***}	0.58^{**}	-0.04	1.16^{***}	0.04^{**}	5.54	-0.008
	(0.02)	(0.18)	(0.02)	(0.28)	(0.02)	(0.38)	(0.02)	(5.07)	(0.00)
REV	0.07^{***}	-0.80^{***}	0.03^{***}	0.88^{**}	-0.05	1.12^{***}	-0.03^{*}	4.09	-0.005
	(0.02)	(0.20)	(0.01)	(0.39)	(0.04)	(0.44)	(0.02)	(3.26)	(0.00)
STR	0.09^{***}	-0.86^{***}	-0.03^{**}	0.76^{*}	-0.06	1.21^{***}	0.03	3.52	-0.007
	(0.03)	(0.25)	(0.01)	(0.41)	(0.05)	(0.51)	(0.02)	(2.84)	(0.00)
LS	0.14^{***}	-0.78^{***}	-0.04^{***}	0.69^{**}	-0.12^{*}	1.18^{***}	0.04^{*}	3.94	-0.005
	(0.03)	(0.21)	(0.01)	(0.34)	(0.06)	(0.46)	(0.02)	(3.11)	(0.00)
CC	0.06^{***}	-0.79^{***}	0.03	0.52^{**}	-0.03	1.10^{**}	-0.04	4.33	-0.007
	(0.02)	(0.24)	(0.02)	(0.32)	(0.03)	(0.49)	(0.04)	(4.67)	(0.00)
LE	0.13^{**}	-1.02^{**}	-0.02^{**}	0.91	-0.14	1.62^{*}	0.03	2.02	-0.005
	(0.06)	(0.46)	(0.01)	(0.60)	(0.11)	(0.88)	(0.02)	(1.50)	(0.00)

Notes: Table reports parameter estimates for the following model:

$Y_t = \phi_1^{(1)} + \phi_2^{(1)} CBD_{t-3} + \phi_3^{(1)} PI_{t-4} + \phi_4^{(1)} TO_{t-4}$

$+ (\phi_1^{(2)} + \phi_2^{(2)} CBD_{t-3} + \phi_3^{(2)} PI_{t-4})(1 + \exp[-\gamma(TO_{t-4} - c)])^{-1} + \epsilon_t.$

The numbers in parentheses represent standard errors.

***, **, * indicates significance at the 1%, 5% and 10% level respectively.

Figure 4.4. Time-varying Effects of Financial Development (CBD) and Trade Openness on Growth Using Various Political Instability Measures. Results Obtained From the Parameter Estimates of Table 4.4.

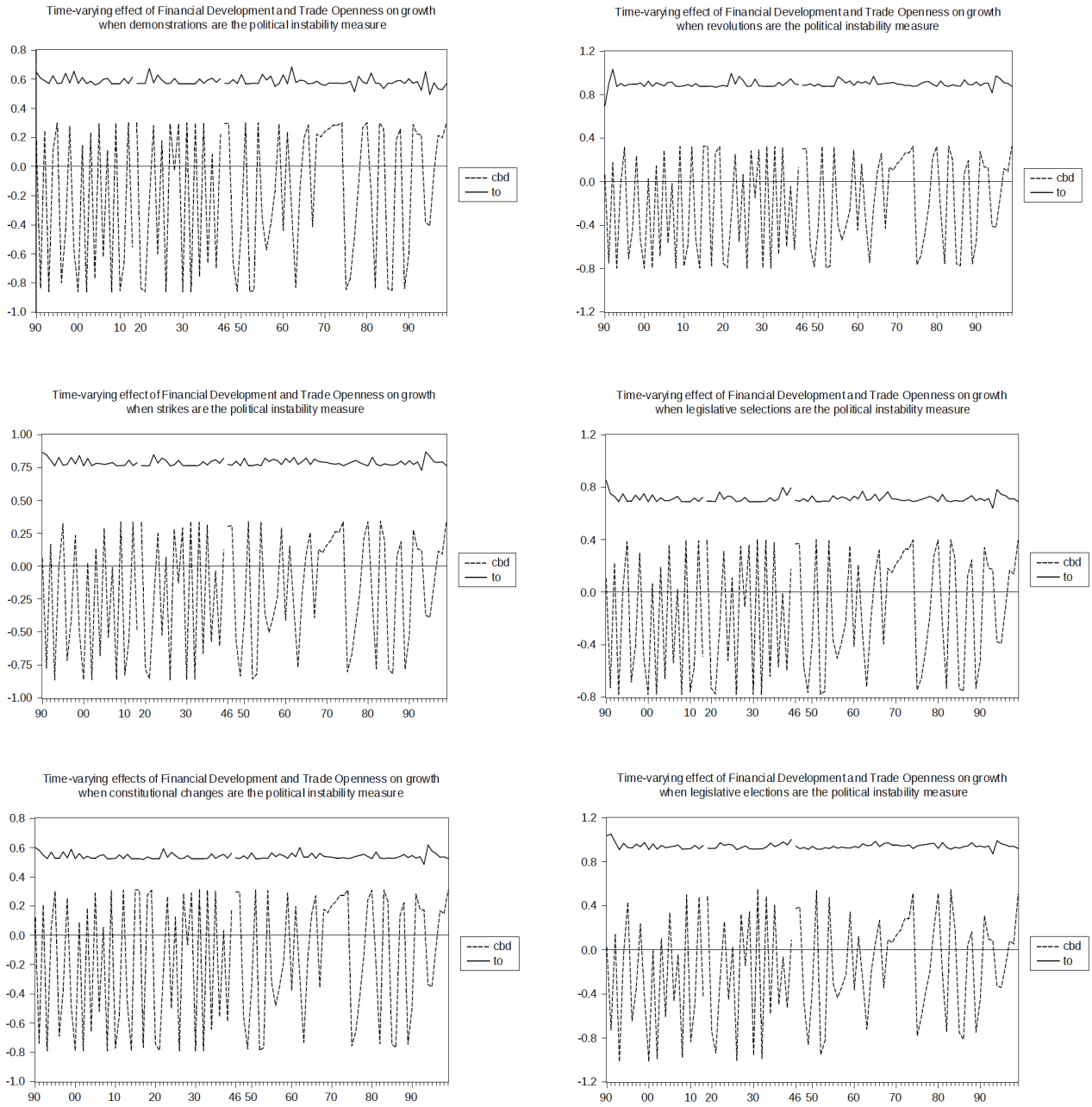
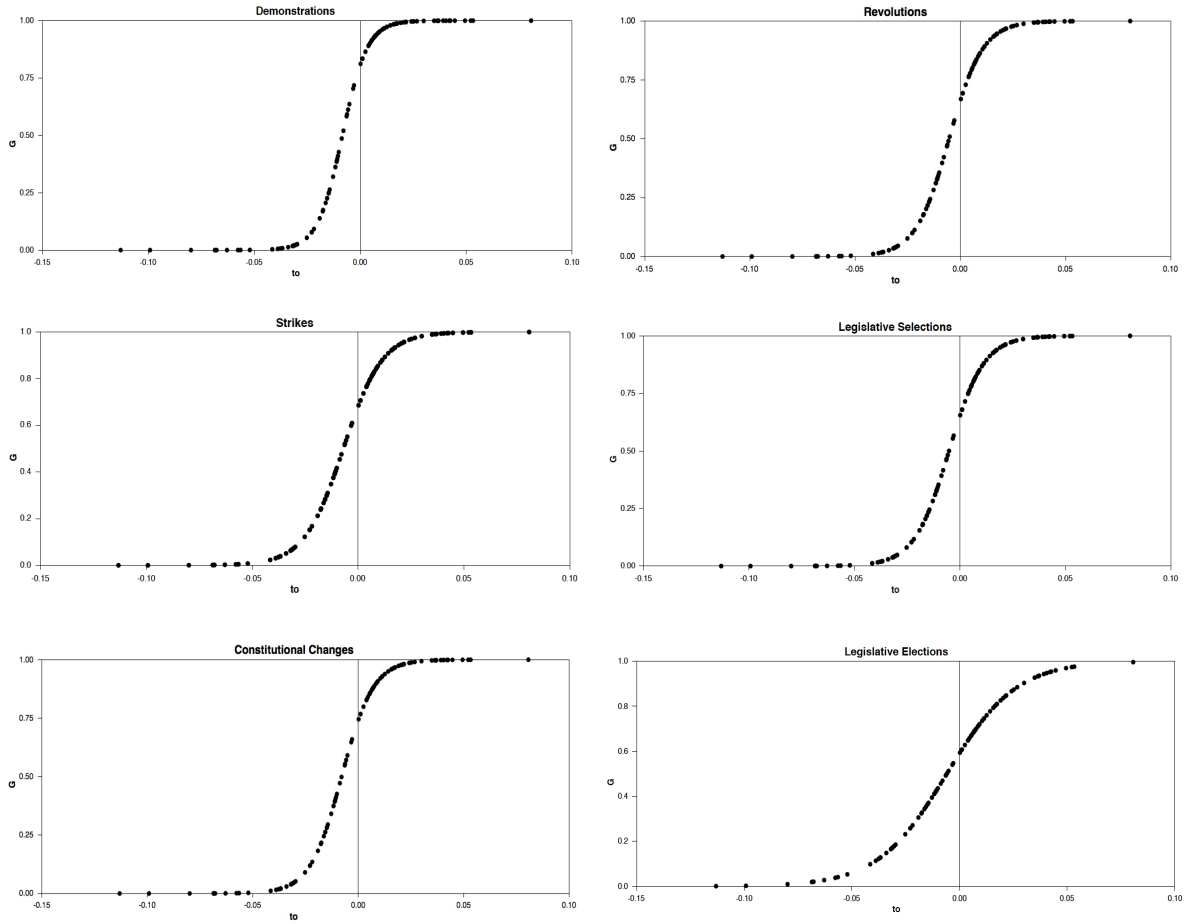


Figure 4.5. Smooth Transition Function ($G(s_{t-d})$) vs Transition Variable (TO_{t-4}). Results Obtained from the Parameter Estimates of Table 4.4.



4.5.2. Other Financial Development Measures

To validate our results we additionally used money supply and deposits at Banco do Brasil as financial development measurements. As noted above, given M1's and DBB's more restrictive nature we use both of them as a robustness check of our results and thereby we attach greater weight to commercial bank deposits. The results in general are in full compliance with the ones reported in Table 4.4 above. Accordingly, the parameter estimates of Tables 4.5 and 4.6 below report the estimation outputs when either M1 or DBB is considered as the financial development measure. First notice that there is a positive (in all 104 cases\years) and statistically significant time-varying link between trade openness and economic growth in most of the models, 10 out of 12 (see equation 4.3 above on how we estimate this effect, the parameter estimates of Tables 4.5 and 4.6, the summary Table 4.7 below and Figures A.4.7 and A.4.8 in the Appendix). These findings confirm our primary results on the time-varying link between trade openness and economic growth when commercial bank deposits were considered as the measure of financial development.

Regarding the time-varying relation between political instability (either informal or formal) on growth the results are as follows. From the estimated parameters of Table 4.5 below we found a negative effect of DEM, STR and LS throughout the years (see equation 4.4 above on how we calculate this effect), a beneficial effect of purges (this effect is measurable during the same periods when revolutions, see the parameter estimates of Table 4.4 and Figure 4.4 above, had a positive impact on growth), but quite low in most of the cases (in 60 out of 104 cases\years), and a mixed impact of coups (positive effect in 69 cases\years out of 104) on economic growth. As far as the CC is concerned, its effect was statistically insignificant. Results from Table 4.6, when DBB is the financial development measure, are in line with the ones reported in Table 4.4. Specifically we observe a statistically significant negative effect between political instability and growth [with the exception of CC, where there is a mixed effect, (negative effect in 48 out of 104 cases\years), similarly with the results provided by the parameter estimates of Tables 4.4 and 4.5].

Regarding our baseline findings for M1, (see equation 4.5 above on how we calculate this effect, the parameter estimates of Table 4.5, the summary Table 4.7 and Figure A.4.7 in the Appendix) we find a mainly negative effect on growth, but significantly reduced in magnitude especially during 1968-74, 1991-93 and 1997-99 (periods where the parameter estimates of Table 4.4 suggested a positive link between CBD and economic growth as well) whereas the results from Table 4.6 (dbb is considered as the financial development indicator) show a mixed time-varying link between DBB and economic growth (negative in 55 out of 104 cases\years, see equation 4.5 above on how we calculate this effect, the parameter estimates of Table 4.6, the summary Table 4.7 and Figure A.4.8 in the Appendix). Notably, the periods where DBB appeared to have a positive impact on growth were identical with the ones provided by the parameter estimates of Table 4.4 (see also the summary Table 4.7 below).

Finally, as far as the level of γ is concerned the change between the two regimes is not so smooth, with the exception of STR and LE (see the parameter estimates of Tables 4.5 and 4.6 respectively), where the transition is smoother (see Figures A.4.9 and A.4.10 in the Appendix respectively). The value of c represents the point when the transition between the two regimes happens (see the parameter estimates of Tables 4.5 and 4.6 below).

Table 4.5. Logistic Smooth Transition Model (M1 as the Financial Development Measure)

	$\phi_1^{(1)}$	$\phi_2^{(1)}$	$\phi_3^{(1)}$	$\phi_4^{(1)}$	$\phi_1^{(2)}$	$\phi_2^{(2)}$	$\phi_3^{(2)}$	γ	c
DEM	0.09^{***}	-2.18^{***}	-0.04^{**}	0.86^{*}	-0.07	1.17	0.05^{*}	3.52	-0.005
	(0.03)	(0.75)	(0.02)	(0.45)	(0.05)	(1.35)	(0.03)	(3.02)	(0.00)
COUPS	0.08^{***}	-2.63^{***}	0.11^{**}	0.82^{*}	-0.06	1.63	-0.13	3.45	-0.005
	(0.03)	(0.82)	(0.05)	(0.48)	(0.05)	(1.49)	(0.12)	(3.42)	(0.00)
STR	0.13^{*}	-1.97^{**}	-0.04^{**}	1.31	-0.14	0.85	0.04	2.11	-0.006
	(0.08)	(0.91)	(0.02)	(0.91)	(0.14)	(1.75)	(0.03)	(1.73)	(0.00)
PUR	0.07^{***}	-2.02^{***}	0.02^{*}	0.66^{**}	-0.04	1.16	-0.01	5.57	-0.007
	(0.02)	(0.68)	(0.01)	(0.34)	(0.03)	(1.15)	(0.01)	(5.74)	(0.00)
LS	0.17^{***}	-1.91^{***}	-0.05^{***}	0.95^{**}	-0.17^{**}	0.63	0.05^{**}	3.10	-0.003
	(0.05)	(0.72)	(0.01)	(0.48)	(0.08)	(1.45)	(0.03)	(2.44)	(0.00)
CC	0.05^{***}	-1.99^{***}	0.06^{***}	0.52^{**}	-0.03	0.47	-0.09^{**}	9.78	0.001
	(0.01)	(0.60)	(0.02)	(0.25)	(0.02)	(1.13)	(0.04)	(14.99)	(0.00)

Notes: Table reports parameter estimates for the following model:

$Y_t = \phi_1^{(1)} + \phi_2^{(1)} M1_{t-3} + \phi_3^{(1)} PI_{t-4} + \phi_4^{(1)} TO_{t-4} +$
$+(\phi_1^{(2)} + \phi_2^{(2)} M1_{t-3} + \phi_3^{(2)} pi_{t-4})(1+\exp[-\gamma(TO_{t-4}-c)])^{-1} + \epsilon_t.$

The numbers in parentheses represent standard errors.

***, **, * indicates significance at the 1%, 5% and 10% level respectively.

Table 4.6. Logistic Smooth Transition Model (dbb as the Financial Development Measure)

	$\phi_1^{(1)}$	$\phi_2^{(1)}$	$\phi_3^{(1)}$	$\phi_4^{(1)}$	$\phi_1^{(2)}$	$\phi_2^{(2)}$	$\phi_3^{(2)}$	γ	c
dem	0.08^{***}	-1.78^{***}	-0.05^{***}	0.69^{**}	-0.05^{*}	2.32^{**}	0.05^{**}	6.49	-0.008^{*}
	(0.02)	(0.58)	(0.02)	(0.31)	(0.03)	(1.01)	(0.02)	(7.15)	(0.00)
rev	0.08^{***}	-1.68^{***}	0.04^{***}	1.09^{***}	-0.06	2.44^{**}	-0.05^{***}	4.15	-0.005
	(0.02)	(0.63)	(0.01)	(0.46)	(0.05)	(1.23)	(0.02)	(3.69)	(0.00)
str	0.09^{***}	-1.44^{**}	-0.03^{*}	0.91^{*}	-0.07	2.16	0.03	3.32	-0.005
	(0.04)	(0.71)	(0.02)	(0.53)	(0.06)	(1.44)	(0.03)	(3.08)	(0.00)
ls	0.18^{***}	-1.69^{**}	-0.05^{***}	0.90^{**}	-0.18^{**}	2.56^{*}	0.06^{**}	3.14	-0.003
	(0.04)	(0.73)	(0.01)	(0.44)	(0.08)	(1.52)	(0.03)	(2.32)	(0.00)
cc	0.06^{***}	-1.53^{***}	0.06^{***}	0.52^{*}	-0.02	2.14^{**}	-0.08^{**}	6.55	-0.007
	(0.02)	(0.57)	(0.02)	(0.30)	(0.02)	(1.04)	(0.04)	(10.93)	(0.00)
le	0.17^{*}	-2.06	-0.03^{**}	1.22	-0.20	3.25	0.05	1.84	-0.005
	(0.10)	(1.33)	(0.02)	(0.92)	(0.19)	(2.67)	(0.03)	(1.61)	(0.00)

Notes: Table reports parameter estimates for the following model:

$y_t = \phi_1^{(1)} + \phi_2^{(1)} dbb_{t-3} + \phi_3^{(1)} pi_{t-4} + \phi_4^{(1)} to_{t-4} +$
$+(\phi_1^{(2)} + \phi_2^{(2)} dbb_{t-3} + \phi_3^{(2)} pi_{t-4})(1+\exp[-\gamma(to_{t-4}-c)])^{-1} + \epsilon_t.$

The numbers in parentheses represent standard errors.

***, **, * indicates significance at the 1%, 5% and 10% level respectively.

4.6. Conclusions

This Chapter has provided evidence about the time-varying link between financial development, trade openness, political instability and economic growth in Brazil over a very long time window covering the period 1890 to 2003. Employing the smooth transition framework and annual time series data, the study tried first to investigate the aforementioned relationship, second whether or not the intensity and the sign of these effects varied over time as well as the smoothness of this transition (if such a transition took place). The results of our Chapter can be summarised as follows (see also the summary Table 4.7 below).

In particular for all models we detect a positive impact of trade openness on growth. However, among others we detect low positive size effects during 1929 to 1933, namely the Great Depression. The reduction in exports and imports in that period subsequently reduced the level of trade openness. That may be a good reason why low size effects of trade liberalization on growth were observed during that time.

As far as the results for political instability measures are concerned, there is a mainly negative impact of both informal and formal political instability on growth. Nevertheless in the case of REV we detect a

number of occasions when a positive link exists between the latter and output growth. In particular one of them covers the period from 1975-1978 (see the summary Table 4.7 below). The economic achievements of that period, despite the establishment of the military junta that took place shortly before, promoted economic growth that was growing with an average of 11%.

Regarding our principal findings for financial development, unlike the previous literature, which reports a negative short-run relation between financial development and growth, we argue in favor of a mixed time-varying effect (in the short-run) for CBD and DBB but a mainly negative one for M1. As far as the time-varying results are concerned we detect three periods where financial development has a clearly positive effect on economic growth, namely 1968-1974, 1991-1993 and 1997-1999.

Finally, the γ parameter measuring whether or not the change between the two regimes is smooth shows that in the majority of the models the aforementioned transition was not smooth.

Summarizing, the finance-growth nexus in Brazil intrinsically depends on political institutions and on the regime-switching factor, which is trade openness. However, a breakpoint analysis (this could be conducted by employing structural change models), and the implementation of an LST econometric framework that takes into account the estimated breaks are issues we feel future research should try to address.

Table 4.7. Effects of Financial Development, Trade Openness and Political Instability on Economic Growth and Periods Where a Time-Varying Effect was Detected

Variables	Final effect	Periods
Financial Development measures		
CBD	*mixed*	positive effects during: $1968-1974$, $1991-1993$ $1997-1999$
M1	$-$	$-$
DBB	*mixed*	positive effects during: $1968-1974$, $1991-1993$ $1997-1999$
Trade Openness		
TO	$+$	low size effects during: 1893, $1908-1910, 1929-1933$, $1947-1954$ (not $1948, 1950$), $1969-1973, 1974, 1978-1980$, $1982-1989$(not 1988), 1993, $1996-1999$
Informal Political Instability		
DEM	$-$	$-$
REV	*mixed*	positive effects during: $1899-1902$, $1920-1926$(not 1923), $1930-1938$(not $1931, 1933, 1935$), $1948-1958$(not $1951, 1954$), $1975-1978, 1994-1995$
STR	$-$	$-$
COUPS	*mixed*	positive effects during: the same as those of rev
Formal Political Instability		
PUR	$+$	$-$
LS	$-$	$-$
LE	$-$	
CC	*mixed*	positive effects during: the same as those of rev

Notes: Table reports a summary of the results obtained from the parameter estimates of Tables 4.4 4.5 and 4.6.

Appendix 4

APPENDIX 4.A

Table A.4.1. Zivot and Andrews (1992) Unit Root tests with Breaks

	Type of Break		
Variable	With Intercept	With trend	Both
GDP	-10.77^{***} (1981)	-10.37^{***} (1973)	-10.72^{***} (1981)
CBD	-12.94^{***} (1906)	-13.87^{***} (1906)	-14.34^{***} (1919)
M1	-7.79^{***} (1939)	-7.39^{***} (1908)	-7.79^{***} (1939)
DBB	-7.54^{***} (1935)	-7.28^{***} (1908)	-7.77^{***} (1935)
TO	-13.85^{***} (1909)	-13.81^{***} (1916)	-14.09^{***} (1920)
DEM	-9.76^{***} (1984)	-9.58^{***} (1981)	-9.66^{***} (1984)
REV	-5.52^{***} (1922)	-5.14^{***} (1932)	-5.48^{***} (1930)
STR	-9.41^{***} (1978)	-9.15^{***} (1988)	-9.82^{***} (1978)
COUPS	-11.20^{***} (1930)	-10.89^{***} (1938)	-11.27^{***} (1930)
PUR	-5.71^{***} (1967‘)	-5.49^{***} (1964)	-6.47^{***} (1963)
LS	-7.09^{***} (1930)	-6.75^{***} (1933)	-7.58^{***} (1946)
CC	-12.37^{***} (1930)	-11.58^{***} (1958)	-12.31^{***} (1930)
LE	-4.78^{*} (1940)	-3.72 (1971)	-4.80^{*} (1940)

Notes: ***,* indicate significance at 1% and 10% level respectively. Columns 2, 3 and 4 report estimated t-statistics when we allow for breaks in the intercept, in the trend and in both respectively. Numbers in parentheses represent break points. Only the case of *LE* is unit root when we allow for a break in the trend.

Table A.4.2. Lumsdaine Papell Unit Root Tests with two Breaks in the Intercept

Variable	Break in intercept	Breakpoints
GDP	-10.88^{***}	1929, 1974
CBD	-13.27^{***}	1906, 1932
M1	-14.26^{***}	1938, 1975
DBB	-10.47^{***}	1934, 1975
TO	-14.08^{***}	1919, 1974
DEM	-9.91^{***}	1951, 1983
REV	-10.71^{***}	1921, 1937
STR	-9.61^{***}	1933, 1977
COUPS	-11.32^{***}	1929, 1950
PUR	-6.43^{**}	1954, 1972
LS	-9.38^{***}	1929, 1950
CC	-12.78^{***}	1929, 1960
LE	-6.17^{**}	1939, 1981

Notes: ***,** indicate significance at 1% and 5% level respectively. Column 2 reports estimated t-statistics when we allow for two breaks in the intercept. Column 3 reports the estimated breakpoints. In all cases we reject the unit root hypothesis.

Table A.4.3. Linearity Testing, Using Money Supply (M1) as the Transition Variable.

Variable	Linearity LM_2	d-delay parameter
DEM	0.00	4
COUPS	0.03	4
PUR	0.00	4
LS	0.00	4
CC	0.00	4
LE	0.02	4

Notes: Column 2 represents p-values of the linearity rejection. Based on Teräsvirta (1994) all the cases reject linearity.

Table A.4.4. Linearity Testing, Determining the Delay Parameter and Selection Between LSTAR and ESTAR. Results when M1 is the Financial Development Measure and Trade Openness is Used as a Threshold.

Variable	Linearity LM_2	p-value H01	p-value H02	p-value H03	d-delay parameter	TP choice
DEM	0.03	0.16	0.84	0.00	4	LSTAR
COUPS	0.01	0.07	0.23	0.04	4	LSTAR
PUR	0.00	0.58	0.63	0.00	4	LSTAR
LS	0.10	0.26	0.69	0.03	4	LSTAR
CC	0.10	0.18	0.94	0.01	4	LSTAR
LE	0.04	0.47	0.06	0.08	4	ESTAR*

Notes: Column 2 represents the p-value (strength) of the linearity rejection. Based on Teräsvirta (1994) selection process, columns 3 to 5 suggest an LSTAR model except from *le*. However the use of the LSTAR model fits better in our data. Column 6 represents the delay parameter, which in our case is 4, since the power of linearity rejection is stronger relatively to other values of d. The usage of LM_2, H01, H02 and H03 follows Teräsvirta (1994).

Table A.4.5. Linearity Testing, Using Deposits Bank do Brazil (*DBB*) as the Transition Variable.

Variable	Linearity LM_2	d-delay parameter
DEM	0.71	4
REV	0.86	4
STR	0.33	4
LS	0.17	4
CC	0.32	4
LE	0.71	4

Notes: Column 2 represents p-values of the linearity rejection. Based on Teräsvirta (1994) all the cases fail to reject linearity.

Table A.4.6. Linearity Testing, Determining the Delay Parameter and Selection Between LSTAR and ESTAR. Results when DBB is the Financial Development Measure and Trade Openness is Used as a Threshold.

Variable	Linearity LM_2	p-value H01	p-value H02	p-value H03	d-delay parameter	TP choice
DEM	0.01	0.05	0.18	0.03	4	LSTAR
REV	0.02	0.03	0.06	0.27	4	LSTAR
STR	0.00	0.15	0.09	0.02	4	LSTAR
LS	0.02	0.05	0.28	0.05	4	LSTAR
CC	0.08	0.03	0.46	0.19	4	LSTAR
LE	0.00	0.05	0.10	0.00	4	LSTAR

Notes: Column 2 represents the p-value (strength) of the linearity rejection. Based on Teräsvirta (1994) selection process, columns 3 to 5 suggest an LSTAR model Column 6 represents the delay parameter, which in our case is 4, since the power of linearity rejection is stronger relatively to other values of d. The usage of LM_2, H01, H02 and H03 follows Teräsvirta (1994).

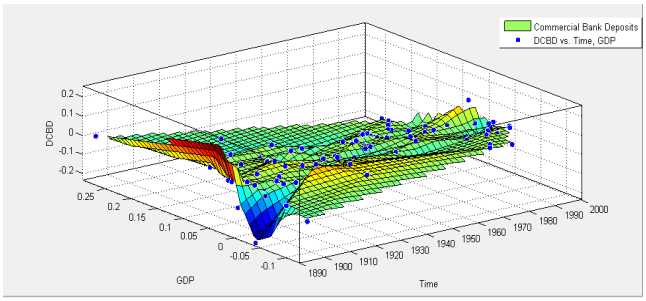
Table A.4.7. Lag Specification

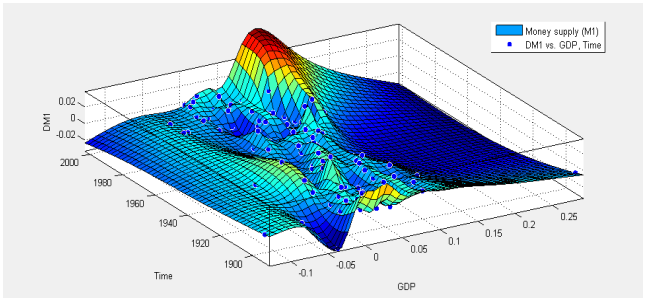
Variables	Information Criteria				
	AIC	SBIC	LBQ	LM	GS
CBD	0	0	1	0	2
DBB	2	0	0	0	2
M1	2	2	2	0	2
TO	5	1	1	1	**4**
DEM	**3**	2	2	2	2
REV	**4**	2	2	1	4
STR	0	0	0	0	0
COUPS	0	0	0	0	7
PUR	2	0	0	0	2
LS	7	1	**4**	1	**3**
CC	**4**	0	0	0	4
LE	8	1	1	1	8

Notes: The Table reports the maximum lag-length on the basis of minimum information criteria*. For the cases of *TO, REV, LS and CC* we choose four lags (numbers in bold). For *CBD*, *DBB*, *M1*, *DEM* and *PUR* the optimal lag-length is two, for *STR* and and *COUPS* zero while for *LE* is eight. However for linearity rejection purposes we use three lags for *CBD, DBB and M1* and four for *DEM, STR, COUPS,* PUR and *LE* respectively.

*AIC stands for Akaike information criterion.
SBIC stands for Schwarz information criterion.
LBQ stands for Ljung-Box test for residual serial correlation.
LM stands for Lagrange multiplier test for residual serial correlation.
GS stands for General-to-Simple reduction test.

Figure A.4.1. 3D Graphs for Financial Development (CBD, M1,DBB) vs GDP % and time





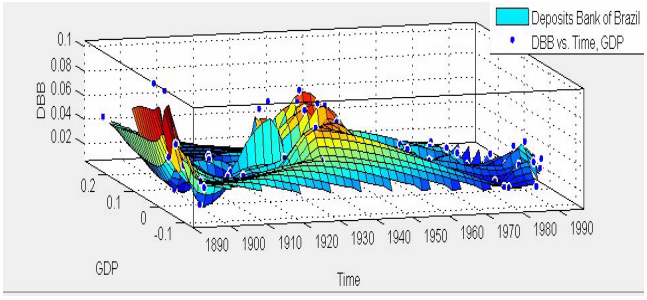


Figure A.4.2. 3D Graphs for Informal Political Instability vs GDP % and time

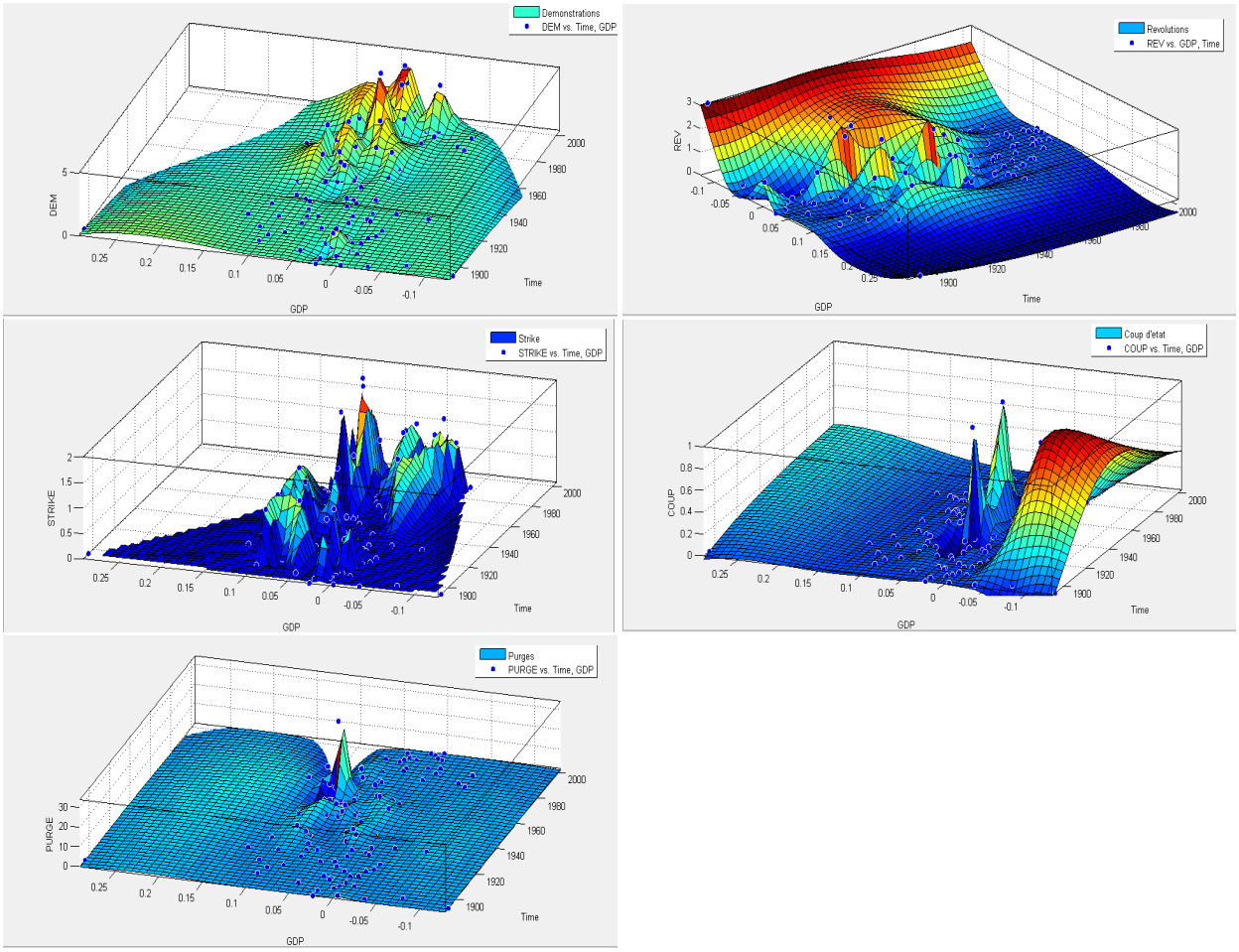
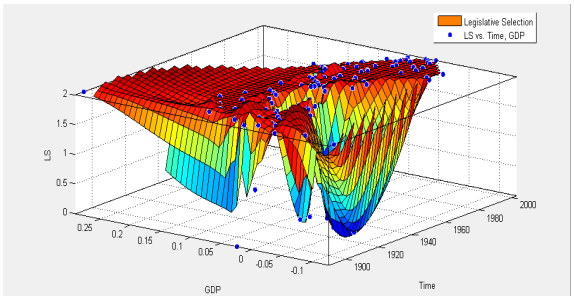
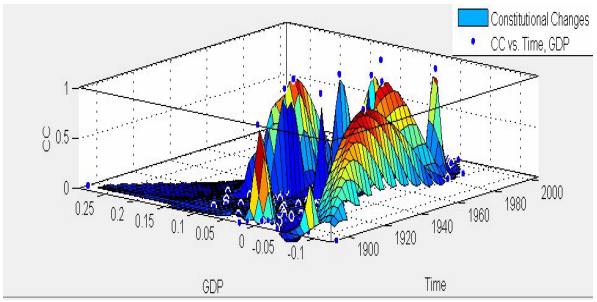


Figure A.4.3. 3D Graphs for Formal Political Instability vs GDP % and time





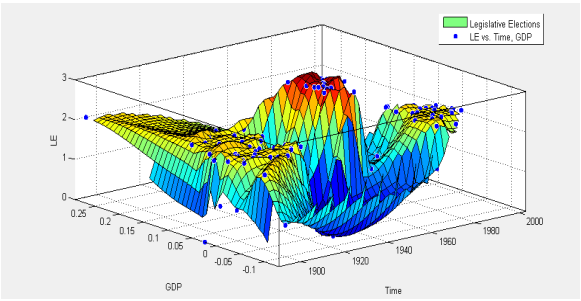
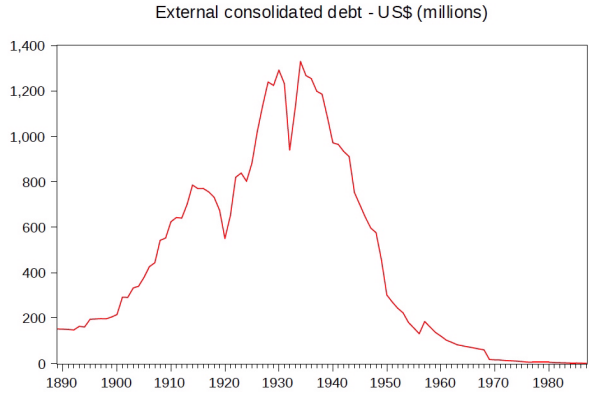
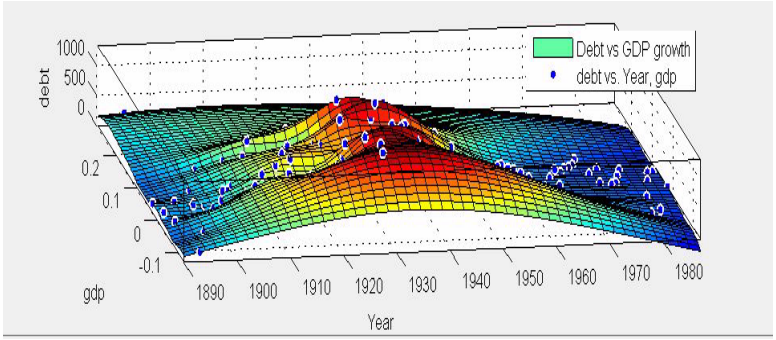


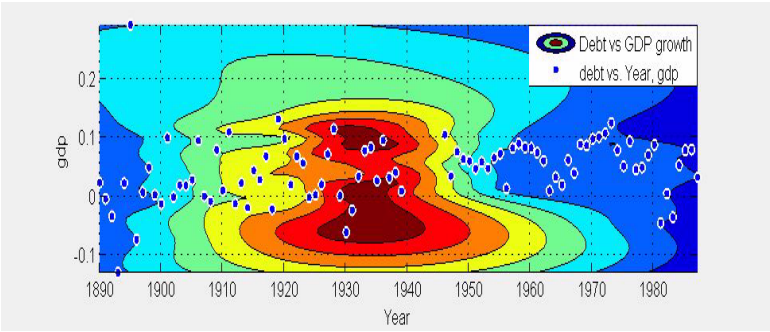
Figure A.4.4. Brazilian External Consolidated Debt in US$ (Millions) from 1889 to 1987.



Source: Ipeadata-http://www.ipeadata.gov.br

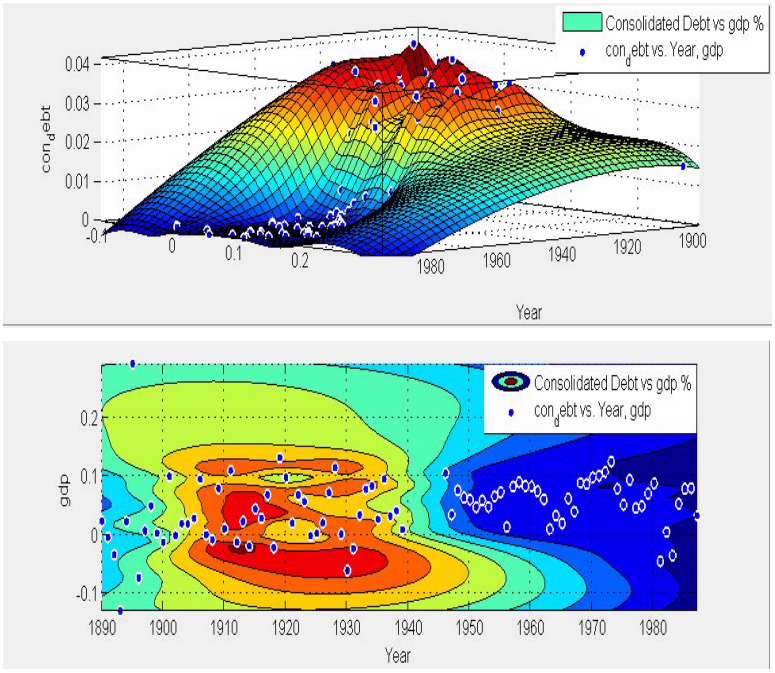
Figure A.4.5. Debt (US$ Millions) vs GDP % and time (3D and 2D graphs)





Notes: Both graphs plot consolidated debt (in US$ millions) and GDP growth across the time. Brown colour represents high amounts of debt while deep blue low amounts of debt. In particular debt after 1905 started rising, in 1934 reached its highest value and from 1935 started displaying a downward trend. It was not before 1950 where Brazilian debt levels will begin to rationalize (blue).

Figure A.4.6. Consolidated Debt as a share of GDP (CD/GDP) vs GDP % and time (3D and 2D graphs)



Notes: Both graphs plot consolidated debt as a share of GDP and GDP growth across the time. Brown colour represents high levels of consolidated debt as a % of GDP while deep blue low level. In particular after 1904 debt started rising, in 1914 reached its highest value while from 1937 it showed a downward trend. It was not before 1946 where Brazilian debt levels will begin to rationalize (blue). For the construction of the Consolidated debt as a share of GDP we used data from the following links:

1) http://www.ipeadata.gov.br/ (for consolidated debt)

2) http://www.ggdc.net/maddison/maddison-project/home.htm (for GDP)

Figure A.4.7. Time-varying Effects of Financial Development (M1) and Trade Openness on Growth Using Various Political Instability Measures. Results Retrieved from the Parameter Estimates of Table 4.5.

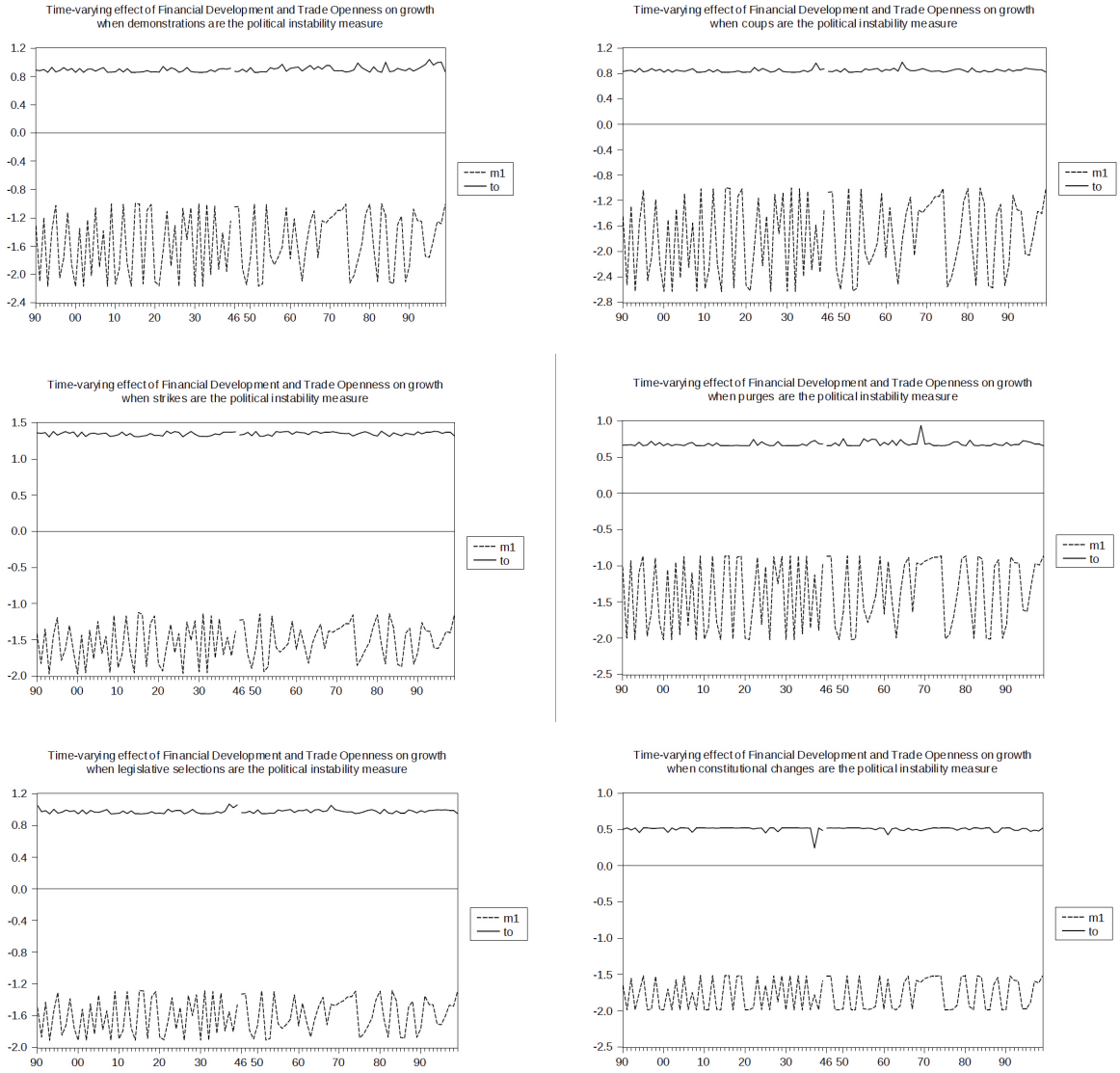


Figure A.4.8. Time-varying Effects of Financial Development (DBB) and Trade Openness on Growth Using Various Political Instability Measures. Results Retrieved from the Parameter Estimates of Table 4.6.

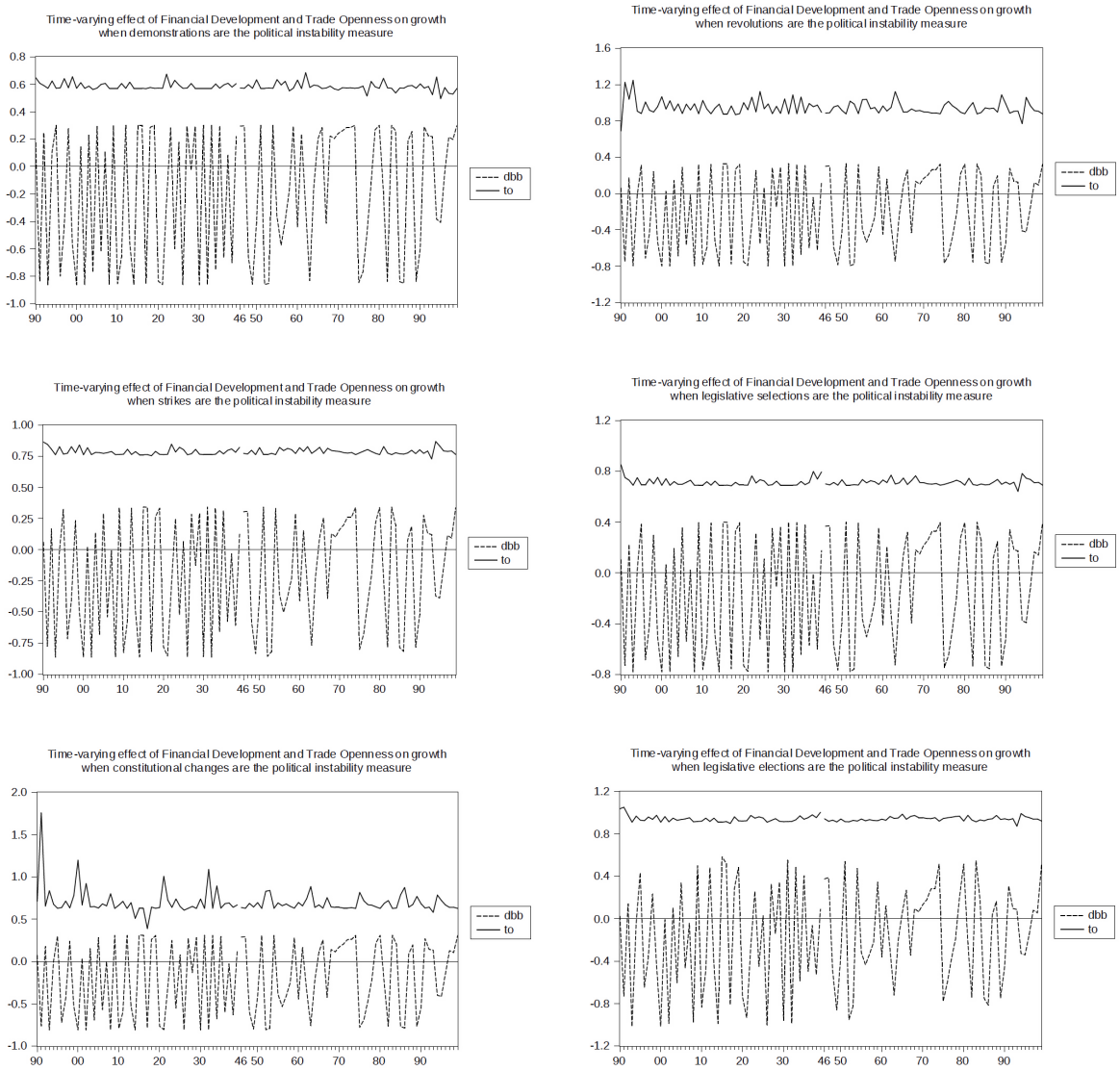


Figure A.4.9. Smooth Transition Function ($G(s_{t-d})$) vs Transition Variable (TO_{t-4}). Results Retrieved from the Parameter Estimates of Table 4.5.

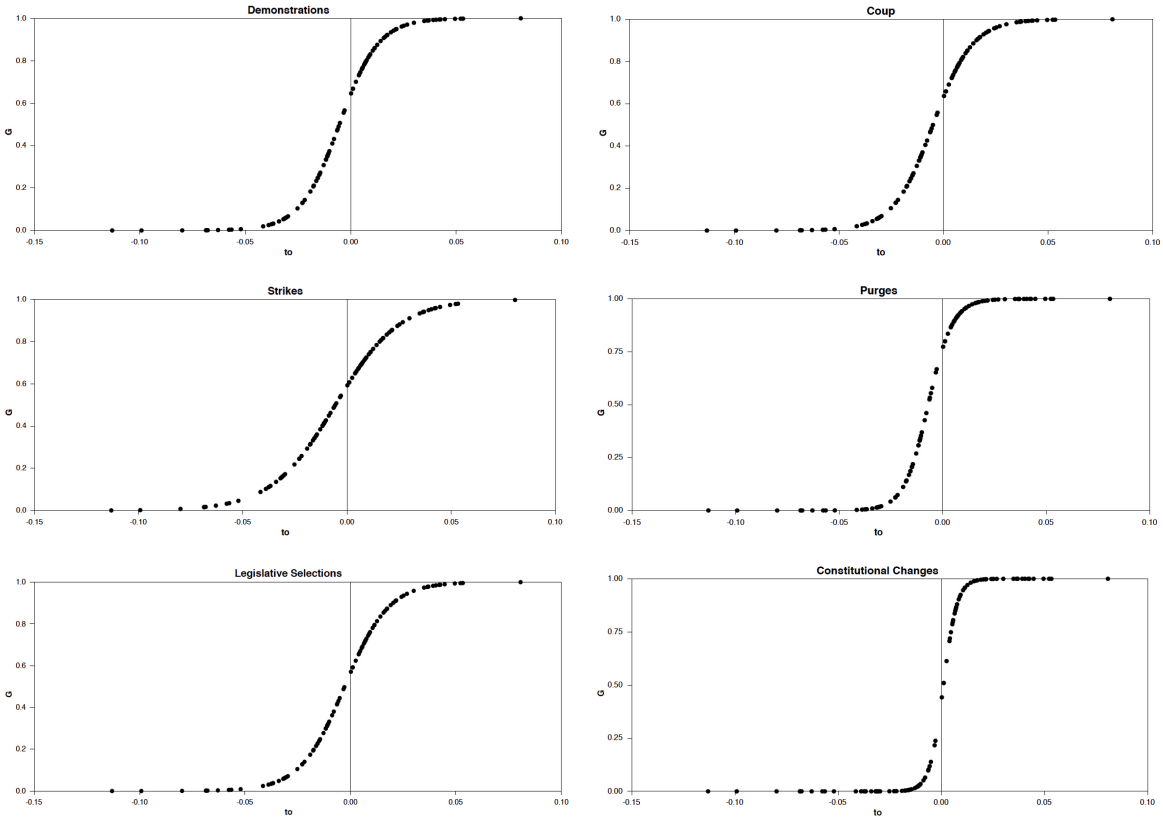
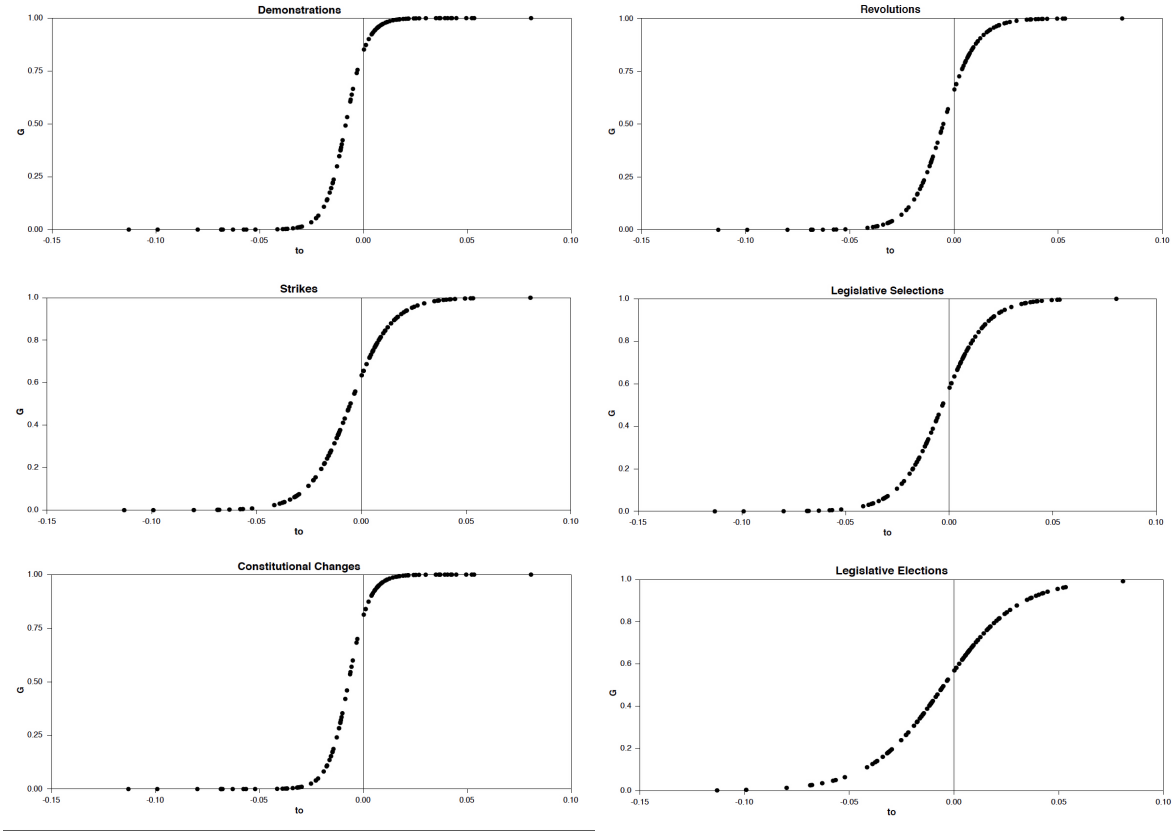


Figure A.4.10. Smooth Transition Function ($G(s_{t-d})$) vs Transition Variable (TO_{t-4}). Results Retrieved from the Parameter Estimates of Table 4.6.



APPENDIX 4.B

Table B.4.1. Timeline of Brazilian History-main political events (1899-1929)

Year	Old Republic (1889-1930) events		
1889	Deodoro da Fonseca 1^{st} president of Brazil	1922	18 of the Copacabana Fort revolt
1891	Deodoro da Fonseca was ousted by a navy revolt	1922	Communist Party founded
1891	Floriano Peixoto 2^{st} president known as the Iron Marshal	1922 1924-27	Tenentes Revolts
1893	Naval Revolt	1922	Arthur da Silva Bernardes 12^{th} president
1893-5	Federalist Riograndense Revolution	1926	Washington Luis Pereira de Sousa 13^{th} president
1894	Prudente Jose de Morais Barros 3^{rd} civilian president	1929	Great Depression
1896-7	Canudos war		
1898	Dr. Manuel Ferraz de Campos Sales 4^{th} president		
1902	Coffee crisis		
1902	Francisco de Paula Rodrigues Alves 5^{th} president		
1904	Vaccine Revolt		
1906	Afonso Augusto Moreira Pena 6^{th} president		
1909	Nilo Procopio Pecanha 7^{th} president		
1910	Hermes Rodrigues da Fonseca 8^{th} president		
1914	World War I		
1914	Venceslau Bras Pereira Gomes 9^{th} president		
1917	Brazil declares war in Central Powers		
1918	Delfim Moreira da Costa Ribeiro 10^{th} president		
1919	Epitacio Lindolfo da Silva Pessoa 11^{th} president		
1921	Crisis of the False Letters		

Table B.4.1. Timeline of Brazilian History-main political events (1930-1964)

Year	Getulio Vargas era (1930-1954) events	Year	Post Vargas era (1954-1964) events
1930	Revolution of 1930	1954	João Fernandes Campos Cafe Filho 18^{th} president
1930	Getulio Dornelles Vargas 14^{th} president, Father of the Poor	1955	Carlos Coimbra da Luz 19^{th} president, shortest president of Brazil
1932	Constitutionalist Revolution or Paulista war	1956	Nereu de Oliveira Ramos 20^{th} president
1934	Constitution of 1934	1956	Juscelino Kubitschek de Oliveira 21^{st} president
1935	Intentona Comunista, Communist Attempt to take power failed	1960	Brasilia new capital
1937-45	Estado Novo, New State established Constitution of 1934 abolished	1961	Janio da Silva Quadros 22^{nd} president
1939	World War II outbreaks	1961	Relations with USSR and Cuba reestablished
1942	Brazil declares war on Axis powers	1961	Parliamentary system established
1944	Brazilian expeditionary forces sent to Italy	1961	Pascoal Ranieri Mazzilli 23^{rd} president
1945	Military coup disposes Vargas	1961	João Belchior Marques Goulart 24^{th} president
1945	Jose Linhares 15^{th} president	1963	Presidential system restored
1946	Eurico Gaspar Dutra 16^{th} president	1964	Brazilian coup d'etat
1946	5^{th} Constitution established	1964	Pascoal Ranieri Mazzilli 25^{th} president
1947	forfeiture of Communist Party Interruption of diplomatic tights with USSR		
1948	Salte Plan		
1951	Getulio Dornelles Vargas 17^{th} president		
1954	Vargas commits suicide		

Table B.4.1. Timeline of Brazilian History-main political events (1964-1995)

Year	Military Republic (1964-1985) events	Year	Redemocratization (1985-2003) events
1964	Humberto de Alencar Castelo Branco 26^{th} president	1985	Military Republic era ends
1964	First Institutional Act legislated	1985	Jose Sarney de Araujo Costa 31^{st} president
1965	Second Institutional Act All political parties are out of the law	1986	Cruzado Plan
1966	Third Institutional Act replaces direct election of governors with indirect ones	1987	Bresser Plan
1967	Artur da Costa e Silva 27^{th} president	1988	Constitution institutionalized the 1^{st} presidential election from the people since 1960
1967	Fourth Institutional Act gives to the army the total control over national security	1988	Presidential system restored
1968	Fifth Institutional Act gives to Silva absolute powers	1989	Summer Plan
1969	Military junta	1989	First Presidential Election since 1960
1969	Emilio Garrastazu Medici 28^{th} president	1990	Fernando Affonso Collor de Mello 32^{nd} president
1973	First oil Shock	1990	Collor Plan implemented
1974	Ernesto Beckmann Geisel 29^{th} president	1992	Itamar Augusto Cautiero Franco 33^{rd} president
1974	Relations with China officially established	1993	Referendum reconfirms presidential republic
1975	Diplomatic links with Angola	1994	Congress reduces presidential term of office to four years
1975	Signing of the nuclear energy accord with West Germany	1994	Real Plan, New currency the Real introduced
1977	Repudiation of alliance between Brazil-US	1995	Fernando Henrique Cardoso 34^{th} president
1978	Second oil Shock		
1979	Decree ends Fifth Institutional Act providing political amnesty		
1979	João Baptista de Oliveira Figueiredo 30^{th} president		
1979	IMF austerity plan		

Chapter 5

Inflation Convergence in the EMU and the Link Between Inflation Differentials and their Uncertainty

5.1. Introduction

Divergences in inflation rates could lead to imbalances in real interest rates, since the policy rate is the same for all the euro area countries.[32] These disparities among the member states' inflation rates could be exacerbated further by circular patterns. For instance, when a country's economic activity is relatively weak then low inflation rates are observed and thus real interest rates increase, which in turn contribute towards inflation divergence. There is an argument which supports the claim that inflation differentials within euro-area countries increased in magnitude since the start of the third Stage of the Economic and Monetary Union (EMU) in 1999. The implication of that (if true) could lead to difficulties not only in the field of the common currency but also in the production of the proper and harmonious macroeconomic policies for the individual countries. Moreover, diversifications among the eurozone countries may occur due to the Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964), which states that dissimilarities exist among the countries' relative productivity of tradable and and non-tradable sectors.

Since 1999 (with the implementation of Stage three of EMU), the elimination of the national stabilizers made euro-area economies vulnerable to economic shocks. Hence among others, relative prices and wage flexibility became extremely important factors in order to sustain the balance among the euro-area countries. Inflation differentials could be a part of this adjustment procedure and not the obstacle to economic policy (ECB, 2003). Thus, it is not surprising that inflation convergence within the eurozone countries has attracted a great deal of attention over the last twenty years, and that quite a few studies have addressed this issue.

In this Chapter we analyze the process of inflation convergence among the EMU countries by considering the stationarity properties of inflation differentials. Contrary to the studies examined so far (with a few notable exceptions, see for example, Busetti et al., 2007 and Lopez and Papell, 2012), we investigate whether the introduction of the euro currency has made any difference in this process. We use twelve EMU countries and taking advantage of the third stage of EMU mentioned before we split the sample into two parts. The first subsample consists of the period before the introduction of the common currency (that is 1980-1997) and the second subsample commences after the birth of the common currency, namely 1998-2013.

We consider whether inflation rates in the EMU countries converge using four testing procedures: Some recently developed panel unit root tests, pairwise unit root/stationarity tests on bilateral inflation differentials, a clustering algorithm to identify stability sub-groups using multivariate stationary tests, and a Bayesian pairwise convergence framework. These procedures allow us to consider whether the inflation convergence process differs for the early accession countries and the late accession ones. Our analysis will attempt to answer three distinct questions regarding the dynamics of national inflation rates in the euro-area. The first two are whether convergence actually occurred by 1997 as required by the Maastricht criteria for joining the EMU, and did the Exchange Rate Mechanism (ERM) support the stability process? And the third, if yes, was inflation convergence among the Member States sustained during the post-euro period?

[32] As pointed out by Busetti et al. (2007) differences in real interest rates are effective on private consumption and might be relevant for investment expenditure depending on the degree of market integration.

We use the four alternative methodologies to address all three issues. Firstly, we employ some recently developed panel unit root tests, among others the ones proposed by Karavias and Tzavalis (2014, 2015). Since due to globalization there is high dependence among economies, we also investigate the stationarity properties using the testing procedure, which takes into account cross-sectional dependence (CSD)-see also Arestis et al., 2014.

Secondly, we utilize univariate unit root and stationarity tests. We test the hypothesis of absolute convergence, that is, whether or not inflation differentials were converging to zero, first by the launch of the common monetary policy (pre-euro period) and, second, whether they tended to drift away from zero in subsequent periods (post-1997 period). As pointed out by Busetti et al. (2007) for detecting absolute convergence, it is appropriate to run unit root and stationarity tests without intercept terms, otherwise their lower power might provide spurious evidence for the no convergence hypothesis in the case of unit root tests and for stability in the case of stationarity tests. We also investigate whether or not the inflation rates of the twelve EMU countries were converging relatively by applying univariate unit root and stationarity tests, which take into account breaks.

A middle way between the panel and univariate unit root/stationarity methodologies could help us reveal the degree of heterogeneity among the European countries. Thus, thirdly, following Busetti et al. (2007) we employ an algorithm developed by Hobjin and Franses (2000) in the context of multivariate stationarity tests, which allows us to identify separate clusters of countries or convergence clubs for the pre-1998 and post-euro periods in terms of either absolute or relative convergence. Fourthly, we also consider an alternative approach for robustness purposes. In particular, we employ the methodology of Arakelian and Moschos (2008) for testing pairwise relative convergence in the presence of transitional dynamics, which is a flexible approach as it allows the parameters (both in the mean and the variance) of the underlying process to change over time.

Finally, in the spirit of Conrad and Karanasos (2015a), we show that in time series models with in-mean effects, and in the presence of structural breaks (either in the mean or in the variance) time-varying persistence will be transmitted from the conditional variance to the conditional mean. Conrad and Karanasos (2015b) demonstrate that in the presence of volatility spillovers, if this transmission mechanism is ignored, unit root tests will fail to indicate a unit root (and hence, in the case of inflation differentials falsely reject the null hypothesis of divergence). Preliminary simulation results in Canepa and Karanasos (2015) indicate that the additional presence of transitional dynamics will increase the severity of the aforementioned problem, in other words it will exacerbate the size distortion of the unit root tests.

The results of the panel unit root tests show that, for both the pre-1998 and post-euro periods, the stationarity hypothesis seems to hold even when CSD is accounted for. This means that some differentials are stationary and therefore there might be clubs of countries which have been in the process of converging absolutely or relatively. The results of the univariate unit root/stationarity tests for both periods show that all inflation rates, that is, not only the inflation rates of the countries that joined the ERM from the beginning but those that joined at a later stage (Spain, Portugal and Greece) as well, displayed strong relative convergence (and for the post-1997 period absolute as well) with each other. However, for the pre-euro period, regarding absolute stability, the stationarity tests provide weak overall evidence and the unit root tests provide moderate evidence for the pairwise contrasts that include one early and one late accession country.[33]

Having obtained mixed evidence in favor of convergence using the univariate testing procedure, next, by employing the clustering algorithm we are able to identify separate stability clubs. For example, as regards absolute convergence, for the pre-euro period we statistically detect three separate 'early accession' sub-groups made up of: i) France and Germany, ii) Finland and The Netherlands, and iii) Austria, Belgium and Luxembourg. For the post-1997 period there is a high degree of absolute stability among the inflation rates of i) Germany, Austria, Belgium and Luxembourg, and ii) France and Finland,

[33] This result might be due to either non stationary behaviour or to different underlying means.

all of which are early accession countries. As regards relative stability the sub-group of Austria, Belgium and Luxembourg is detected in both periods, while for the post-euro period The Netherlands forms a cluster with Germany and Finland. For the rest of the countries/cases we find evidence of divergent behaviour. In general, the evidence produced by the Bayesian framework points in the same direction as the one of the clustering algorithm. Specifically, the decline in the mean is achieved in five out of the six pairs (for both the pre-1998 and post-euro periods) of the Austria, Belgium, Luxemburg sub-group, and for all three pairs (for the post-1997 period) of the Germany, The Netherlands and Finland cluster.

The remainder of the Chapter is organized as follows. Section 5.2 reviews the previous literature on the topic. Sections 5.3 and 5.4 describe the panel econometric methodology and the data, respectively. In the next Section we report the empirical results and discuss them within the concept of whether or not ERM promoted the convergence process between eurozone inflation rates even before 1997 (as claimed by the European Commission, 2014), and of whether or not these inflation rates remained stable after the implementation of the common currency. The last Section summarizes and concludes.

5.2. Literature Review

Quite a few studies have addressed the issue of inflation convergence within the eurozone countries. Some studies, including Engel and Rogers (2004), Busetti et al. (2007), and Rogers (2007) concluded that inflation rates among euro-area countries converged in the mid-1990s. In contrast, some studies, including Engel and Rogers (2004), Rogers (2007) and Fritsche and Kuzin (2011), agreed that in the post-1997 period there is a weakening of inflation convergence among the euro-area countries (see Lopez and Papell, 2012).

De Grauwe (1996a) stressed that convergence of inflation rates between countries participating in the European Monetary System (EMS) occurred even before the Maastricht Treaty of 1992 and that the claims of the treaty for further inflation convergence in the following years were very strict and narrow (a point that would be difficult to be achieved by some countries). In another study, DeGrauwe (1996b) argued that inflation differentials continued to decrease after the signing of the Maastricht Treaty. However, he concluded by suggesting that EMU should focus its efforts on the efficiency of the monetary institutions and not on convergence criteria.

Kočenda et al. (1997) based their research on two pillars. The first one attempted to ascertain if there is any convergence between inflation rates among the European Union (EU) countries and the second if the ERM promoted such a convergence process. To answer these fundamental questions, Kočenda et al. (1997) employed quarterly data for a group of EU and non-EU countries under the panel unit root econometric framework. The empirical results promoted the idea that inflation convergence among the EU countries did indeed exist. Moreover, countries that belonged to the narrow ERM group appeared to have greater convergence properties than those that were not a member.

Busetti et al. (2007), by applying univariate and multivariate unit root and stationarity tests on monthly inflation data for the period 1980-2004, tried to shed light on the inflation convergence issue among the EMU countries. By splitting their sample into two periods, the one before (1980-1997) and the other after (1998-2004) the implementation of the common currency, they attempted to find out firstly, whether or not the inflation rates of the eurozone countries converged by 1997, and secondly if stability among the member countries inflation rates was achieved during the post-euro period (such questions are going to be answered in this Chapter as well). Their empirical evidence suggested that ERM did indeed contribute towards convergence between inflation rates in the pre-1998 period. However, there was some kind of a divergent pattern after 1997. In particular, they distinguished three convergence clubs quantitatively: a low inflation sub-group with Germany, France, Belgium, Austria, Finland; a medium club with Italy, The Netherlands and Luxembourg; and a high inflation sub-group with Spain, Portugal, Greece and Ireland. For the rest of the pairwise contrasts/countries they find evidence of divergent behaviour.

Cavallero (2011) studied the inflation convergence properties for twelve EU countries, covering a period from 1979 to 2006, by applying the distribution dynamics econometric approach. The baseline results reported that convergence took place but with not the same pace over time. Similarly, Estrada et al. (2013) argued in favor of inflation convergence among eurozone countries covering a period from 1985 to 2012. However, their results question the contribution of the EMU in that direction (of convergence) and the boost that it offered.

Lopez and Papell (2012) proposed a new procedure that increases the power of panel unit root tests when used to study group-wise convergence. For the EU11 and EU10 group of countries (which include the twelve countries under investigation in the present Chapter-see the next Section- excluding Greece and Ireland respectively) they found the strongest degree of inflation convergence for the entire period studied (1979-2010). However, their results for the EU12 group showed a weaker degree of inflation convergence, even weaker after the financial crisis of 2007-2008.

Lastly, Arestis et al. (2014) examined whether or not countries with different monetary policies (i.e. inflation and non-inflation-targeting) experienced inflation convergence. Using quarterly data from 1990 to 2011 for eleven inflation and eleven non-inflation targeting countries (the majority of the latter were EMU member states) and employing the unit root techniques developed by Pesaran (2007a) (such techniques are going to be implemented in this Chapter as well) they showed that convergence in inflation rates occurred in both groups regardless of their monetary policy orientation.

5.3. Panel Testing

To test whether inflation convergence has taken place between two countries we need to test whether the series of inflation differentials are stationary or not. Denote x_{it} the inflation of country i at time j. Then inflation convergence has occurred when the series

$$y_t^{i,j} = x_{it} - x_{jt}, \qquad i, j = 1, ..., n, \ i \neq j$$

is stationary. To test for convergence in all the inflation differentials, [the total number is defined to be $N = n(n-1)/2$], we need to test whether all are stationary. This can be done by either panel unit root tests or by panel stationarity tests. For the $y_t^{i,j}$ series we assume the typical structure of an AR(1) model:

$$\Delta y_t^{i,j} = a + (\phi - 1) y_{t-1}^{i,j} + \varepsilon_t^{i,j}.$$

where a is a parameter denoting the mean of $y_t^{i,j}$, ϕ captures the rate of convergence, with divergence occurring when $\phi = 1$, and $\varepsilon_t^{i,j}$ is the innovation process. There are two types of convergence that may have occurred; absolute convergence which implies that $\phi < 1$ and $a = 0$ or, in other words, that the stationary difference of the two inflation rates is on average 0. The other one is relative convergence, which implies that $\phi < 1$ and $a \neq 0$. This more realistic mode occurs when the difference between the two inflation rates is stationary but on average not zero. This can happen because of increasing costs of convergence or because of barriers to absolute convergence due to country heterogeneity.

In this Chapter we focus on inflation convergence among the twelve (that is, $n = 12$ and $N = 66$) countries of the EMU. The first hypothesis of interest is whether there has been absolute convergence in all the countries or not. Denote $y_{d,t}$ the differential d at time t where $d = 1, ..., N$, then all series together can be written in panel data form as

$$\Delta y_{d,t} = a_d + (\phi_d - 1) y_{d,t-1} + \varepsilon_{d,t}, \qquad d = 1, ..., N$$

where a_d are the individual intercepts. Absolute convergence occurs when $\phi_d < 1$ and $a_d = 0$ for all differentials and relative convergence when $\phi_d < 1$ for all differentials and $a_d \neq 0$ for some of them. To test these hypotheses we employ a battery of panel unit root and stationarity tests.

Particular emphasis will be placed on the panel unit root test of Karavias and Tzavalis (2015). To test whether the differentials are integrated of order one or stationary, we need to take into account some data characteristics. First, structural changes might have occurred which have changed the means or linear trends of the series (but not their order of integration). Some suspicious events that may have resulted in these types of breaks include the German reunification in 1989 and the European Union Treaty in 1993. Second, shocks to inflation may last more than one quarter, meaning that the errors are serially correlated, something typical in time series data. Finally, there might be systematic factors between the differences in inflation, such as shock contagion between neighbouring countries where a neighborhood may be described either by a geographical or an economic measure of distance. To address these issues we employ the very general panel unit root test of Karavias and Tzavalis (2015), which allows for multiple structural breaks, serial correlation and CSD. The test has some further very attractive robustness properties that suit our analysis: a) the dates of the breaks can be unknown, b) the CSD structure need not be decided by the researcher and c) the time dimension is not assumed infinite, which improves the small sample properties of the test.

Specifically, the model considered is

$$\begin{aligned} y &= \sum_{j=1}^{S_b+1} e_T^{(j)} \otimes a^{(j)} + \zeta, \text{ and} \\ \zeta &= \varphi \zeta_{-1} + u, \end{aligned}$$

where S_b is the number of breaks in the individual effects a_d, and y, ζ, and u are $NT \times 1$ vectors of the data and the error terms $\zeta_{d,t}$ and $u_{d,t}$. $a^{(j)}$ is the $N \times 1$ vector of broken individual effects, $a_d^{(j)}$, i.e. for $S_b = 1$, $a^{(1)}$ are the individual effects before the break and $a^{(2)}$ are the individual effects after the break. The break is common to all units but its magnitude may be different. $e_T^{(j)}$ is a $T \times 1$ vector whose elements are defined as follows: $e_{Tt}^{(j)} = 1$ if $\lambda_{j-1} < t \leq \lambda_j$ and 0 otherwise, where λ_j is the date of a break and $\lambda_0 = 1$ while $\lambda_{S_b+1} = T$. With λ we will denote dependence on the date of the break. The within groups estimator which is employed is given by $\hat{\varphi}^{(\lambda)} = (y'_{-1}Q^{(\lambda)}y_{-1})^{-1}(y'_{-1}Q^{(\lambda)}y)$ where $Q^{(\lambda)}$ is the within groups transformation matrix which purges the broken individual effects. Unfortunately, this estimator is shown to be inconsistent, i.e.:

$$p\lim_N \left(\hat{\varphi}^{(\lambda)} - 1 - \frac{b^{(\lambda)}}{d^{(\lambda)}} \right) = 0,$$

where $b^{(\lambda)}/d^{(\lambda)}$ is the bias of the estimator, which is a function of the number and position of breaks, the form of serial correlation and the type of spatial dependence. Karavias and Tzavalis suggest estimating this inconsistency and subtracting it from $\hat{\varphi}^{(\lambda)}$. This can be done in a simple linear way utilizing a non-parametric error component variance estimator, which is able to reproduce the time and spatial characteristics of the error terms. The corresponding $Z^{(\lambda)}$ statistic is based on a doubly modified estimator (DME) given by

$$Z^{(\lambda)} \equiv V^{(\lambda)-1/2} \hat{d}^{(\lambda)} \left(\hat{\varphi}_{DME}^{(\lambda)} - 1 \right) \xrightarrow{d} N(0,1)$$

for the case of known break dates and by

$$\min_{\lambda_1,\ldots,\lambda_{S_b}} Z^{(\lambda_1,\ldots,\lambda_{S_b})} \xrightarrow{d} \psi \equiv \min_{\lambda_1,\ldots,\lambda_{S_b}} N(0,\Sigma)$$

for the case of unknown dates. $\hat{d}^{(\lambda)} = (1/N)\left(y_{-1}Q^{(\lambda)}y_{-1}\right)$ and $V^{(\lambda)}$ is the variance of $\hat{d}^{(\lambda)}\hat{\varphi}_{DME}^{(\lambda)}$. The limiting distribution of $\min_{\lambda_1,\ldots,\lambda_{S_b}} Z^{(\lambda_1,\ldots,\lambda_{S_b})}$ can be described as the minimum of a fixed number of correlated normal variables with correlation matrix Σ. Because this matrix cannot always be consistently estimated the Chapter proposes the application of the bootstrap.

5.4. Data

In this Chapter we study the level of convergence of inflation rates among the countries of the EMU covering a period from 1980 to 2013. The main data source is Datastream. The data we employ consist of quarterly and monthly log-differences of the Consumer Price Index (CPI), $log(CPI_t/CPI_{t-1})$, for each individual country.[34] Busetti et al. (2007) distinguish the group of countries into two categories, low inflation countries (i.e., Germany, France, and Austria) and high inflation ones (i.e., Spain, Portugal, and Greece). Further, we divide the countries into two alternative categories, that is the early accession countries (i.e., Germany, France, The Netherlands, and Italy) and the late accession ones: Spain, Portugal and Greece (see Tables 5.1 and 5.2 below).

Table 5.1. Adoption of ERM

Year of adoption	Countries
1979 (Early Accession)	Belgium, France, Germany, Ireland, Italy, Luxembourg and The Netherlands
1995, 1996	Austria and Finland, respectively*
1989, 1992, 1998 (Late Accession)	Greece, Portugal and Spain respectively

Notes: * Austria and Finland are included in the early accession category, see Busetti et al. (2007) for more information and Table 2 below.

Table 5.2. Classification of European Countries

Category 1-ERM Early accession	Austria, Belgium, Finland France, Germany, Ireland Italy, Luxembourg, The Netherlands
Category 2-ERM Late accession	Greece, Spain, Portugal

Under the Maastricht Treaty of 1992 among others the EU began the journey towards economic and monetary union. In particular, this policy consisted of three stages. The first stage liberalised the movement of capital (starting date January 1, 1990), the second stage (January 1, 1994) provided the principles for convergence between the Member States' economic policies and the final one pre-established a deadline (January 1, 1999) by which the creation of a single currency and the foundation of an ECB should be initiated. Taking advantage of the third stage mentioned before we split the sample into two parts. The first sub-sample consists of the period before the birth of the common currency, that is 1980Q1-1997Q4 and the second sub-sample commences after the launch of the euro currency, namely 1998Q1-2013Q4 (see Figures 5.1 and 5.2 below).

Before analysing our results we would expect that the inflation convergence between the countries that adopted the ERM from the beginning would be stronger. From the graphs in Figure 5.1 we can notice that the differential between countries' inflation rates and their average diminishes through time as we approach the introduction of the common currency. The latter holds especially for the countries that belong to the core of the ERM (countries that adopted it from the beginning), i.e., Germany, France, Italy (see Table 5.1 above). In addition, the case of Austria and Finland follows the same pattern. In particular, the gap between inflation rate and the euro-area average is becoming shorter and shorter especially after their accession to the ERM (Austria, 1995 Finland, 1996). As far as Spain and Portugal is concerned it is clear from the graphs that the rates of inflation were starting to de-escalate after 1989 and 1992 (dates of incorporation in the ERM). Only in the case of Greece does the differential between its inflation rate and the average not seem to decline dramatically. However, in total we could say that the implementation of the ERM led European inflation rates to lower levels and possibly (at least for

[34] The results from the monthly data set are not reported since they are very similar to those from the quarterly data.

some sub-groups of countries) to convergence, see Figure 5.1. Finally, a point worth mentioning is that the countries in category 1 report inflation rates that are below the euro-area average (the descriptive statistics are presented in Tables B.5.1 and B.5.2 in the additional Appendix).

Figure 5.1. Quarter on Quarter Inflation Rates for European Countries and their Average, 1980Q1-1997Q4

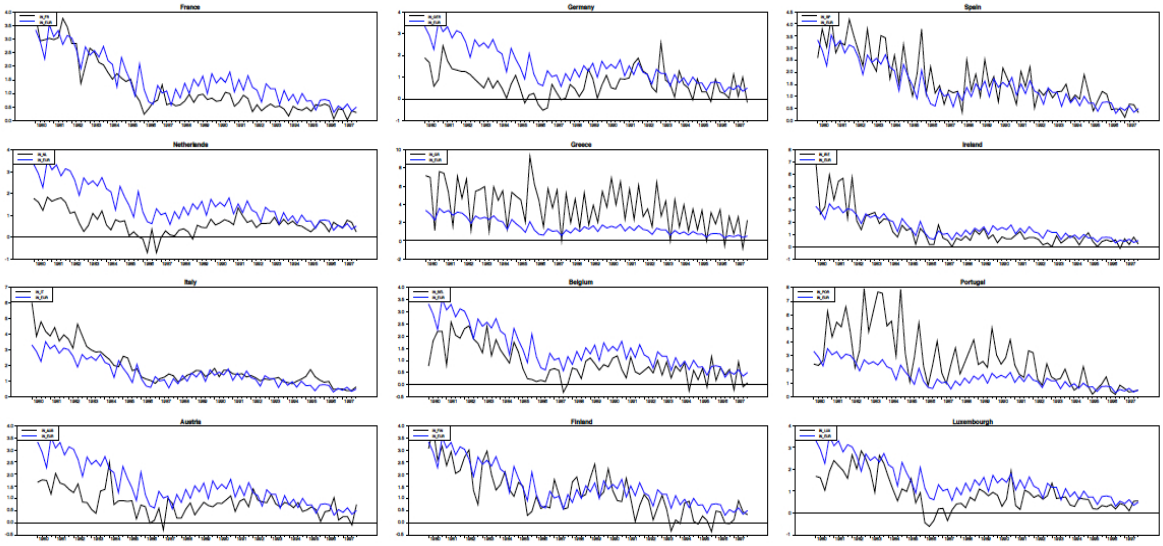
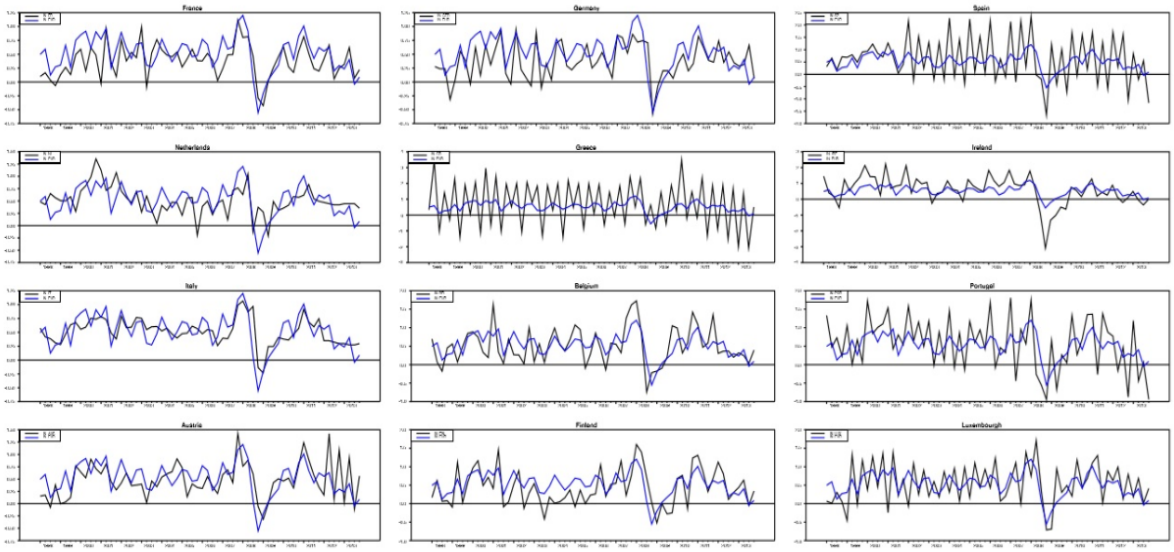


Figure 5.2. Quarter on Quarter Inflation Rates for European Countries and their Average, 1998Q1-2013Q4



We will consider the stationarity properties of inflation differentials between countries and interpret the presence of stationarity as evidence of convergence. A similar strategy was followed by Busetti et al. (2007) and Arestis et al. (2014). We would like to address three different questions regarding the inflation convergence behaviour of the euro-area countries. The first two are, did the convergence occur by 1997 as required by the Maastricht criteria for joining the EMU? and if yes, did the ERM (see Table

5.1 above for more details) support the convergence process? The third one is did the Member States sustain convergence during the post-euro era?

5.5. Empirical Results

5.5.1. Panel Tests

In this Section, we wish to test for joint stationarity of all inflation differentials. The reason for this is that it might be the case that a single or multiple time series may not be powerful enough to reject the null hypothesis (see Sections 5.5.2-5.5.4 below). We conduct both panel unit root and stationarity tests. For the unit root tests, the null hypothesis of divergence is $H_0 : \rho = 1$, i.e, all differentials are unit root processes against either $H_{1a} : \rho_i = \rho < 1$ for all i or $H_{1b} : \rho_i < 1$ for all i, depending on the type of the test used. Here we employ a variety of tests whose properties are summarized in the following table. The tests below are the panel unit root tests of: Im et al. (2003), or IPS, Levin et al (2002), or LLC, Harris and Tzavalis (1999), or HT, Breitung and Das (2005), or BD, Pesaran (2004, 2007b), or CADF, Karavias and Tzavalis (2014, 2015), or KT14 and KT15 respectively.

Table 5.3. Panel Unit Root/Stationarity Tests

Test	Alternative	Asymptotics	CSD	Breaks
IPS	H_{1b}	$T, N \to \infty$, seq.	No	No
LLC	H_{1a}	$N/T \to 0$	No	No
HT	H_{1a}	T $fixed$	No	No
BD	H_{1a}	$T, N \to \infty$, seq.	Yes	No
CADF	H_{1b}	$T, N \to \infty$, joint	Yes	No
KT14	H_{1a}	T fixed	No	Yes
KT15	H_{1a}	T fixed	Yes	Yes

Notes: T and N denote the sample size and the number of countries respectively. CSD means cross sectional dependence.

First, we test for the null hypothesis of a unit root using the panel unit root tests with no constant. The results are reported in Panels A of Tables 5.4 and 5.5. For this case we can see that all tests reject the null hypothesis at 1% level. This means that some differentials are stationary and therefore there might be clubs of countries which have been in the process of converging absolutely. This result holds firmly for both the pre-1998 and post-euro periods.

When testing for the null hypothesis of unit root/stationarity using panel unit root/stationarity (i.e., the KPSS) tests with constant but with no breaks the results (not reported) are mixed. One reason for why this is the case could be structural breaks in the intercepts of the series. This means that there is stationarity but the level of this stable relationship changed at one or more points in time. However, when we apply the KT14 and KT15 tests for various break specifications we find evidence of stationarity for both pre-euro and post-1997 periods (see Panels B in Tables 5.4 and 5.5 respectively). We favor the results of the KT15 test, which are more general and, for the pre-1998 period, we find that there might be one or two breaks late in the sample. For the post-euro period we detect one or two breaks sometime in the middle of the sample.

Table 5.4. Panel Unit Root tests.Pre-Euro Period

	Statistic	Significance Level	Breakpoint 1	Breakpoint 2
Panel A	**Panel Unit Root Tests (No Constant)**			
BD	−12.55	1%		
BD CSD	−2.74	1%		
LLC	−13.07	1%		
HT	−18.68	1%		
CADF	−3.56	1%		
Panel B	**Panel Unit Root Tests with Breaks**			
KT14(1)	−151.63	1%	1997:01	
KT15(1) CSD	−110.79	1%	1994:02	
KT15(2) CSD	−113.76	5%	1994:03	1995:03

Table 5.5. Panel Unit Root Tests-Post Euro Period

	Statistic	Significance Level	Breakpoint 1	Breakpoint 2
Panel A	**Panel Unit Root Tests (No Constant)**			
BD	−16.35	1%		
LLC	−17.31	1%		
HT	−54.19	1%		
CADF	−4.31	1%		
Panel B	**Panel Unit Root Tests with Breaks**			
KT14(1)	−241.48	1%	2013:01	
KT15(1) CSD	−47.08	1%	2005:02	
KT15(2) CSD	−56.35	1%	2005:02	2008:01

Since due to globalization there is high dependence among economies, we also investigate the stationarity properties using the testing procedure, which takes into account CSD (see also Arestis et al., 2014). As shown in Tables 5.4 and 5.5, for both periods and all tests under investigation [BD CSD, CADF, KT15 (1) or (2) CSD] the results suggest that the stationarity hypothesis seems to hold when CSD is accounted for. In other words, the application of cross-sectional panel unit root testing procedures leads to the same conclusions as before. The null hypothesis of a unit root is rejected both in the pre-euro and the post-1997 periods.

5.5.2. Univariate Tests

5.5.2.1. Pre-Euro Period

Although the whole panel of the series has the advantage of increased power, as a robustness check we look into the time series properties of each differential by performing the pairwise testing approach. That is, we use univariate unit root and stationarity tests in order to investigate the behaviour of European countries' inflation rates before the birth of the euro currency, 1980Q1-1997Q4. In particular, we will apply unit root tests, namely, Augmented Dickey Fuller (ADF), Zivot-Andrews (ZA), and Lumsdaine-Papell (LP) tests, and stationarity tests, namely KPSS tests.

ADF TESTS WITH NO INTERCEPT

Regarding the principal findings from the pairwise contrasts, for the pre-euro period we report our results in Table 5.6 (and in more detail in Table A.5.3 in the additional Appendix). [35] The pairwise constrasts include the 9 countries in category 1: Germany (GE), France (FR), Italy (IT), The Netherlands (NE), Austria (AU), Belgium (BE), Finland (FI), Luxembourg (LU), and Ireland (IR), and the three countries in category 2: Spain (SP), Portugal (PT) and Greece (GR), see Table 2 above. Similarly to Busetti et al. (2007) we order the countries based on their GDP weights in the euro-area. To analyse the empirical results, inflation differentials are divided in three different groups. The first two consist of pairwise contrasts including countries only from either category 1 or from category 2 (36 and 3 pairs respectively). The third group incorporates inflation differentials between one country from category 1 and one from the second category (27 pairs). Thus in total we have 66 pairs.

By testing the time series properties of differentials in each group, we are able to examine whether there is inflation convergence within each of the three groups. In other words, apart from convergence within each category (that is, $N = 36$ for group 1 and $N = 3$ for group 2), it is of interest to explore any pattern of convergence considering both early and late accession countries as a single group, i.e. when the countries are grouped together irrespective of when they adopt the ERM (that is, $N = 27$ for group 3).

For group 1 the null hypothesis (H_0: No absolute convergence) is rejected in 35 out of 36 cases, and in all three cases for the narrower group 2. In other words, as far as the early accession countries are concerned, under the null of unit root the percentage of rejection is 97% whereas for the late accession ones it is 100%. These results provide clear evidence of inflation rates (absolute) convergence among either the early or late accession countries. For the inflation differentials of group 3, the findings are much weaker concerning the support of the absolute convergence hypothesis. The percentage of rejections reaches only 37% as only 10 out of 27 pairwise differentials are found to be stationary.

Our findings show that in the majority of the cases absolute convergence actually occurred by 1997 and that the ERM accelerated the convergence process between the countries that joined the mechanism from the beginning despite the fact that countries that became part of the ERM at a later point suffered from inflation rates which were higher than the average (see also Figure 5.1 for graphical representation above and Table B.5.1 in the additional Appendix). These results are in line with those in Busetti et al. (2007).

Table 5.6. Unit Root and Stationarity Tests.Pre-Euro Period

	Rejection Rates		
	Group 1	Group 2	Group 3
Panel A-Unit Root tests			
ADF	97%	100%	37%
Zivot-Andrews	97%	100%	100%
Lumsdaine-Papell	86%	100%	93%
Panel B-KPSS tests			
KPSS-no intercept	78%	100%	81%
KPSS-1 break	0%	0%	0%
KPSS-2 breaks	8%	0%	15%

Notes: Each entry in Panels A and B shows the percentage rate of rejection of the null hypothesis at either 1% (in the case of the KPSS tests) or 5% or 10% level of statistical significance.

[35] The ADF tests with no intercept are displayed in the first three columns of Table A.5.3 and are jointly labeled ADF no intercept. The first column reports the inflation differentials, the second the ADF statistic and the third one the power of the rejection of the null hypothesis (using three alternative significance levels: either 1% or 5% or 10%). Rejection of the null indicates that the two inflation rates are in the process of converging.

Given the fact that we consider all possible differentials, a potential problem that may be raised is that of CSD (see Arestis et al., 2014). Such issues, however, can be circumvented by performing the CDS test proposed by Pesaran (2007a). Therefore, for robustness test purposes we also use a pairwise testing procedure developed by Pesaran, which takes into account all pairwise differential combinations and the existence of CSD- the so called cross sectional ADF tests or CADF, see also Arestis et al., 2014. The results (not reported) are very similar to those of the ADF tests.

ZA TESTS WITH ONE BREAK

Table 5.6 also reports the baseline results when we use the ZA unit root tests, which allow for one break in the intercept (for more details see the three columns jointly labeled 'ZIVOT-ANDREWS' in Table A.5.3 in the additional Appendix). The results for the first two groups are very similar to those from the ADF unit root tests. Specifically, for the first group in 35 out of 36 cases or 97% of the pairwise contrasts, and in all 3 cases for group 2, we face rejection of the null hypothesis at a very high statistical significance level (in the majority of the cases at 1%).

The breakpoint date for group 1, in 10 out of 36 cases, is either the second or the third quarter of 1983 (see the last column of the three ones jointly labeled 'ZIVOT-ANDREWS' in Table A.5.3 in the additional Appendix). During that year unemployment rates continued to rise, reaching 18.5 million or nearly 11% of the labor force a number more than triple the rate in 1973. European inflation rates started to slow down and this was because of the rise in the commodity prices, with the exemption of oil, which fell by 15% in dollar terms from its 1982 level. However, despite the deceleration in inflation rates there appears to have been disparity among the EU members. Countries belonging to the north had inflation rates lower than the European average while the Mediterranean south experienced higher inflation rates than average. Finally, an appreciation of the US dollar was another reason responsible for the slumberous recovery of the European economy (see Ostry, 1983).

The results for group 3 are also in favor of relative convergence in all 27 cases and at a high statistical significance level (1% in most of the cases). The estimated breakpoint for group 3, in 13 out of 27 pairwise contrasts (and for the three cases of group 2), is either the first or third or fourth quarter of 1985. During that year events of great importance took place, such as the signing of the Schengen Agreement, the agreement between the Member States of European Communities concerning Spain and Portugal's accession into the European Community and finally the adoption by the latter of the European symbols such as the European Flag.[36]

In sum, within all three groups inflation seems to converge relatively.

LP TESTS WITH TWO BREAKS

The third row of Panel A in Table 5.6 reports, for the first period of examination: 1980Q1-1997Q4, the results for the LP unit root tests, which allow for two breaks in the intercept instead of one as is the case of the ZA unit root tests (for more details see Columns 7-9 in Table A.5.3 in the additional Appendix). In order to interpret the results we use the same classification as before, namely groups 1 and 2 consist of inflation differentials between countries that belong in the first category and between those of category 2, respectively (i.e. GE-FR and SP-GR, respectively) and the third group incorporates pairwise contrasts with one country from the first category and one from category 2, i.e. GE-SP. For all three groups, with the exception of eight pairwise contrasts that include Ireland, the null hypothesis of no relative convergence is rejected.

As far as the breakpoint estimation is concerned results from the LP tests (similarly to the ones from the ZA tests) report that for the early accession countries the breaks occur more frequently (in 16 out of 36 cases, see Table A.5.3 in the additional Appendix) during 1983, and in 22 out of 36 cases during 1993-1994. Following the ratification of the Treaty on European Union by several Member States' parliaments

[36]Information regarding the history of the EU was obtained from the following link: http://europa.eu/about-eu/eu-history/index_en.htm.

in 1992, on the 29st of October 1993 the European Council agreed that the second stage of EMU would come into force by January the 1st 1994. Three days later, on the 1st of November 1993 the Treaty on European Union was launched and at the end of the same year representatives of the states attending the Uruguay's Round negotiations signed an agreement, namely the General Agreement on Tarifs and Trades (GATT) in Switzerland marking a new Chapter in the history of international trade. The new year (1994) brought Greece at the helm of EU. Stage II of EMU commenced and the European Monetary Institute (EMI) is established. The agreement establishing the European Economic Area (EEA) came into act as well.

For the late accession countries the two more frequent structural breaks occur in 1985 and 1990 in 9 and 10 out of 30 cases, respectively. During 1985 legislative elections were held in Greece, strengthening measures (towards the EMS) were undertaken by the Committee of Governors of the Central Banks, and Spain and Portugal signed the accession treaties with EU.

After the fall of the Berlin Wall in 1989, a European Council was held in Dublin in Ireland on the 28^{th} of April 1990. The Council decided on a joint deal with the issue of the German reunification and on the Community's relationships with the countries of the Former Eastern Bloc. A month later the agreement establishing the European Bank for Reconstruction and Development (EBRD) was signed in Paris of France. The main purpose of this agreement was to provide financial assistance to Central and Eastern European countries. Two weeks later, on the 19^{th} of June 1990, the Schengen Treaty, which eliminated border controls among its Member States was signed by Belgium, The Netherlands, Luxembourg, France and Germany. Finally, the first phase of the EMU commenced. Four Member States (namely Spain, Portugal, Greece and Ireland) were given a special regime status.

To sum up, using three different unit root tests (namely, ADF, ZA and LP) we tried to capture the European inflation rates behaviour before the adoption of the euro currency, covering a period from 1980Q1 to 1997Q4. The results showed that the ERM accelerated the (absolute or relative) convergence process, especially between the countries that joined the mechanism from the beginning, that is 1979. However, there is moderate evidence of absolute convergence for the third group, which incorporates inflation differentials between one country from category 1 and one country from the second category. For the late accession countries deviations from the ERM policies led to higher inflation rates, which were above the average (see Table B.5.2 in the additional Appendix).

KPSS TESTS

The results of the stationarity tests with either no intercept or with intercept (and with either one or two breaks) on the pairwise contrasts are displayed in Panel B in Table 5.6 (for more details see Table A.5.4 in the additional Appendix). As regards the KPSS tests with no intercept for group 1 the null hypothesis of absolute stability is rejected at 1% significance level in 28 cases out of 36, and in all three cases for group 2 (alternatively 78% and 100% of the cases respectively). Similarly for group 3 the null hypothesis is rejected at 1% significance level in 22 out of 27 cases or 81% of the inflation differentials. Thus in contrast with the ADF tests there is very weak evidence of absolute stability (in only 8 pairs of group 1 and 5 pairs of group 3). [37]

As regards the KPSS tests with one break for all the three groups, the null hypothesis of relative stability is not rejected in all cases (66) of the inflation differentials. Table 5.6 also reports the results for the KPSS test, which allows for two breaks in the intercept instead of one (for more details see columns 7-9 in Table A.5.4 in the additional Appendix). For group 1 the null hypothesis is rejected (at 1% significance level) in only 3 out of 36 cases or 8% of the inflation differentials. For groups 2 and 3, the rejection levels were 0% and 15% (in 4 out of 27 cases) accordingly. In sum, there is strong evidence for relative stability in the pre-euro period.

To conclude, using three different KPSS tests we tried to explore whether the inflation differentials were stable or not from 1980 to 1997. The results (from the KPSS test with no intercept) indicate weak

[37] This might be because the European inflation rates were in the process of converging but they were not yet stable.

absolute stability, but those provided by the KPSS tests with one and two breaks suggest that there is strong relative stability and, therefore concur with the ones from the ZA and LP tests (for the breakpoint analysis see the additional Appendix).

5.5.2.2. Post-Euro Period

In this section we use stationarity tests in order to assess whether the behaviour of European countries' inflation rates was stable or not after the adoption of the common currency, 1998Q1-2013Q4, see Figure 5.2 above. For convergence purposes we also run unit root tests without intercept (ADF tests) and with intercept and either one or two breaks (ZA and LP tests, respectively). Results are reported in Table 5.7 below. In other words, we consider the stationarity of each differential through the use of unit root/stationarity tests.

KPSS TESTS WITH NO INTERCEPT

The results of the stationarity tests with no intercept on the pairwise contrasts are displayed in the first row of Panel A in Table 5.7 (for more details see columns 1-3 in Table A.5.5 in the additional Appendix). For groups 1 and 2 the null hypothesis (of stability) is rejected at 1% significance level in only 4 out of 36 and in 1 out of the 3 cases respectively (alternatively 11% and 33% of the cases). Similarly for group 3 the null hypothesis is rejected at 1% significance level in only 6 out of 27 cases or 22% of the inflation differentials. Therefore there is strong evidence of absolute stability.

Table 5.7. Unit Root and Stationarity Tests. Post-Euro Period

	Rejection Rates		
	Group 1	Group 2	Group 3
Panel A-KPSS Tests			
KPSS-no intercept	11%	33%	22%
KPSS-1 break	0%	0%	0%
KPSS-2 breaks	0%	0%	0%
Panel B-Unit Root Tests			
ADF	100%	100%	93%
Zivot Andrews	100%	100%	96%
Lumsdaine Papell	97%	100%	100%

Notes: Each entry in Panels A and B shows the percentage rate of rejection of the null hypothesis at either 1% (in the case of the KPSS tests) or 5% or 10% level of statistical significance.

KPSS TESTS WITH ONE BREAK

The second row of Panel A in Table 5.7 reports, for the subsample: 1998Q1-2013Q4, the baseline results when we allow for one break in the intercept (for more details see the three columns jointly labeled 'KPSS-ONE BREAK' in Table A.5.5 in the additional Appendix). As shown in the first Panel of Table 5.7 the percentage of rejections is 0% in all the three groups. That is, the null hypothesis of relative stability is not rejected in all 66 cases.

The more frequent breakpoint for group 1 (in 8 out of 36 cases) occurred during 2008 (especially in the first and second quarter). From late 2007 the global financial crisis began to appear. In the first quarter of 2008 Ireland, Finland and Portugal showed signs of recession. It was not until a few months later that the financial crisis erupted, affecting the European economy and causing the European sovereign-debt crisis of the following years.

Regarding the breakpoint estimates for groups 2 and 3 (for more details see columns 4-6 in Table A.5.5 in the additional Appendix) these seem to appear (in 13 out of 30 cases) either in 2011 (the last three

quarters) or in 2012 (the first three quarters). During these years the European Parliament adopted a set of measures to support the European economy (Euro Plus Pact), Greece endorsed a package of austerity and structural reforms in an attempt to reduce the country's growing debt and the European Stability Mechanism inauguration was signed with an ability to lend up to 500 billion Euros to eurozone countries that were severely affected by the crisis. In addition, in July and October of 2011 the EU approved a solidarity package with Greece amounting to 109 billion Euros and eurozone Leaders agreed on a strategy plan to promote sustainable growth, fiscal consolidation/tighter cooperation and assistance to countries facing financial and other difficulties. To sum up, it was not until January of 2012 that the European Council agreed on a tighter system of governance that would be able to supervise the member states towards fiscal discipline and apply sanctions when it is necessary. With the Greek issue still active, Euro area ministers of finance agreed on a second programme (on 21^{st} of February 2012) in order to avoid a Grexit from the eurozone. As a response to the crisis, EU leaders promoted actions in June 2012 to restore investors' confidence in the European Economy by adopting the "Compact for Growth and Jobs".

KPSS TESTS WITH TWO BREAKS

Table 5.7 also reports the results for the KPSS tests, which allow for two breaks in the intercept instead of one (for more details see Columns 7-9 in Table A.5.3 in the additional Appendix). The application of the KPSS testing procedure with two breaks leads to the same conclusions as with the KPSS test, which allows for only one break. That is, for all the three groups, the null hypothesis is not rejected (at 1% significance level) in all 66 cases. Thus, as in the KPSS tests with one break, there is very strong evidence of relative stability.

For group 1 the majority of the first breakpoint estimates (in 8 out of 36 cases) occurred during the period 2000-2002. In particular, after three years of benign macroeconomic environment (1996 to 1999), inflation rates began to rise in 2000 as a result of the higher oil and commodity prices (EC, 2000). Following the Council's meeting in late 2000 in Nice, an amendment to the Treaty on European Union was introduced in February 2001 by establishing the European Community (the well known Treaty of Nice). Later the same year (in December) the eurozone citizens could buy euro coins and from the 28^{th} of February 2002 euro was the only currency among the twelve member countries (the dual circulation period came to an end). The majority of the second breaks (in 21 out of 36 cases) occurred in 2006 (housing bubble in United States, which triggered the subprime mortgage crisis of 2007-2009) and in the years 2010 and 2011 (European sovereign debt crisis).

The results for groups 2 and 3 (see Table A.5.3 in the additional Appendix) suggest that the majority of the cases (in 8 out of 36 cases) for the first break took place during the period 2001-2004[38] and for the second break (in 23 out of 30 cases) in either 2008 or 2010 or 2011, reflecting the beginning of the financial crisis and the European sovereign-debt crisis.

To conclude, using three different KPSS tests, we tried to explore whether the inflation differentials were stable after the adoption of the common currency in 1998. The KPSS tests with no intercept in the post-1997 period reject the null hypothesis much less frequently than those in the pre-euro period. Thus we provide strong evidence of absolute stability. When we employ the KPSS test with either one or two breaks all European inflation rates appear to move relatively harmoniously after the introduction of the euro. Thus the inflation differentials are characterized by relative stability since the null hypothesis is not rejected in all 66 cases. In other words, there is strong evidence that the European inflation rates remained relatively stable after the adoption of the common currency for all the three groups despite the recent financial crisis of 2008/2009.

ADF, ZA and LP TESTS

The unit root tests on the pairwise contrasts with either no intercept or with intercept (with one or two breaks) are displayed in Panel B in Table 5.7 (for more details see Table A.5.4 in the additional

[38] On May the 1^{st} 2004 the biggest enlargement in the history of Europe took place with the accession of 10 new countries, namely Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic and Slovenia.

Appendix). Using the ADF tests with no intercept, for the first two groups (which consist of pairwise contrasts including countries only from either category 1 or category 2, respectively) the null hypothesis is rejected in all 39 (36+3) cases, that is the empirical evidence establishes that the inflation differentials have remained (absolutely) converged among the two subsets of the European countries: the early accession countries and those of the late joiners category. The third group incorporates pairwise contrasts that involve one country from the first category and one from the second category (see Table 5.2 above). This group seems to have been affected positively by the new currency since the (absolute) convergence percentage rate increases to 93% (25 out of 27 pairwise contrasts) from 37% in the pre-euro period.

Panel B in Table 5.7 also addresses the results from using the ZA unit root tests on the pairwise contrasts and allowing only for 1 break in the intercept for the subsample: 1998Q1-2013Q4. For this test the results from the three groups in all 66 cases but one strongly reject the null hypothesis of no relative convergence (in the majority of the cases at 1% significance level). Finally, Panel B of Table 5.7 summarizes the results of the LP unit root tests on pairwise contrasts, allowing for two breaks in the intercept. For the early accession countries (group 1) the rejection rates reached 97% of the cases (in comparison with 86% for the pre-euro period), that is 35 out of 36 cases, whereas for the pairwise contrasts of groups 2 and 3 the rejection of the null occurred in all cases (in comparison with the 93% for the pre-1998 period) of the pairwise contrasts. The results are in line with the ones provided by the ZA test (for the breakpoint analysis see the additional Appendix).

In sum, the unit root testing provides strong evidence of both absolute and relative convergence, and thus confirms the conclusion of the stationarity tests.

5.5.3. Clustering Algorithm

The considerable degree of heterogeneity among the European countries also hints at the fact that there may be a middle way (between the panel and univariate methodologies), i.e. there are some clusters of countries in which convergence has taken place within the cluster. An explicit algorithm which detects sub-group formation has been proposed by Hobijn and Frances (2000), which uses multivariate sationarity tests on inflation differentials. Its core function is to start with all possible pairs of countries and test their differentials for stability. Suppose that two countries are found to form a cluster. Then all other countries are tested for whether they belong to that cluster or not by testing for joint stationarity of all involved differentials. If the evidence is in favor of stationarity the cluster grows, otherwise other clusters are formed and it may be that some countries do not belong in any cluster. A great virtue of the algorithm is that it is independent of the ordering of the countries in the clusters. Below we apply the algorithm in terms of absolute and relative convergence/stability in both the pre-euro and post-1997 periods. The bandwith parameter of the algorithm is set to 0.05 as in Busetti et al. (2007).

As regards absolute convergence, for the pre-euro period we find three convergence groups, all of which include early accession countries: a) Austria, Belgium and Luxembourg, b) Finland and The Netherlands and c) France and Germany, while for the post-euro era we find two sub-groups: a) Austria, Belgium, Luxembourg, Germany and b) Finland and France (see also Tables A.5.5 in the additional Appendix). The countries of the south such as Greece, Italy, Portugal and Spain do not belong in the above clusters but are also heterogeneous enough not to form a cluster on their own.

When testing for relative convergence, for the pre-1998 period we find three convergence sub-groups: a) Austria, Belgium and Luxembourg, b) Finland and Ireland and c) The Netherlands and Portugal, while for the post-euro era we find two 'early accession' sub-groups: a) Austria, Belgium and Luxembourg and b) Finland, Germany and The Netherlands (see also Tables A.5.6 in the additional Appendix).

In general the results from the clustering algorithm are consistent with the ones obtained from the panel and univariate unit root/stationarity tests.

5.5.4. A Bayesian Approach

We additionally apply the methodology suggested by Arakelian and Moschos (2008) for modelling pairwise convergence in the presence of transitional dynamics, using a flexible approach, which allows the parameters of the underlying process to change over time. According to them, inflation convergence is achieved when the means and the variances of the inflation differentials diminish in successive time periods. If there are subperiods where the criteria do not hold, convergence is still achieved if the mean and the variance have been diminished since the start of the period examined. A key ingredient of this methodology is that the number of the subperiods is unknown. To implement the model a Markov chain Monte Carlo (MCMC) algorithm is adopted. The process explored for the inflation differentials is the white noise with drift. We run the algorithm from 1980Q1:1997Q4 and from 1998Q1:2013Q4, allowing 10 breaks, whose distance is no less than 10 quarters. Starting with zero breaks and after a burn-in period of 5,000 points we obtained the Markov chain output by collecting the next 10,000 points for the two distinct processes. An ergodic estimate of the posterior model probabilities was obtained. Among the models with a different number of thresholds, we chose the one with the highest posterior probability (for more details, see Arakelian and Moschos, 2008).

Our results are reported in Table A.5.7 in the additional Appendix. The top row shows the breakpoints detected by the MCMC algorithm. The second and third rows show, for the various breakpoints, the values of the drifts in the mean and the variance respectively. The vertical line separates the two subsamples. 18 out of 66 pairs showed no regime change. In the rest of the pairs there is at least a regime change. According to the criterion of convergence, 39 pairs converged in the first subsample but only 10 pairs in the second subsample. The decline of the mean is achieved in more pairs (2 more in the pre-1998 period and 7 more in the post-euro period) but it was not accompanied by a volatility decline, breaking the second rule of the convergence definition. In other words, relaxing the assumption of volatility decrease, in the first and the second subsamples 41 and 17 pairs achieved convergence, respectively. During the first subsample, nineteen pairs exhibited a regime change during 1988 and eleven pairs during 1989. From 1998 until the end of the period, twenty one pairs exhibited a regime change during 2005.

As regards relative convergence the results from the Bayesian approach are consistent with the ones obtained from the clustering algorithm. That is, for the convergence club Austria-Belgium-Luxembourg, in five out of the six pairs for the two subperiods the decline in the mean is achieved and in four it was accompanied by a volatility decline. Regarding the Finland, Germany and The Netherlands sub-group for the post-euro period, in all three pairs the decline in the mean is achieved and in two it was accompanied by a volatility decline.

5.5.5. Discussion

Table 5.8. Principal Findings

	Pre-euro		Post-euro	
	Absolute Convergence	Relative Convergence	Absolute Convergence	Relative Convergence
Panel A				
Panel Tests	yes	yes	yes	yes
Univariate Tests	yes/no*	yes	yes	yes
Bayesian Approach	NA[0]	yes/no[△]	NA[0]	no[□]
Panel B (clustering algorithm)				
Multivariate Stationarity tests	yes[§] (for some sub-groups of group 1)	yes (for some sub-groups of group 1)	yes[§] (for some sub-groups of group 1)	yes (for some sub-groups of group 1)

Notes: * Stationarity Tests: very weak evidence for all the three groups
Unit Root Tests: moderate evidence for group 3, around 40%

[0] NA stands for Not Applicable

[△] Moderate evidence: 62% of the cases

[□] Weak evidence: 29% of the cases

[§] i.e. for 3(2) sub-groups, which for the pre(post)-euro period include 7(6) countries out of 9 from group 1.

In this Section we will further discuss and summarize our results. The empirical evidence from the panel unit root tests (with or without CSD) show that, for both the pre-1998 and the post-euro periods, the stationarity hypothesis seems to hold. This means that some differentials are stationary and therefore there might be clubs of countries which have been in the process of converging absolutely or relatively (see the first row of Panel A in Table 5.8).

The table above also shows that there is no evidence for overall absolute stability of inflation differentials in the pre-euro period (see the second row of Panel A). That is, for the pre-1998 period the results from the univariate stationarity tests show that there is a divergent behaviour (around a zero mean) of the inflation rates. Similarly, for the same period the unit root tests provide only moderate evidence of absolute convergence for the pairwise contrasts that include one early and one late accession country. However, inflation rates appear to move (around a broken mean) homogeneously among the twelve European countries. That is, overall the univariate tests are able to accept the relative convergence hypothesis.

This mixed evidence in favor of inflation convergence/divergence, using univariate unit root and stationarity tests, is in line with the results from the clustering algorithm. Overall, we find evidence of divergent behaviour (either relative or absolute) for both periods. However, we are able to statistically detect separate clusters or convergence clubs, all of which include early accession countries. In particular, as regards absolute convergence we detect three(two) sub-groups in the pre(post)-euro period. Seven out of the nine early accession countries, that is Germany, France, Austria, Belgium, Luxembourg and Finland are included in groups in both periods (see Panel B). As pointed out by Busetti et al. (2007) the evidence for divergence is in the sense that countries belonging to different convergence clubs are characterized by inflation dynamics stable within their group but statistically different from other groups, where the difference may be due to either non stationary behaviour or to different underlying (and possible broken) means (or both). When testing for relative convergence, inflation rates appear to move (around a broken mean) homogeneously among two groups of low accession countries, namely Austria-Belgium-Luxembourg (for both periods), Finland-Ireland (for the pre-1998 period) and Finland-Germany-The Netherlands (for the post-euro period). Thus, overall, there is an indication of divergence of inflation rates in both subsamples. That is, it appears that inflation rates began to drift apart, and the inflation differentials began to display unit root behaviour. The outcome from the pairwise convergence Bayesian framework

broadly confirms our findings. That is, relaxing the assumption of volatility decrease in the first and the second subsamples 41 (62%) and 17 (only 29%) pairs are converged, respectively (see the third row of Panel A). Interestingly, for the main convergence sub-group Austria, Belgium and Luxembourg -using the clustering algorithm this was a convergence (either relative or absolute) club in both periods- in five out of the six pairs for the two subperiods the decline in the mean is achieved and in four it was accompanied by a volatility decline.

5.5.6. Transition Mechanism

Conrad and Karanasos (2015a) show that in time series models with in-mean effects persistence will be transmitted from the conditional variance to the conditional mean. Hence, by studying the conditional mean independently one will obtain a biased estimate of the true degree of persistence. In addition, if structural breaks are present as well and one ignores them then the aforementioned bias might be exacerbated. They first consider the case when we are under the null hypothesis of a unit root. Conrad and Karanasos (2015a) show that the size distortion of the unit root tests becomes stronger with the in-mean parameter (λ) increasing. That is, although the process (i.e. the inflation differential in our case) is I(1), the Dickey-Fuller test will reject the null hypothesis in the presence of an in-mean effect. For a given value of λ and c (the 'persistence' in the conditional variance, see below) the size distortion will be the stronger the larger is α (that is, the ARCH effects; see Eq. 5.2 below).

Preliminary results in Canepa and Karanasos (2015) clearly suggest that the aforementioned size distortion will be exacerbated if, in addition to in-mean effects, structural breaks are present as well. In particular, unit root tests will be further oversized for processes that allow for in-mean effects in combination with structural breaks (either in the mean or the variance) and persistent conditional variances. Hence, a non stationary process may easily be confused with a process that is integrated of order zero in the level.

Estimated Breaks

By applying the Bai and Perron (2003) breakpoint specification technique in the data covering a period from 1980:04 to 2013:04 for three inflation differentials (GE-FR, FR-SP and GR-PT) we identify five possible breakpoints for each of the pairwise contrasts (see Table 5.9 below). The results successfully captured events of great significance, such as the talks about convergence issues in Luxembourg (1980:01), the Franco-German pact on the progressive abolition of border checks in Germany (1984:03), the strengthening of the EMS and the accession of Spain and Portugal in EU, as well as the adjustment of the central rates by the Central Banks of the Member States (1985:03). In addition, the ratification of the Treaty on European Union by many European countries directly after the signing of the Maastricht Treaty (1992:04), the launch of the Schengen Agreement (1995:01) and the approval by the European Council of suggestions promoting the smooth transition to the third stage of EMU (1997:02) are some of the events that are linked to statistically significant breaks.

Table 5.9. The Break Points (Inflation Differentials)

Break	GE-FR	FR-SP	GR-PT
1	**1984:03**	**1980:01**	1980:02
2	**1987:04**	**1985:03**	**1983:02**
3	1990:04	**1985:04**	**1983:03**
4	**1992:04**	**1995:01**	1984:04
5	1993:01	**2012:03**	**1997:02**

Notes: The dates in bold indicate breakdates for which, in Table 10 at least one dummy variable is significant, i.e., for the GE-FR for the 1992:04 breakdate β^4 is significant.

Power ARCH-in-mean Models

In this Section, for the three inflation differentials, we will estimate AR power ARCH models with in-mean effects (hereafter AR-PARCH-in-mean) and structural breaks (for applications of GARCH-in-mean models to inflation see, among others, Baillie et al., 1996, Conrad and Karanasos, 2010, Conrad and Karanasos 2015b and the references therein).

Let y_t denote the inflation differential at time t and define its mean equation as:

$$y_t = \varphi_0 + \sum_{\tau=1}^{5} \varphi_0^{\tau} D_t^{\tau} + \sum_{l=1}^{4} (\varphi_l + \sum_{\tau=1}^{4} \varphi_l^{\tau} D_t) y_{t-l} + \lambda \sigma_t^{\delta} + \varepsilon_t, \tag{5.1}$$

where $\varepsilon_t \,|\Omega_{t-1} \sim N(0, \sigma_t^2)$ is the innovation, which is conditionally (as of time $t-1$) normally distributed with zero mean and conditional variance σ_t^2. The λ denotes the GARCH-in-mean parameter, that is it captures the impact of the inflation differential's uncertainty on the inflation differential. D_t^{τ} are dummy variables defined as 0 in the period before each break and 1 after the break. The breakpoints $\tau = 1, 2, .., 5$ are given in Table 5.9 above. In addition σ_t^2 is specified as a PARCH$(1, 1)$ process (a model developed by Ding et al., 1993; see also Karanasos and Kim, 2006):

$$\sigma_t^{\delta} = \omega + \alpha \varepsilon_{t-1}^{\delta} + (\beta + \sum_{\tau=1}^{5} \beta^{\tau} D_t^{\tau}) \sigma_{t-1}^{\delta}, \tag{5.2}$$

where α and β denote the ARCH and GARCH parameters, and δ is the power term. The 'persistence' in the conditional variance, in the absence of breaks, is given by $c = \alpha k + \beta$, where $k = \frac{1}{\sqrt{\pi}}[(1-\gamma_l)^{\delta} + (1+\gamma_l)^{\delta}] 2^{(\delta/2-1)} \Gamma(\frac{\delta+1}{2})$ under normality (see Karanasos and Kim, 2006).

Table 5.10 below reports the baseline results provided by the conditional maximum likelihood estimates of the (P)ARCH(1,1) model,[39] allowing the conditional means and variances to switch across the breakpoints [see Eq. (5.1) and (5.2) above] identified by the Bai and Perron (2003) procedure. Moreover, the tests for remaining serial correlation suggest that all the three models seem to be well-specified since there is no remaining autocorrelation in either the standardized residuals or squared standardized residuals at 5% statistical significance level. In the case of the two constants (ϕ, ω) the effects of breaks are insignificant in all the cases, with the exception of the conditional mean equation of FR-SP differential, whereas for the autoregressive coefficients there seems to exist a statistically significant impact of the breaks. In particular, the parameters of the mean equation show time-varying characteristics across either three (in the case of GE-FR and GR-PT) or four (in the case of FR-SP) breaks. As far as the conditional variance is concerned, the ARCH parameter (α) shows no time-varying behaviour while for the GARCH parameter only one break seems to impact each of the three inflation differentials. The in-mean parameter is positive and significant in all cases. Finally, the power parameter δ is fixed, and for all three cases, equal to 1.2 (different from either zero or unity). Perhaps it is on the same level among the three inflation differentials, due to their common currency and the monetary integration.[40]

[39] In order to distinguish the general PARCH-in-mean model from a version in which δ is fixed (but not necessarily equal to two) we refer to the latter as (P)ARCH.

[40] For the three examples, that is for the three estimated AR(4)-(P)ARCH(1,1)-in-mean-models with breaks both in the mean and the variance, we also calculate the time varying estimated persistence of the inflation differentials and compare it with the one without breaks and in-mean effects (results not reported).

Table 5.10: The Estimated (P)ARCH in-mean Model for Germany-France, France-Spain and Greece-Portugal Inflation Differentials, Allowing for Breaks in the Conditional Mean and Variance.

Coefficients	GE-FR	FR-SP	GR-PT
		Mean Equation	
φ_0	-0.88^{***} (-4.37)	-0.73^{***} (-3.13)	-0.13 (-0.35)
φ_0^4	–	0.37^{***} (3.40)	–
φ_0^5	–	-0.30^{***} (-4.43)	–
φ_1	–	–	-0.22^{***} (-3.95)
φ_3	-0.11^{*} (-1.87)	–	-0.17^{***} (-2.87)
φ_4	0.59^{***} (11.29)	0.39^{***} (-1.87)	0.59^{***} (9.96)
φ_l^1	0.42^{***} $(3.16)_{l=1}$	–	
φ_l^2	0.36^{***} $(2.38)_{l=4}$	-2.55^{***} $(-3.44)_{l=1}$	-0.82 $(-1.22)_{l=1}$
φ_l^2	–	–	0.92^{***} $(4.20)_{l=2}$
φ_l^3	–	2.44^{***} $(3.36)_{l=1}$	0.92^{***} $(4.20)_{l=1}$
φ_l^4	-0.03 $(-0.34)_{l=1}$	–	-0.84^{***} $(-3.93)_{l=1}$
λ	1.21^{*} (1.80)	0.79^{*} (1.70)	0.05^{***} (68.06)
		Variance Equation	
ω	0.14^{***} (2.84)	0.04 (1.44)	0.03 (1.36)
α	0.36^{***} (2.72)	0.14^{**} (2.16)	0.29^{***} (9.54)
β	0.33^{*} (1.78)	0.75^{***} (16.92)	0.73^{***} (58.00)
β^1	–	0.05 (1.22)	–
β^4	-0.24^{**} (-2.03)	–	–
β^5	–	-0.23^{**} (-2.00)	0.01^{***} (7.80)
δ	1.20	1.20	1.20
$LB(4)$	7.41 [0.11]	4.53 [0.34]	12.73 [0.02]
$MCL(4)$	4.16 [0.38]	7.39 [0.11]	2.50 [0.64]

Notes: Table reports parameter estimates for the following model:
$y_t = \varphi_0 + \sum_{\tau=1}^{5} \varphi_0^\tau D_t^\tau + \sum_{l=1}^{4} (\varphi_l + \sum_{\tau=1}^{4} \varphi_l^\tau D_t^\tau) y_{t-l} + \lambda \sigma_t^\delta + \varepsilon_t$
$\sigma_t^\delta = \omega + \alpha \varepsilon_{t-1}^\delta + (\beta + \sum_{\tau=1}^{5} \beta^\tau D_t^\tau) \sigma_{t-1}^\delta$
The number in parentheses represent t-statistics. LB and MCL denote Ljung-Box and McLeod-Li tests for serial correlation of four lags on the standardized and squared standardized residuals, respectively (p-values reported in brackets). ***,** ,* ,indicates significance at the 1%, 5%, 10% , level respectively.

The above analysis calls for some caution on the interpretation of the results (and henceforth on the

policy recommendations drawn from them) from the unit root and stationarity tests.

5.6. Conclusions

This study has provided evidence about the behaviour of European inflation rates covering a period from 1980 to 2013. By applying panel unit root tests we show that the stationarity hypothesis seems to hold, before and after the birth of the common currency in 1997, even when CSD is accounted for. This means that some differentials are stationary and therefore there might be clubs of countries which have been in the process of converging absolutely or relatively. For the pre-euro period, regarding absolute convergence, the univariate stationarity tests provide weak overall evidence and the unit root tests provide moderate evidence for the pairwise contrasts that include one early and one late accession country. However, in all other cases they show that inflation rates displayed strong convergence with each other.

Next, having obtained mixed evidence in favor of convergence using the univariate unit root testing procedures, we examined the possibility that stability had occurred only for some subset of the countries by employing multivariate stationarity tests and the clustering algorithm for the identification of stability clubs. We found no evidence of overall stability-around either a zero mean or a broken mean-of inflation differentials. However, inflation rates appeared to move homogeneously among sub-groups of early accession countries. For the pre-euro period three absolute convergence clubs were identified, all of which included early accession countries: a sub-group with Germany and France, one with The Netherlands and Finland, and a bigger sub-group with Austria, Belgium and Luxembourg. For the post-1997 period Germany turned out to belong to a big sub-group together with Austria, Belgium and Luxembourg while France clustered with Finland. For the rest of the countries/cases we find evidence of divergent behaviour.

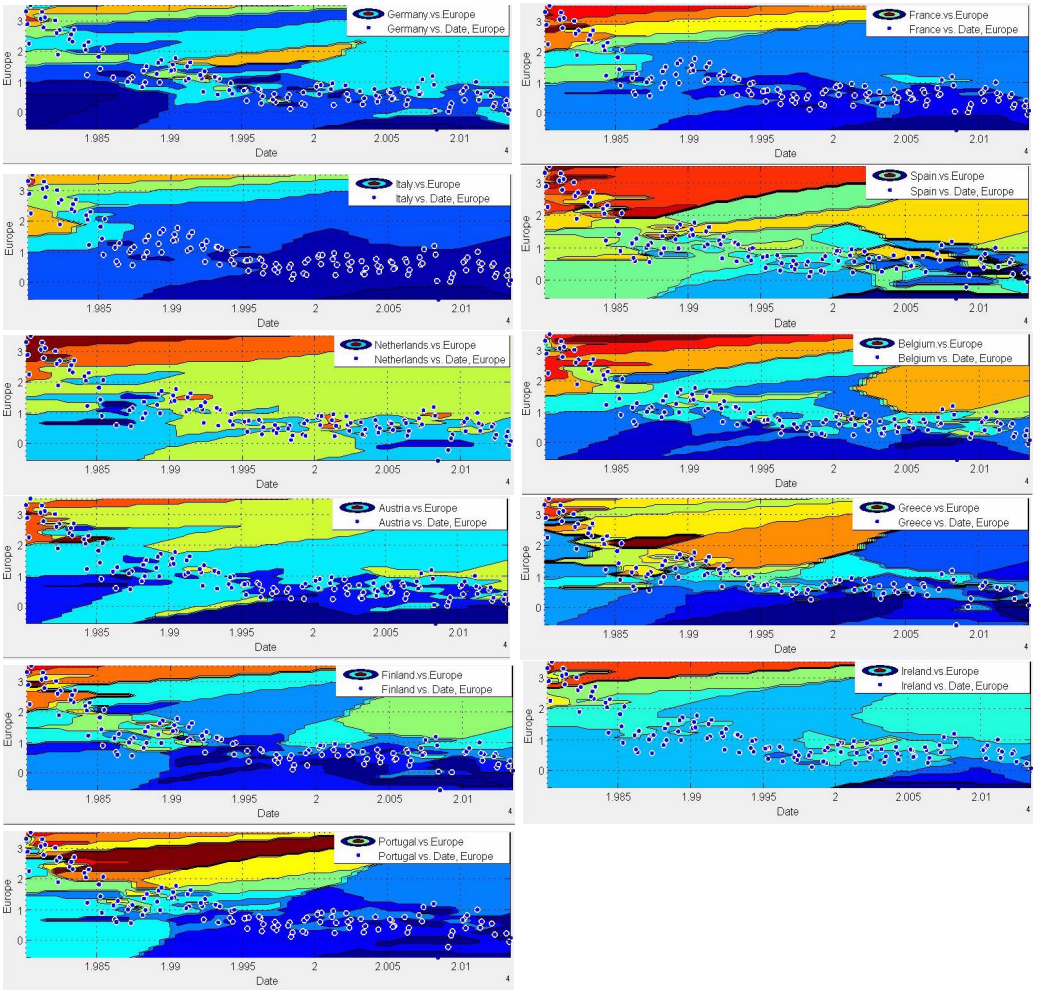
However, the analysis in Conrad and Karanasos (2015a) and Canepa and Karanasos (2015) about the size distortion and low power of the unit root/stationarity tests in the presence of strong PARCH in-mean effects and of structural breaks, together with our evidence on such effects (for at least a few inflation differentials), call for some caution on the interpretation of the results from the unit root/stationarity testing procedures.

For the high inflation countries deviations from the ERM policies led to higher inflation rates that were above the average. This can be easily seen from graphical representations in Figures 5.1-5.3. In particular, Figure 5.3 displays quarter on quarter contour plots of inflation rates of European countries and their average. The vertical axis reports the average European inflation rates and the horizontal one the period that this research examines. The colours in each graph represent each European member's level of inflation rate. From these graphs we can notice that the more we move to the right of the horizontal axis the blue colour becomes darker. This means that the differential between the average European and each country's inflation rate is diminishing.

Finally, Figures 5.4 to 5.10 below show the average inflation rates of each of the twelve eurozone countries distinguished into seven different periods and in particular the two periods before the launch of the EMU (1980-1983, 1984-1989), the three EMU stages, the post enlargement period (2004-2007) and the years covering the financial and EU sovereign-debt crisis (2008-2013). The first four figures clearly verify the downward trend of average inflation rates for all the countries, the beneficial impact of ERM and the faster pace of the early accession countries relatively to the late accession ones. In contrast, with the launch of the third stage of EMU (Figure 5.8), average inflation rates started rising (with the exception of Germany, Greece and Italy) whereas the same pattern continued to occur [with the exception of Italy (though the drop is very slight), Portugal, Spain and The Netherlands] during the post enlargement period (Figures 5.9). Finally, Figure 5.10 reports the deflationary dynamics that the financial crisis and the EU-sovereign debt crisis imposed on the eurozone economies.

However, the impact of the recent financial and EU sovereign-debt crises on inflation differentials (this could be tested by employing sensitivity analysis), the role of the persistence of inflation pairwise contrasts on the European economy and forecasting (of inflation differentials), are issues we feel future research should try to address.

Figure 5.3. Quarter on Quarter Inflation Rates for European Countries and their Average, 1980Q1-2013Q4 (contour plots).



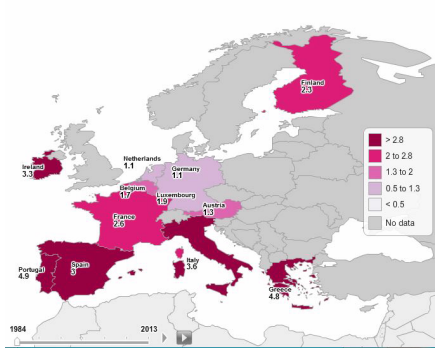


Figure 4.1 Pre-EMU period average inflation rates for European countries, 1980-1983.

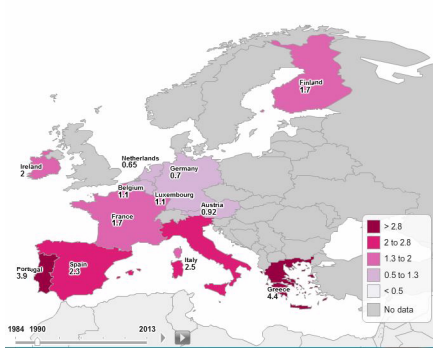


Figure 4.2 Pre-EMU period average inflation rates for European countries, 1984-1989.

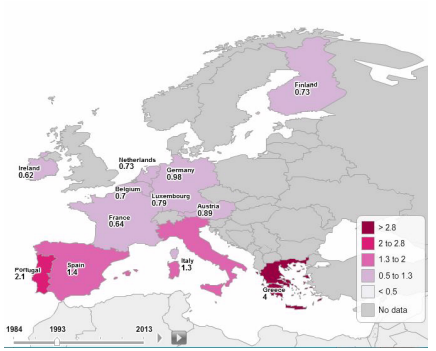


Figure 4.3 1^{st} stage EMU period average inflation rates for European countries, 1990-1993.

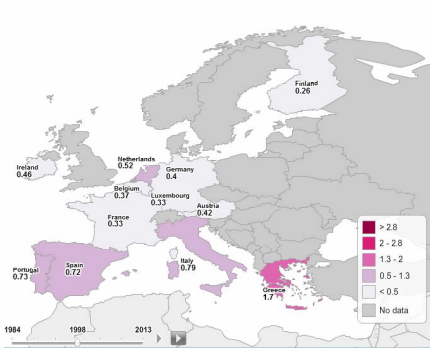


Figure 4.4 2^{nd} stage EMU period average inflation rates for European countries, 1994-1998.

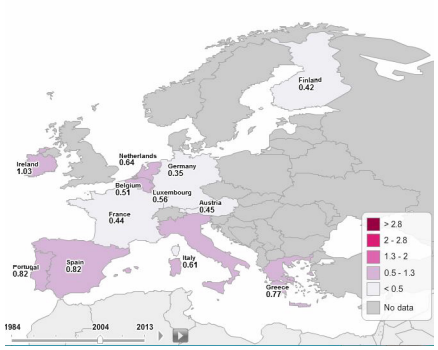


Figure 4.5 3^{rd} stage EMU period average inflation rates for European countries, 1999-2003.

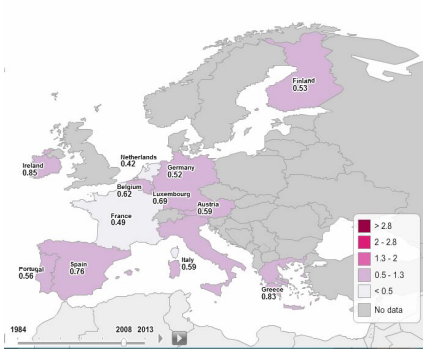


Figure 4.6 Average inflation rates for European countries after the EU enlargement, 2004-2007.

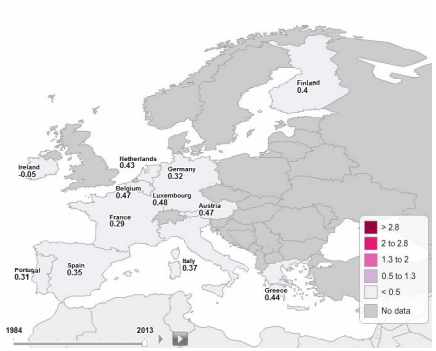


Figure 4.7 Average inflation rates for European countries during the financial and the EU sovereign debt crisis, 2008-2013.

Appendix 5

APPENDIX 5.A

Beakpoint analysis

Pre-Euro Period

KPSS TESTS WITH ONE BREAK

The results of breakpoint analysis from the KPSS test with one break report that for the early accession countries (club 1) the breaks occur more frequently between 1981-83 covering the period of the early 1980s recession (in 16 out of 36 cases; see Table A.5.2) and secondly during 1991 and 1993 (in 9 out of 36 cases) capturing the inauguration of the European Bank for Reconstruction and Development (EBRD) in London and the begginings of the single European market (which guarantees the free movement of goods, capital, services and people, the so-called "four freedoms" between the 28 Member States) respectively. Regarding club 2 results, the break in 2 out of 3 pairwise contrasts occured during the first quarter of 1992 when the Treaty on the European Union was signed in Maastricht by the finance and foreign ministers of the EU member states. The estimated breakpoints for club 3, in 14 out of 27 pairwise contrasts, cover the periods firstly from 1981 to 1983 (similarly to club 1 above) and secondly from 1985 to 1986 when European Union foreign ministers reached a political agreement towards the amendment of the Treaty of Rome by finalising the text of the Single European Act (SEA). The Act was signed at Luxembourg in early 1986.

KPSS TESTS WITH TWO BREAKS

As far as the breakpoint analysis from the KPSS test with two breaks for the early accession countries is concerned (club 1), the results comply with those presented when we employed the Lumsdaine-Papell unit root tests with two breaks (see results in the main text). In particular, the first breakpoints were more frequently concentrated (in 21 out of 36 cases; see Table A.5.3) during 1982 (second and third quarter) and 1983 capturing the early 1980s global recession which affected much of the developed world. The second breakpoint in 17 out of 36 cases of the pairwise contrasts occured in the period from 1992 to 1994. During 1992 the Treaty on European Union was signed (in Maastricht February the 7^{th} 1992.) and an agreement on the European Economic Area (EEA) was reached in Porto, Portugal (2^{nd} of May 1992). On the 29^{st} of October 1993 the European Council agrees that the second phase of economic and monetary union will come into effect on 1^{st} of January 1994. After a year or so since 1992 all the ratification procedures[41] were completed and the Treaty on the European Union comes into effect on the 1^{st} of November 1993. At the end of the same year on the 13^{th} and 15^{th} of December an agreement towards the creation of the European Economic Area (the so-called EEA) and the signing of the most liberalised policies in the history of trade occured respectively. Finally, during 1994 Stage II of EMU and the EEA came into force, the European Monetary Institute (EMI) is established and free trade agreements were signed with the Baltic countries (Estonia, Latvia, Lithuania) in Brussels. Moreover, the first European Monetary Institute Council was held in Frankfurt and the Commission, the Council and the Parliament adopt the financial perspective of 1995-99 taking under consideration the enlargement of European Union that was going to take place in 2004.

For the late accession countries the first structural break occured more often in the period 1982-83 (in full compliance with results presented in club 1 above) and in 1987 (either first, second or fourth quarter) in 14 and 5 out of 30 cases, respectively (see Table A.5.3). During 1987 Bank of Spain and Portugal signed an agreement which allowed them to enter the European Monetary System (EMS), the Single European Act comes into act and the ministers of economic affairs agree on measures towards

[41] Each Member State should ratify the Treaty on European Union. The last country that approved the Treaty was United Kingdom.

strengthening of the EMS. The majority of the second breaks cover the years 1990-92 and 1994 (in 18 out of 30 cases). During 1990-92 (for events that happened during 1994 see explanation for club 1 in the paragraph above) events of great importance occured. Specifically, during the 1990 the following events took place: the Unification of Germany, the signing of the agreement establishing the EBRD (European Bank for Reconstruction and Development), the beginning of the negotiations for the EEA, and the first phase of EMU comes into force with four Member States, namely Greece, Ireland, Spain and Portugal obtaining a special status due to their unsatisfactory progress towards financial integration. The following year (1991) EBRD launches its operations in London and the Council agrees on the foundation of the EEA. In 1992 the Escudo (National currency of Portugal) joins the exchange rate mechanism of EMS, the agreement on the EEA was finally signed, and a series of countries voted in favor of the Treaty on European Union (among them Greece, Spain and Portugal).

Post-Euro Period

ZA TESTS WITH 1 BREAK

For club 1 the majority of the breakpoint estimates in 19 out 36 cases (provided by the ZA unit root tests on the pairwise contrasts and allowing only for 1 break in the intercept for the 2^{nd} subsample:1998Q1-2013Q4) occured during either the end of 2001 or the beginning of 2002 (the period of dual circulation comes to an end) or during the second, third and fourth quarter of 2008 when a major financial crisis hit the world economy with several European banks struggling (see Table A.5.4).

For clubs 2 and 3 the more frequent breakpoints concentrated (in 12 out of 30 cases) around the financial crisis period (third and fourth quarter of 2008 and 2009 respectively; see Table A.5.4). Pairwise contrasts that include Greece show a break during the third quarter of 2011 (see Table A.5.4). At this time, 31^{st} of October 2011, the Greek goverment announced its intention to conduct a referendum to decide whether or not Greece was to accept the conditions under which the three counterparts, European Union (EU), International Monetary Fund (IMF) and the European Central Bank (ECB) would allow a 50% haircut of Greek debt owed to private creditors.

LP TESTS WITH 2 BREAKS

For the LP unit root tests on pairwise contrasts, which allow for two breaks in the interecept, the majority of the first break for all the three clubs (in 48 out of 66 cases) occured either in 2001-03 or during the first four quarters of 2008.

The second break for the majority of the pairwise contrasts (in 55 out of 66 cases) took place either in 2008/2009 when the financial crisis outburst or in 2010 (when a series of events occured such as the support to the Greek government in order to fullfil the Stability Programme targets for 2010, the agreement for deeper fiscal consolidation, stronger economic coordination and budgetary surveillance to defend the euro and the EU support to the Irish economy) and 2011, when comprehensive package of measures to strengthen the European economy finalised and the Euro Plus Pact was set up to reinforce economic policy coordination in the Economic and Monetary Union (see Table A.5.4). For pairs that include Greece the break arode around the second quarter of 2011 when the Greek government adopted a package of spending cuts and structural reforms to reduce the country's high debt and to make the economy more competitive (30^{th} of June 2011).

Table A.5.1. Unit root tests on pairwise inflation contrasts

	1st subsample:1980:Q1-1997:Q4							
	ADF-NO INTERCEPT		ZIVOT–ANDREWS			LUMSDAINE-PAPELL		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
GE-FR	−2.39	5%	−8.17	1%	1994;02	−8.29	1%	1990;04, 1994;01
GE-IT	−2.82	1%	−4.60	10%	1994;03	−9.40	1%	1983;04, 1994;02
GE-SP	−1.85	10%	−7.85	1%	1994;02	−9.25	1%	1986;04, 1990;03
GE-NE	−3.14	1%	−4.82	5%	1993;04	−10.18	1%	1983;01, 1993;02
GE-BE	−1.94	5%	−7.02	1%	1993;04	−7.72	1%	1985;01, 1990;04
GE-AU	−7.60	1%	−8.60	1%	1983;03	−9.59	1%	1983;03, 1993;02
GE-GR	−1.39	–	−7.69	1%	1985;04	−8.68	1%	1985;03, 1990;01
GE-FI	−2.43	5%	−5.52	1%	1991;02	−6.88	1%	1991;02, 1994;02
GE-IR	−2.17	5%	−3.96	–	1993;04	−4.61	–	1983;02, 1993;03
GE-PT	−1.10	–	−7.90	1%	1982;04	−9.19	1%	1982;02, 1985;01
GE-LU	−1.52	–	−7.50	1%	1986;01	−8.33	1%	1985;04, 1990;04
FR-IT	−1.74	10%	−7.61	1%	1983;01	−7.86	1%	1982;04, 1995;02
FR-SP	−1.38	–	−4.67	1%	1985;03	−11.17	1%	1980;02, 1995;01
FR-NE	−1.78	10%	−8.62	1%	1994;03	−8.77	1%	1983;03, 1994;03
FR-BE	−2.50	5%	−11.47	1%	1982;03	−11.37	1%	1990;03, 1994;02
FR-AU	−1.96	5%	−8.10	1%	1983;03	−8.81	1%	1983;02, 1994;03
FR-GR	−1.14	–	−7.55	1%	1985;04	−9.44	1%	1985;03, 1990;01
FR-FI	−1.67	10%	−4.70	10%	1991;02	−5.95	10%	1991;01, 1994;03
FR-IR	−2.59	5%	−7.98	1%	1982;04	−3.73	–	1988;03, 1993;01
FR-PT	−0.83	–	−5.75	1%	1983;02	−6.41	5%	1983;01, 1989;03
FR-LU	−3.21	1%	−6.76	1%	1982;03	−6.99	1%	1985;04, 1994;01

Table A.5.1. Unit root tests on pairwise inflation contrasts

	1st subsample:1980:Q1-1997:Q4							
	ADF-NO INTERCEPT		ZIVOT–ANDREWS			LUMSDAINE-PAPELL		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
IT-SP	−3.61	1%	−12.20	1%	1983; 03	−12.31	1%	1983; 02, 1995; 01
IT-NE	−2.30	5%	−8.01	1%	1983; 02	−8.48	1%	1983; 01, 1994; 02
IT-BE	−2.58	5%	−10.82	1%	1983; 02	−11.10	1%	1983; 01, 1994; 02
IT-AU	−2.05	5%	−5.46	1%	1983; 03	−6.52	5%	1983; 02, 1994; 03
IT-GR	−0.78	–	−8.13	1%	1985; 04	−9.27	1%	1985; 03, 1990; 01
IT-FI	−1.76	10%	−5.11	5%	1991; 02	−6.22	5%	1990; 02, 1993; 01
IT-IR	−2.44	5%	−10.07	1%	1982; 03	−8.65	1%	1982; 03, 1989; 04
IT-PT	−1.57	–	−8.24	1%	1982; 04	−8.75	1%	1982; 03, 1985; 01
IT-LU	−2.74	1%	−8.21	1%	1983; 03	−8.50	1%	1985; 04, 1993; 04
SP-NE	−1.46	–	−11.65	1%	1982; 04	−12.14	1%	1982; 03, 1986; 04
SP-BE	−1.68	10%	−5.31	5%	1985; 03	−8.51	1%	1985; 02, 1993; 02
SP-AU	−1.54	–	−11.78	1%	1984; 01	−12.11	1%	1983; 04, 1991; 04
SP-GR	−2.88	1%	−8.05	1%	1985; 04	−10.94	1%	1984; 04, 1989; 04
SP-FI	−3.03	1%	−9.67	1%	1987; 01	−10.23	1%	1986; 04, 1995; 02
SP-IR	−1.72	10%	−4.78	10%	1983; 03	−4.94	–	1983; 02, 1994; 04
SP-PT	−1.66	10%	−4.66	10%	1985; 01	−5.68	12%	1984; 04, 1992; 01
SP-LU	−2.03	5%	−4.84	1%	1985; 03	−10.45	1%	1985; 03, 1993; 02
NE-BE	−1.79	10%	−5.41	1%	1994; 04	−6.19	5%	1985; 02, 1990; 03
NE-AU	−4.23	1%	−10.16	1%	1984; 01	−10.74	1%	1983; 04, 1991; 04
NE-GR	−1.97	5%	−8.85	1%	1985; 04	−10.52	1%	1985; 03, 1990; 01
NE-FI	−1.90	10%	−5.97	1%	1991; 02	−6.44	5%	1986; 03, 1991; 01
NE-IR	−2.01	5%	−7.03	1%	1983; 03	−4.90	–	1983; 02, 1993; 04
NE-PT	−2.65	1%	−5.25	5%	1985; 01	−5.91	1%	1984; 04, 1991; 01
NE-LU	−1.89	10%	−7.12	1%	1986; 01	−7.30	1%	1985; 04, 1990; 04

Table A.5.1. Unit root tests on pairwise inflation contrasts

	1st subsample:1980:Q1-1997:Q4							
	ADF-NO INTERCEPT		ZIVOT–ANDREWS			LUMSDAINE-PAPELL		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
BE-AU	−4.34	1%	−6.50	1%	1984; 01	−7.14	1%	1983; 04, 1990; 03
BE-GR	−1.39	–	−7.81	1%	1985; 04	−10.40	1%	1985; 03, 1990; 01
BE-FI	−2.59	5%	−5.19	5%	1991; 02	−5.90	10%	1986; 04, 1991; 01
BE-IR	−2.27	5%	−5.33	5%	1983; 02	−5.52	13%	1983; 01, 1993; 04
BE-PT	−1.17	–	−5.92	1%	1983; 02	−6.57	5%	1983; 01, 1985; 04
BE-LU	−9.93	1%	−10.16	1%	1986; 01	−10.59	1%	1985; 04, 1995; 01
AU-GR	−1.37	–	−8.90	1%	1985; 04	−11.65	1%	1985; 03, 1990; 01
AU-FI	−1.87	10%	−7.64	1%	1991; 02	−8.75	1%	1983; 03, 1991; 02
AU-IR	−2.88	1%	−6.81	1%	1983; 03	−4.84	–	1983; 02, 1994; 03
AU-PT	−0.96	–	−7.76	1%	1982; 04	−8.89	1%	1982; 03, 1985; 01
AU-LU	−2.78	1%	−7.64	1%	1984; 01	−7.92	1%	1983; 04, 1991; 01
GR-FI	−1.19	–	−6.81	1%	1985; 04	−9.66	1%	1984; 03, 1990; 01
GR-IR	−0.78	–	−5.18	5%	1993; 03	−5.96	5%	1982; 04, 1993; 02
GR-PT	−2.11	5%	−4.73	10%	1985; 01	−11.05	1%	1984; 04, 1990; 01
GR-LU	−1.35	–	−7.85	1%	1985; 04	−9.60	1%	1985; 03, 1990; 01
FI-IR	−2.43	5%	−6.39	1%	1983; 01	−4.94	–	1990; 02, 1993; 01
FI-PT	−1.07	–	−4.59	10%	1985; 01	−6.81	1%	1983; 01, 1985; 04
FI-LU	−2.92	1%	−6.07	1%	1986; 01	−6.89	1%	1985; 04, 1991; 01
IR-PT	−1.64	10%	−7.70	1%	1982; 04	−4.82	–	1983; 01, 1989; 03
IR-LU	−2.90	1%	−5.07	5%	1983; 03	−3.65	–	1985; 04, 1993; 01
PT-LU	−2.91	1%	−8.63	1%	1982; 04	−9.31	1%	1982; 03, 1985; 01

Table A.5.2. KPSS tests on pairwise inflation contrasts

	1st subsample:1980:Q1-1997:Q4							
	KPSS-NO INTERCEPT		KPSS-ONE BREAK			KPSS-TWO BREAKS		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
GE-FR	4.12	1%	0.08	–	1991; 01	0.03	–	1982; 02, 1991; 01
GE-IT	3.32	1%	0.19	–	1987; 01	0.07	10%	1984; 03, 1988; 03
GE-SP	2.93	1%	0.04	–	1981; 04	0.05	5%	1983; 02, 1989; 01
GE-NE	1.76	5%	0.05	–	1982; 01	0.05	–	1982; 02, 1994; 03
GE-BE	3.58	1%	0.06	–	1982; 04	0.07	10%	1984; 01, 1993; 03
GE-AU	0.96	–	0.07	–	1982; 01	0.07	5%	1984; 01, 1992; 04
GE-GR	4.02	1%	0.12	–	1985; 04	0.06	–	1987; 04, 1994; 01
GE-FI	2.44	1%	0.09	–	1991; 02	0.06	–	1987; 04, 1990; 02
GE-IR	3.08	1%	0.15	–	1986; 04	0.05	–	1987; 04, 1990; 02
GE-PT	4.65	1%	0.03	–	1982; 04	0.04	–	1982; 04, 1995; 01
GE-LU	4.29	1%	0.15	–	1993; 01	0.04	–	1984; 01, 1993; 02
FR-IT	4.56	1%	0.16	–	1992; 01	0.06	10%	1987; 01, 1992; 01
FR-SP	4.38	1%	0.05	–	1994; 02	0.04	–	1983; 01, 1994; 02
FR-NE	0.27	–	0.22	–	1985; 04	0.04	10%	1985; 04, 1992; 02
FR-BE	2.82	1%	0.08	–	1982; 02	0.05	–	1982; 02, 1987; 04
FR-AU	4.67	1%	0.05	–	1993; 02	0.04	–	1992; 04, 1994; 04
FR-GR	0.15	–	0.11	–	1997; 02	0.04	–	1985; 02, 1988; 04
FR-FI	4.81	1%	0.10	–	1983; 02	0.08	10%	1982; 02, 1987; 04
FR-IR	2.97	1%	0.09	–	1990; 03	0.06	–	1987; 02, 1991; 02
FR-PT	3.65	1%	0.21	–	1991; 01	0.05	–	1982; 01, 1990; 01
FR-LU	4.89	1%	0.13	–	1986; 03	0.05	5%	1985; 04, 1991; 04

Table A.5.2. KPSS tests on pairwise inflation contrasts

	1st subsample:1980:Q1-1997:Q4							
	KPSS-NO INTERCEPT		KPSS-ONE BREAK			KPSS-TWO BREAKS		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
IT-SP	1.37	10%	0.12	–	1984;04	0.04	–	1982;02,1984;03
IT-NE	4.62	1%	0.06	–	1993;02	0.05	–	1992;04,1994;04
IT-BE	0.71	–	0.05	–	1980;04	0.04	–	1986;03,1995;01
IT-AU	1.92	5%	0.06	–	1985;04	0.05	–	1983;03,1985;04
IT-GR	4.65	1%	0.17	–	1986;04	0.04	–	1986;02,1990;02
IT-FI	4.41	1%	0.15	–	1990;04	0.06	10%	1986;04,1992;01
IT-IR	3.81	1%	0.08	–	1981;03	0.04	–	1983;03,1993;02
IT-PT	4.83	1%	0.10	–	1993;02	0.04	–	1988;04,1993;02
IT-LU	3.79	1%	0.27	–	1993;02	0.04	–	1983;03,1993;02
SP-NE	4.85	1%	0.20	–	1989;02	0.06	5%	1986;04,1991;04
SP-BE	1.48	5%	0.06	–	1983;02	0.04	–	1983;02,1991;04
SP-AU	2.87	1%	0.42	–	1980;03	0.08	1%	1983;03,1990;04
SP-GR	4.60	1%	0.17	–	1992;01	0.06	–	1987;04,1992;01
SP-FI	2.64	1%	0.07	–	1985;04	0.05	10%	1986;02,1993;01
SP-IR	4.71	1%	0.07	–	1990;03	0.05	–	1988;04,1994;04
SP-PT	3.66	1%	0.08	–	1992;01	0.06	10%	1987;01,1992;01
SP-LU	4.48	1%	0.15	–	1990;04	0.06	10%	1987;02,1992;01
NE-BE	2.86	1%	0.09	–	1982;01	0.04	–	1982;03,1993;03
NE-AU	4.32	1%	0.12	–	1993;02	0.04	–	1984;02,1993;04
NE-GR	3.71	1%	0.19	–	1983;02	0.08	1%	1983;02,1989;02
NE-FI	2.66	1%	0.10	–	1982;01	0.05	10%	1982;02,1989;01
NE-IR	3.24	1%	0.21	–	1981;03	0.08	5%	1983;03,1992;01
NE-PT	4.79	1%	0.12	–	1981;04	0.06	5%	1983;02,1990;03
NE-LU	1.08	–	0.05	–	1981;03	0.05	–	1982;02,1994;04

Table A.5.2. KPSS tests on pairwise inflation contrasts

	1st subsample:1980:Q1-1997:Q4							
	KPSS-NO INTERCEPT		KPSS-ONE BREAK			KPSS-TWO BREAKS		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
BE-AU	2.84	1%	0.09	–	1983; 02	0.06	1%	1983; 02, 1989; 01
BE-GR	0.84	–	0.08	–	1983; 04	0.04	–	1982; 02, 1984; 02
BE-FI	4.54	1%	0.23	–	1983; 02	0.07	1%	1983; 04, 1990; 02
BE-IR	3.09	1%	0.09	–	1995; 03	0.10	5%	1982; 02, 1990; 04
BE-PT	4.75	1%	0.16	–	1986; 02	0.05	5%	1985; 04, 1991; 04
BE-LU	4.43	1%	0.16	–	1991; 01	0.05	10%	1986; 04, 1992; 01
AU-GR	3.38	1%	0.15	–	1991; 01	0.05	–	1982; 02, 1990; 04
AU-FI	0.97	–	0.51	–	1983; 02	0.04	–	1985; 02, 1989; 01
AU-IR	3.08	1%	0.40	–	1983; 03	0.07	5%	1983; 04, 1989; 01
AU-PT	4.84	1%	0.11	–	1993; 02	0.04	–	1987; 04, 1993; 02
AU-LU	1.58	5%	0.09	–	1987; 03	0.04	–	1983; 04, 1986; 11
GR-FI	4.06	1%	0.24	–	1987; 01	0.11	1%	1985; 02, 1989; 03
GR-IR	4.06	1%	0.09	–	1992; 01	0.07	–	1991; 01, 1994; 04
GR-PT	4.86	1%	0.12	–	1991; 02	0.04	–	1988; 02, 1992; 04
GR-LU	3.60	1%	0.08	–	1981; 03	0.04	–	1982; 02, 1994; 04
FI-IR	3.18	1%	0.07	–	1991; 01	0.07	–	1983; 01, 1992; 02
FI-PT	1.93	5%	0.07	–	1986; 04	0.06	–	1986; 04, 1988; 04
FI-LU	3.51	1%	0.14	–	1981; 04	0.05	10%	1982; 02, 1988; 03
IR-PT	4.60	1%	0.21	–	1985; 04	0.08	5%	1984; 03, 1998; 04
IR-LU	3.21	1%	0.39	–	1982; 01	0.08	1%	1983; 02, 1998; 04
PT-LU	4.84	1%	0.23	–	1986; 02	0.11	1%	1983; 03, 1991; 01

Table A.5.3. KPSS tests on pairwise inflation contrasts

	2nd subsample:1998:Q1-2013:Q4							
	KPSS-NO INTERCEPT		KPSS-ONE BREAK			KPSS-TWO BREAKS		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
GE-FR	1.17	10%	0.07	–	2005; 03	0.04	–	2006; 01, 2007; 02
GE-IT	0.29	–	0.08	–	2006; 03	0.04	–	2001; 01, 2004; 04
GE-SP	2.07	5%	0.07	–	1999; 01	0.05	–	2003; 02, 2005; 03
GE-NE	1.54	5%	0.09	–	2008; 01	0.04	10%	2001; 01, 2006; 04
GE-BE	1.19	10%	0.13	–	2006; 01	0.04	–	2001; 04, 2005; 04
GE-AU	1.41	5%	0.09	–	2008; 01	0.04	–	2000; 02, 2006; 04
GE-GR	1.82	5%	0.09	–	2006; 01	0.05	–	2003; 02, 2006; 01
GE-FI	1.13	–	0.16	–	2001; 02	0.04	–	2002; 01, 2005; 03
GE-IR	2.25	5%	0.20	–	2006; 01	0.06	10%	2000; 04, 2008; 01
GE-PT	3.59	1%	0.04	–	2001; 01	0.04	–	2001; 01, 2011; 02
GE-LU	3.17	1%	0.05	–	2012; 04	0.08	–	2000; 01, 2010; 03
FR-IT	1.37	10%	0.09	–	2007; 01	0.04	–	2004; 01, 2008; 01
FR-SP	2.37	5%	0.07	–	2011; 02	0.06	–	2000; 01, 2010; 02
FR-NE	0.16	–	0.19	–	2006; 01	0.03	–	2002; 04, 2005; 03
FR-BE	0.89	–	0.08	–	2007; 02	0.04	–	2007; 01, 2011; 01
FR-AU	2.43	1%	0.06	–	2011; 03	0.06	–	2000; 02, 2010; 04
FR-GR	0.16	–	0.06	–	1999; 01	0.04	–	2000; 01, 2002; 02
FR-FI	0.25	–	0.07	–	2003; 03	0.03	–	2001; 03, 2004; 03
FR-IR	0.26	–	0.08	–	2002; 03	0.04	–	2003; 02, 2011; 01
FR-PT	0.37	–	0.15	–	2001; 02	0.04	–	2002; 04, 2005; 03
FR-LU	2.42	5%	0.54	–	2013; 03	0.06	–	2005; 01, 2009; 03

Table A.5.3. KPSS tests on pairwise inflation contrasts

	2nd subsample:1998:Q1-2013:Q4							
	KPSS-NO INTERCEPT		KPSS-ONE BREAK			KPSS-TWO BREAKS		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
IT-SP	0.83	–	0.13	–	2011; 02	0.08	–	2006; 01, 2008; 04
IT-NE	1.94	5%	0.06	–	1998; 02	0.06	–	2000; 02, 2011; 01
IT-BE	2.29	5%	0.13	–	2002; 04	0.04	–	2003; 02, 2007; 03
IT-AU	2.63	1%	0.10	–	1999; 01	0.05	–	2000; 01, 2001; 04
IT-GR	3.41	1%	0.03	–	2011; 03	0.06	–	2005; 03, 2011; 01
IT-FI	2.60	1%	0.07	–	2007; 01	0.04	–	2004; 01, 2010; 04
IT-IR	0.20	–	0.16	–	2008; 01	0.05	–	2007; 01, 2011; 02
IT-PT	1.67	5%	0.06	–	2012; 02	0.06	10%	2004; 03, 2010; 02
IT-LU	2.05	5%	0.07	–	2011; 02	0.06	–	2008; 01, 2010; 02
SP-NE	1.28	10%	0.06	–	2012; 03	0.06	–	2001; 03, 2008; 03
SP-BE	1.66	5%	0.14	–	2013; 03	0.05	–	2008; 03, 2011; 01
SP-AU	0.96	–	0.06	–	2007; 01	0.04	–	2004; 01, 2011; 01
SP-GR	1.02	–	0.09	–	2007; 01	0.05	10%	2004; 01, 2010; 04
SP-FI	0.31	–	0.05	–	2002; 01	0.05	5%	2002; 01, 2008; 01
SP-IR	2.07	5%	0.09	–	2008; 01	0.07	5%	2003; 03, 2009; 01
SP-PT	0.31	–	0.05	–	2012; 03	0.04	–	2003; 04, 2007; 03
SP-LU	0.95	–	0.05	–	2012; 01	0.05	–	2008; 03, 2011; 01
NE-BE	0.67	–	0.10	–	2008; 01	0.04	–	2007; 01, 2010; 04
NE-AU	0.54	–	0.05	–	1998; 02	0.10	–	2006; 03, 2008; 04
NE-GR	0.67	–	0.10	–	2008; 01	–	–	2005; 01, 2007; 01
NE-FI	0.80	–	0.11	–	2008; 01	0.04	–	2000; 02, 2006; 04
NE-IR	0.26	–	0.16	–	2008; 02	0.04	–	2008; 04, 2010; 04
NE-PT	0.22	–	0.10	–	1999; 01	0.05	10%	2003; 01, 2010; 03
NE-LU	0.23	–	0.10	–	2007; 02	0.05	–	2006; 04, 2011; 01

Table A.5.3. KPSS tests on pairwise inflation contrasts

	2nd subsample:1998:Q1-2013:Q4							
	KPSS-NO INTERCEPT		KPSS-ONE BREAK			KPSS-TWO BREAKS		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
BE-AU	1.13	–	0.08	–	2008; 01	0.04	10%	2001; 01, 2006; 04
BE-GR	1.67	5%	0.05	–	2012; 01	0.04	10%	2003; 01, 2008; 03
BE-FI	1.43	10%	0.09	–	2003; 04	0.04	–	2004; 02, 2010; 03
BE-IR	1.03	–	0.07	–	2003; 02	0.04	–	2002; 01, 2002; 03
BE-PT	2.63	1%	0.07	–	2012; 03	0.05	–	2005; 03, 2010; 03
BE-LU	1.70	5%	0.08	–	2007; 01	0.04	–	2004; 01, 2011; 01
AU-GR	0.24	–	0.08	–	2000; 02	0.04	–	2001; 02, 2011; 04
AU-FI	0.59	–	0.06	–	2012; 02	0.05	–	2002; 01, 2011; 02
AU-IR	0.81	–	0.06	–	2010; 02	0.05	–	2002; 04, 2006; 03
AU-PT	2.47	1%	0.07	–	2011; 02	0.06	–	2001; 02, 2010; 03
AU-LU	1.66	5%	0.07	–	1999; 03	0.05	–	2006; 04, 2008; 03
GR-FI	1.72	5%	0.14	–	2001; 04	0.04	5%	2002; 01, 2008; 01
GR-IR	2.51	5%	0.08	–	2007; 01	0.05	–	2002; 03, 2011; 01
GR-PT	3.12	1%	0.15	–	2011; 02	0.07	–	2008; 01, 2010; 03
GR-LU	3.34	1%	0.07	–	2012; 03	0.06	–	2001; 02, 2010; 03
FI-IR	0.65	–	0.06	–	2011; 04	0.04	–	2002; 01, 2006; 02
FI-PT	1.82	5%	0.11	–	2011; 04	0.04	–	2010; 01, 2011; 02
FI-LU	1.32	10%	0.15	–	2001; 01	0.04	–	2000; 02, 2004; 04
IR-PT	3.40	1%	0.08	–	2003; 04	0.04	–	2004; 02, 2011; 02
IR-LU	1.71	5%	0.08	–	2008; 01	0.03	10%	2001; 04, 2006; 04
PT-LU	0.20	–	0.17	–	2001; 04	0.05	10%	2003; 02, 2008; 04

Table A.5.4. Unit root tests on pairwise inflation contrasts

	2nd subsample:1998:Q1-2013:Q4							
	ADF-NO INTERCEPT		ZIVOT–ANDREWS			LUMSDAINE-PAPELL		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
GE-FR	−3.07	1%	−8.85	1%	2001;03	−9.18	1%	2001;02, 2009;02
GE-IT	−2.15	5%	−9.18	1%	2004;01	−10.16	1%	2003;04, 2011;04
GE-SP	−1.89	10%	−5.06	1%	2008;03	−7.32	1%	2002;02, 2009;04
GE-NE	−2.34	1%	−4.95	5%	2003;01	−6.46	1%	2003;02, 2008;03
GE-BE	−8.60	1%	−7.92	1%	2009;04	−8.42	1%	2002;03, 2009;03
GE-AU	−2.77	1%	−8.53	1%	2005;03	−8.97	1%	2005;02, 2007;03
GE-GR	−1.63	10%	−6.97	1%	2011;03	−7.56	1%	2009;01, 2011;02
GE-FI	−2.99	1%	−4.62	10%	2006;02	−5.50	13%	2005;04, 2009;04
GE-IR	−4.37	1%	−4.78	5%	2008;02	−6.27	1%	2008;02, 2010;02
GE-PT	−1.78	10%	−10.45	1%	2009;04	−10.89	1%	2001;03, 2009;03
GE-LU	−1.87	1%	−7.26	1%	2010;01	−11.43	1%	2002;01, 2009;04
FR-IT	−2.51	5%	−9.61	1%	2001;02	−9.96	1%	2001;01, 2011;04
FR-SP	−2.03	5%	−5.00	5%	2008;03	−6.02	1%	2001;01, 2008;02
FR-NE	−2.75	1%	−5.29	5%	2002;03	−5.70	10%	2002;02, 2008;03
FR-BE	−2.73	1%	−8.06	1%	2001;02	−8.82	1%	2001;01, 2011;04
FR-AU	−3.68	1%	−5.53	1%	2002;01	−5.83	10%	2001;04, 2004;01
FR-GR	−1.33	–	−8.16	1%	2011;03	−8.84	1%	2009;01, 2011;02
FR-FI	−2.35	1%	−5.13	5%	2001;03	−6.29	5%	2006;01, 2010;03
FR-IR	−2.44	5%	−6.86	1%	2008;02	−7.85	1%	2002;01, 2008;01
FR-PT	−2.00	5%	−6.10	1%	2010;01	−6.62	5%	2004;04, 2009;04
FR-LU	−3.88	1%	−7.68	1%	2002;01	−8.28	1%	2005;01, 2010;01

Table A.5.4. Unit root tests on pairwise inflation contrasts

	2nd subsample:1998:Q1-2013:Q4							
	ADF-NO INTERCEPT		ZIVOT–ANDREWS			LUMSDAINE-PAPELL		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
IT-SP	−3.38	1%	−5.89	1%	2008; 03	−6.27	1%	2001; 02, 2008; 02
IT-NE	−3.22	1%	−5.52	5%	2003; 01	−5.62	12%	2002; 04, 2005; 03
IT-BE	−6.72	1%	−7.21	1%	2008; 03	−7.91	1%	2003; 03, 2009; 03
IT-AU	−3.88	1%	−5.19	5%	2002; 01	−5.60	12%	2001; 04, 2007; 04
IT-GR	−1.72	10%	−8.55	1%	2011; 03	−9.06	1%	2009; 01, 2011; 02
IT-FI	−1.86	10%	−8.72	1%	2001; 03	−9.48	1%	2006; 01, 2010; 03
IT-IR	−3.18	1%	−5.05	1%	2008; 03	−6.68	1%	2002; 03, 2008; 02
IT-PT	−2.70	1%	−6.03	1%	2009; 04	−6.59	5%	2007; 03, 2009; 04
IT-LU	−2.92	1%	−7.06	1%	2008; 03	−7.81	1%	2001; 03, 2008; 02
SP-NE	−2.79	1%	−4.63	1%	2008; 03	−7.08	1%	2003; 03, 2008; 01
SP-BE	−2.56	5%	−5.18	5%	2007; 04	−8.71	1%	2001; 04, 2007; 03
SP-AU	−2.38	5%	−6.06	1%	2008; 03	−6.21	1%	2008; 02, 2010; 02
SP-GR	−3.20	1%	−4.70	10%	2011; 03	−7.21	1%	2008; 02, 2011; 04
SP-FI	−2.88	1%	−5.23	5%	2002; 03	−6.09	5%	2002; 02, 2006; 01
SP-IR	−2.74	1%	−4.75	10%	2008; 02	−6.04	5%	2003; 01, 2008; 03
SP-PT	−3.10	1%	−4.46	10%	2009; 04	−6.62	5%	2003; 04, 2009; 03
SP-LU	−2.79	1%	−6.93	1%	2008; 03	−7.06	1%	2008; 02, 2010; 02
NE-BE	−8.41	1%	−4.75	10%	2003; 04	−5.12	–	2003; 03, 2009; 03
NE-AU	−3.55	1%	−11.20	1%	2003; 03	−11.40	1%	2003; 02, 2008; 03
NE-GR	−4.24	1%	−7.55	1%	2011; 03	−8.27	1%	2002; 03, 2011; 02
NE-FI	−2.63	1%	−9.05	1%	2005; 04	−9.69	1%	2000; 02, 2008; 03
NE-IR	−3.00	1%	−5.61	1%	2008; 02	−6.57	1%	2008; 03, 2010; 03
NE-PT	−2.48	5%	−5.85	1%	2008; 02	−6.24	5%	2001; 04, 2009; 04
NE-LU	−3.04	1%	−12.77	1%	2008; 04	−13.06	1%	2002; 01, 2008; 03

Table A.5.4. Unit root tests on pairwise inflation contrasts

	2nd subsample:1998:Q1-2013:Q4							
	ADF-NO INTERCEPT		ZIVOT–ANDREWS			LUMSDAINE-PAPELL		
	Statistic	Reject	Statistic	Reject	Breakpoint	Statistic	Reject	Breakpoint
BE-AU	−7.57	1%	−7.85	1%	2003; 02	−8.33	1%	2000; 01, 2011; 04
BE-GR	−2.03	5%	−7.68	1%	2011; 03	−8.06	1%	2008; 02, 2011; 02
BE-FI	−7.77	1%	−7.34	1%	2003; 02	−8.07	1%	2006; 01, 2011; 04
BE-IR	−2.05	5%	−4.62	10%	2007; 03	−5.80	10%	2003; 01, 2007; 02
BE-PT	−2.48	5%	−5.14	5%	2007; 02	−5.94	10%	2003; 01, 2007; 02
BE-LU	−3.87	1%	−8.54	1%	2007; 03	−9.25	1%	2003; 04, 2007; 02
AU-GR	−1.57	–	−8.37	1%	2011; 03	−8.73	1%	2009; 01, 2011; 02
AU-FI	−2.40	5%	−9.23	1%	2006; 02	−9.86	1%	2003; 02, 2005; 03
AU-IR	−2.55	5%	−4.89	5%	2008; 02	−5.90	10%	2003; 01, 2008; 02
AU-PT	−2.14	5%	−6.51	1%	2009; 04	−7.19	1%	2001; 03, 2009; 03
AU-LU	−3.21	1%	−8.18	1%	2005; 02	−8.50	1%	2005; 01, 2007; 02
GR-FI	−1.62	10%	−5.83	1%	2011; 03	−6.80	1%	2006; 01, 2011; 02
GR-IR	−2.64	1%	−3.38	–	2010; 04	−5.66	12%	2008; 02, 2010; 03
GR-PT	−2.29	5%	−4.66	1%	2010; 04	−10.58	1%	2008; 01, 2010; 03
GR-LU	−2.16	5%	−8.66	1%	2011; 03	−9.07	1%	2008; 03, 2011; 02
FI-IR	−2.48	5%	−5.74	1%	2008; 02	−7.91	1%	2008; 02, 2010; 02
FI-PT	−2.44	5%	−6.08	1%	2006; 02	−7.14	1%	2001; 03, 2009; 03
FI-LU	−2.28	5%	−9.90	1%	2006; 03	−11.01	1%	2006; 01, 2010; 03
IR-PT	−2.94	1%	−5.00	1%	2008; 04	−7.10	1%	2002; 04, 2008; 03
IR-LU	−2.54	5%	−4.62	10%	2008; 02	−11.01	1%	2006; 01, 2010; 03
PT-LU	−2.47	5%	−8.60	1%	2009; 04	−9.58	1%	2000; 04, 2009; 04

Table A5.5a. Pre-Euro Period Absolute Convergence

Countries	Group 1	Group 2	Group 3
Austria	x		
Belgium	x		
Finland		x	
France			x
Germany			x
Greece			
Ireland			
Italy			
Luxembourg	x		
Netherlands		x	
Portugal			
Spain			

Table A.5.5b. Post-Euro Period Absolute Convergence

Countries	Group 1	Group 2
Austria	x	
Belgium	x	
Finland		x
France		x
Germany	x	
Greece		
Ireland		
Italy		
Luxembourg	x	
Netherlands		
Portugal		
Spain		

Table A.5.6a. Pre-Euro Period Relative Convergence

Countries	Group 1	Group 2	Group 3
Austria	x		
Belgium	x		
Finland		x	
France			
Germany			
Greece			
Ireland		x	
Italy			
Luxembourg	x		
Netherlands			x
Portugal			x
Spain			

Table A.5.6b. Post-Euro Period Relative Convergence

Countries	Group 1	Group 2
Austria	x	
Belgium	x	
Finland		x
France		
Germany		x
Greece		
Ireland		
Italy		
Luxembourg	x	
Netherlands		x
Portugal		
Spain		

Table A.5.7. Pairwise Inflation Differentials.
The table contains the results from the MCMC algorithm. In the first line, they appear the break dates estimated by the algorithm as well as the end each subperiod, 1997Q4 and 2013Q4, respectively. In the second and third row, the calculated mean and variance of the inflation differential in each subperiod. In bold, it is denoted either the decline of the mean or of the mean and the variance altogether. In italics, it is denoted the decline of the variance which is not accompanied by a decline of the mean.

Austria

Belgium			
1989Q1	1997Q4	2005Q4	2013Q4
-0.2279	**0.1175**	-0.0556	**-0.0149**
0.7000	**0.4464**	0.4199	0.5419

Finland			
1985Q4	1997Q4	20005Q4	2013Q4
-0.8315	**-0.1562**	0.0901	**-0.0082**
0.8241	**0.7171**	0.4312	0.4369

France			
1988Q2	1997Q4	20005Q4	2013Q4
-0.8696	**0.1040**	0.0377	0.1520
0.7770	**0.3482**	0.2693	*0.2476*

Germany			
1988Q2	1997Q4	20005Q4	2013Q4
0.2559	**-0.0293**	0.0953	0.1081
0.5093	0.5536	0.3525	0.3839

Greece			
1986Q4	1997Q4	2013Q4	
-3.7686	**-2.3872**	-0.2207	
2.2588	**1.9427**	1.3742	

Ireland			
1986Q2	1997Q4	2013Q4	
-1.5395	**0.0025**	-0.1079	
1.5905	**0.5226**	0.8530	

Italy			
1988Q2	1997Q4	20005Q4	2013Q4
-1.7311	**-0.4977**	-0.1362	**0.0592**
1.0205	**0.3776**	0.2445	**0.3369**

Luxembourg				
1988Q2	1997Q4	20005Q4	2013Q4	
-0.2288	**0.0475**	-0.0984	**-0.0381**	
0.7637	**0.3504**	0.5066	**0.3969**	

Netherlands			
1988Q2	1997Q4	20005Q4	2013Q4
0.2762	**0.0959**	-0.1338	**0.0719**
0.5140	**0.3371**	0.3707	0.3916

Spain		
1988Q2	1997Q4	2013Q4
-1.4415	**-0.4776**	-0.1512
0.9066	**0.5979**	1.0032

The pair Austria-Portugal supported no regime change.

Table A.5.7. – Continued

Belgium

Finland		
1988Q2	1997Q4	2013Q4
-0.5585	**-0.1090**	0.0762
0.6879	**0.6630**	0.5776

France		
1988Q3	1997Q4	2013Q4
-0.6413	**0.0311**	0.1301
0.6854	**0.3836**	0.4963

Germany		
1984Q1	1997Q4	2013Q4
0.6396	**0.0189**	0.1369
0.8660	**0.6780**	0.5415

Ireland		
1989Q3	1997Q4	2013Q4
-0.9142	**0.0018**	-0.0726
1.3895	**0.4536**	0.7669

Italy		
1988Q2	1997Q4	2013Q4
-1.5006	**-0.5903**	-0.0031
0.9689	**0.4320**	0.4455

Luxembourg				
1986Q4	1997Q4	2003Q2	2009Q4	2013Q4
-0.0399	**-0.0121**	-0.0415	-0.0209	-0.4235
0.7385	**0.5187**	0.6980	0.6516	1.2659

Netherlands		
1988Q2	1997Q4	2013Q4
0.5067	**0.0033**	0.0044
0.5879	**0.3873**	0.4702

Spain		
1988Q2	1997Q4	2013Q4
-1.2109	**-0.5702**	-0.1159
0.8351	**0.5141**	0.9439

The pairs Belgium-Greece and Belgium - Portugal supported no regime change.

Finland

France		
1997Q4	2005Q1	2013Q4
0.0255	-0.0304	0.1237
0.6230	0.4485	*0.3821*

Germany			
1983Q2	1997Q4	2005Q2	2013Q4
1.2670	**0.2983**	0.0290	**0.0887**
0.8440	**0.7671**	0.4391	**0.4180**

Ireland*			
1981Q4	1997Q4	2001Q2	2013Q4
-1.7517	**0.0242**	-0.4629	**-0.0526**
1.6806	**0.7702**	0.8129	0.8314

Italy			
1988Q3	1997Q4	2005Q3	2013Q4
-0.9244	**-0.4855**	-0.2227	**0.0553**
0.9695	**0.5771**	0.4065	**0.3991**

Luxembourg			
1989Q1	1997Q4	2005Q4	2013Q4
0.5603	**0.0213**	-0.1884	**-0.0299**
0.8986	**0.6619**	0.4397	**0.4315**

Netherlands			
1988Q3	1997Q4	2005Q4	2013Q4
1.0583	**0.0931**	-0.2237	**0.0800**
0.5747	0.7144	0.4494	0.4884

Spain		
1985Q4	1997Q4	2013Q4
-0.8219	**-0.4162**	-0.1922
1.0776	**0.7607**	1.0557

The pairs Finland-Greece and Finland-Portugal supported no regime change.

* *In this case, the allowed distance between breaks is 8 quarters.*

Table A.5.7. – Continued

France

Germany		
1997Q4	1998Q1	2013Q4
0.4611	0.0552	**-0.0386**
0.8843	0.2763	**0.2557**

Italy			
1988Q3	1997Q4	2005Q4	2013Q4
-0.8487	**-0.6067**	-0.1738	**-0.0927**
0.6617	**0.2715**	0.2350	0.2003

Luxembourg			
1988Q4	1997Q4	2005Q3	2013Q4
0.6151	**-0.0695**	-0.1227	-0.2009
0.7437	**0.3000**	0.5109	*0.3991*

Netherlands			
1988Q4	1997Q4	2005Q2	2013Q4
1.1240	**-0.0505**	-0.2029	**-0.0577**
0.5368	**0.2944**	0.4409	**0.3150**

Portugal		
1997Q4	2005Q1	2013Q4
-1.6520	-0.3689	**-0.0406**
1.6279	0.5672	0.7764

Spain		
1989Q2	1997Q4	2013Q4
-0.5940	**-0.5579**	-0.2461
0.8585	0.4362	0.9213

The pairs France-Greece and France-Ireland supported no regime change.

Germany

Greece		
1989Q1	1997Q4	2013Q4
-3.7596	**-2.2582**	-0.3222
2.1973	**2.0316**	1.5031

Ireland		
1986Q4	1997Q4	2013Q4
-1.7741	**0.0493**	-0.2095
1.4269	**0.5919**	0.7760

Italy		
1997Q4	2005Q4	2013Q4
-1.1856	-0.2314	**-0.0487**
1.0844	0.2789	**0.2324**

Luxembourg			
1988Q4	1997Q4	2005Q4	2013Q4
-0.4784	**0.1016**	-0.1935	**-0.1461**
0.6497	**0.5259**	0.6106	**0.4305**

Netherlands			
1989Q1	1997Q4	2005Q4	2013Q4
0.0521	0.1004	-0.2290	**-0.0362**
0.4551	0.5711	0.4270	**0.3307**

Portugal			
1984Q3	1997Q4	2004Q3	2013Q4
-3.8354	**-1.4959**	-0.4440	**-0.0155**
2.0414	**1.6090**	0.4811	0.7415

Spain		
1993Q1	1997Q4	2013Q4
-1.2712	**-0.3880**	-0.2528
1.0752	**0.6457**	0.8664

Table A.5.7. – Continued

Greece

Netherlands			Portugal		
1991Q3	1997Q4	2013Q4	1984Q3	1997Q4	2013Q4
3.7541	**1.8858**	0.1897	-0.0799	1.2738	0.1261
2.1489	**1.8139**	1.4546	2.8584	*1.7928*	1.8290

The pairs Greece-Luxembourg, Greece-Ireland, Greece-Italy and Greece-Spain supported no regime change.

Ireland

Italy			Luxembourg		
1988Q4	1997Q4	2013Q4	1988Q2	1997Q4	2013Q4
-0.4897	-0.5618	0.0694	1.0131	**-0.0132**	0.0396
1.0684	*0.4220*	0.7767	1.4139	**0.5000**	0.9483

The pairs Ireland-Netherland, Ireland-Portugal and Ireland-Spain supported no regime change.

Italy

Luxembourg				Netherlands				Spain		
1989Q2	1997Q4	2005Q1	2013Q4	1989Q1	1997Q4	2005Q2	2013Q4	1987Q4	1997Q4	2013Q4
1.4201	**0.5245**	0.0508	-0.1055	1.9501	**0.5329**	-0.0242	0.0355	0.3321	**-0.0003**	-0.1128
0.8250	**0.4104**	0.5058	*0.4370*	0.8738	**0.4233**	0.2807	0.3168	1.0304	**0.5538**	0.9083

The pair Italy-Portugal supported no regime change.

Table A.5.7. – Continued

Luxembourg

Netherlands				Spain		
1989Q1	1997Q4	1999Q4	2013Q4	1989Q1	1997Q4	2013Q4
0.5102	**0.0037**	0.0089	0.0996	-1.1623	**-0.5194**	-0.0831
0.7196	**0.4117**	0.5933	*0.4763*	0.8497	**0.5796**	1.1855

The pair Luxembourg-Portugal supported no regime change.

Netherlands

Spain			
1989Q1	1997Q4	2001Q3	2013Q4
-1.6726	**-0.5230**	-0.0004	-0.1570
0.8383	**0.5308**	0.3736	1.0384

The pair Netherland-Portugal supported no regime change.

Portugal

Spain		
1997Q4	2006Q4	2013Q4
1.0750	-0.0025	-0.1263
1.4116	0.5261	0.6411

APPENDIX 5.B

Table B.5.1. Descriptive Statistics-1980Q1:1997Q4

Variables	Obs	Mean	Variance	Minimum	Maximum
Germany	72	0.705	0.392	−0.518 (1986^3)	2.568 (1993^1)
France	72	1.166	0.961	0.034 (1997^2)	3.844 (1980^1)
Italy	72	1.891	1.508	0.398 (1997^2)	6.040 (1980^1)
Spain	72	1.743	1.102	0.143 (1997^1)	4.271 (1980^4)
Netherlands	72	0.629	0.262	−0.718 (1986^4)	1.823 (1980^4)
Belgium	72	0.870	0.489	−0.313 (1987^3)	2.584 (1981^2)
Austria	72	0.810	0.257	−0.298 (1987^1)	2.488 (1984^1)
Greece	72	3.735	5.234	−0.867 (1997^3)	9.288 (1985^4)
Finland	72	1.192	0.925	−0.369 (1995^4)	3.905 (1980^2)
Ireland	72	1.364	2.294	−0.139 (1996^4)	7.070 (1980^1)
Portugal	72	2.818	4.175	0.174 (1996^3)	7.927 (1984^4)
Luxemburgh	72	0.893	0.606	−0.614 (1986^2)	2.895 (1982^3)
Euro-area	72	1.485	0.719	0.310 (1996^3)	3.536 (1980^4)

Notes: Table reports inflation descriptive statistics for each country and for the Euro area. The numbers in parentheses represent quarter and year that minimum and maximum occurred respectively.

Table B.5.2. Descriptive Statistics-1998Q1:2013Q4

Variables	Obs	Mean	Variance	Minimum	Maximum
Germany	64	0.374	0.101	−0.572 (2008^4)	0.946 (2002^1)
France	64	0.381	0.089	−0.427 (2009^1)	1.119 (2007^4)
Italy	64	0.514	0.055	−0.234 (2009^1)	1.068 (2008^1)
Spain	64	0.627	0.883	−1.664 (2008^4)	2.352 (2008^1)
Netherlands	64	0.506	0.079	−0.210 (2009^2)	1.356 (2000^4)
Belgium	64	0.511	0.239	−0.743 (2008^3)	1.730 (2008^1)
Austria	64	0.476	0.126	−0.317 (2009^1)	1.425 (2007^4)
Greece	64	0.696	2.117	−2.088 (2013^3)	3.493 (2010^2)
Finland	64	0.435	0.238	−0.521 (2009^1)	1.604 (2008^2)
Ireland	64	0.583	0.788	−3.100 (2008^4)	2.229 (2001^1)
Portugal	64	0.570	0.497	−0.948 (2008^4)	1.809 (2007^1)
Luxemburgh	64	0.544	0.287	−0.712 (2008^4)	1.716 (2008^2)
Euro-area	64	0.518	0.101	−0.554 (2008^4)	1.203 (2008^1)

Notes: Table reports inflation descriptive statistics for each country and for the Euro area. The numbers in parentheses represent quarter and year that minimum and maximum occurred respectively.

Chapter 6

The Greek Dra(ch)ma: 5 Years of Austerity. The Three Economists' View and a Comment

6.1. Introduction

After the global financial crisis of 2008-2009, which was characterized by many top economists (such as Behravesh, Rogoff and Roubini during the special economic forum CERAWeek in 2009 in Houston) as the worst since the Great Depression of 1939, the European Union (EU) sovereign debt crisis broke out. Eighteen years earlier, in 1992, the Treaty on the European Union was signed in Maastricht by the EU ministers of finance and foreign affairs. Under this agreement the idea of the single currency was introduced and the main principles of economic and monetary policy were established. Among others one key element of the Treaty was that the member states should refrain from high levels of public deficits [The European Commission (EC), 1992]. However, from the early 2000s many EU countries that signed the Treaty of Maastricht failed to keep their deficit and debt at low levels (see Figures 6.1 and 6.2 below).

In Figures 6.1 and 6.2 below we distinguish the eurozone countries into five different groups depending on the geographical region to which they belong. In particular, the first group consists of the 'Inner Six' countries (e.g., Belgium, France, Germany, Italy, Luxembourg and The Netherlands), the second group the so-called 'PIGS' (i.e., Greece, Ireland, Portugal and Spain), the third group the Central European countries (e.g., Austria, Slovakia, Slovenia), the fourth group the Baltic countries (e.g., Estonia, Latvia, Lithuania) including Finland and the fifth group is Insular Europe (i.e., Cyprus and Malta). Figure 6.1 below shows that government deficits as a share of GDP in the period 2000-2007 were among others quite high for France, Germany, Italy and The Netherlands (countries of the Inner Six group) and Portugal and Greece (countries of the PIGS group). Data for Greece's deficit are available from 2006 and onwards. However, the OECD's economic outlook for Greece reported that the Greek government balance sheets were suffering from high levels of deficit even from the early 1980s. In addition, according to many views (although not scientifically proven) a debt-to-GDP ratio could be optimal if it is around 60 percent. But why is this ratio so important? Simply because the higher the ratio the more difficult it is for the country to repay its debts and hence the higher the probability (for the country) of being downgraded by the rating agencies (such as Standard & Poor's, Moody's and Fitch). In Figure 6.2 data report that among the euro area countries only Belgium (though with a decreasing trend) and Italy from the Inner Six group and Greece and Portugal from the PIGS group had a debt-to-GDP ratio higher than 60 percent.

Nevertheless, despite these disparities between the countries that followed the rules imposed by the Treaty of Maastricht and those that faced difficulties in doing so, the common currency seemed to function well (from 2002 to early 2008 when the financial crisis began). But the weaknesses and the problems for the single currency were to appear shortly after the global financial crisis of 2008-2009, which led to the well-known EU sovereign debt crisis (of Greece, Ireland and Portugal).

In this Chapter we summarize the opinion of three renowned economists (alphabetically), namely Paul De Grauwe, Paul Krugman and Joseph Stiglitz, on the eurozone crisis as well as the Greek case. Table 6.1 below reports some of the notable statements that all the three economists used in order to support their hypotheses.

Krugman (2010) argues that the creation of the common currency was a terrible mistake while according to Stiglitz (2015e) and De Grauwe (2015) euro is poorly designed and the European Central Bank (ECB) focuses single-mindedly in inflation and it is not provided with the adequate tools to address unemployment. These weaknesses in the designs of the euro and the ECB damage Europe's prospects

(Greek ones even more). Troika used bad models and forecasts and the result of the macro-policies it demanded was a deep Greek depression without end, which possibly will lead to even greater economic, political and social chaos. The cost in human suffering has already been too high. Similar austerity programmes (and structural reforms) imposed by the International Monetary Fund (IMF) on the East Asian countries in the late 1990s had devastating effects. Greece might end up as a depleted country-one that has sold all its assets, and whose bright young people have emigrated.

The Greek disaster (tragedy) is a very short story, just a few paragraphs (and only five years) long, and it goes like that.

The Boom

During the period 2000-2008 there was an influx of cheap loans and large amounts of capital that created the boom. The Greek government for many years borrowed and spent in excess of the country's capabilities. For example, Goldman Sachs structured irresponsible deals that enabled the Greek government at the time of the Maastricht Treaty to skew the numbers of its debt.

De Grauwe (2015) points out that the booming economy experienced high inflation rates and increases in unit labour costs, and this boom led to large current account deficits. The nominal interest rate (set by ECB) was too low and, thus, when inflation rose the low real interest aggravated the boom.

The Bust

When the capital inflows (the music as Krugman puts it) stopped Greece was faced with high costs and prices. Also as a result of the financial crisis debt to GDP ratios started to increase (Greece's debt was 117% of its GDP). When the boom turned into a bust there was a massive outflow of liquidity when investors massively sold Greek government bonds pushing interest rates to unsustainably high levels. Due to a poorly designed euro, money during the crisis flew from the weak country's (that is Greece) banks to the strong, leading to divergence (for the issue of divergence in the eurozone see also Hatgioannides et al., 2015). The North unwillingly provided funds to Greece but under strict macroeconomic and fiscal conditions, even though almost none of the surprisingly large amount of money loaned to Greece has actually gone there. Instead it has gone to pay off private sector creditors, including German and French banks.

Instantaneous austerity programmes were applied (ruthlessly cutting spending and raising taxes), leading to a deep recession, which reduced government revenues and as a result the austerity programmes were intensified (Hatgioannides et al., 2015, argue against the policies of austerianism). At this point is worth mentioning that although the large deficit of Greece was partially due to the financial crisis and the global recession, which revealed the deep-rooted structural problems of the Greek economy, the rapid fiscal consolidation and tightening of the budget deficit deliberately threw Greece into a deep recession with long standing effects and catastrophic consequences.

De Grauwe (2015) claims that there was a unilateral absorption of the crisis. That is, a drastic reduction in wages and in prices (an internal devaluation), which in turn produced a deeper recession. Consequently, deflationary dynamics developed (imposed by the common monetary policy), which plunged not only Greece but the euro area as well into a double-dip recession. Because of the incoming deflation the debt burden in Greece worsen. This resound increase in debt levels, eventually led to unsustainable debt to GDP ratios.

Also as deflation took its toll on growth and employment the Greek government attempted to discipline its debt with more drastic spending cuts and tax increases, which further increased the already high unemployment rate and led the bond markets to lose confidence and 'push the situation to the brink'. Therefore, the macro-policies demanded by the troika were a built-in destabilizer, which led to unacceptable levels of unemployment and ever growing inequality.

Thus due to a lack of monetary sovereignty Greece did not have any power to break the cycle of deflation and inflate away part of its debt. The toxic combination of drastic fiscal retrenchment with a lack of any monetary policy tool (easy money or devaluation) resulted in the Greek disaster.

As Krugman (2015b) highlights the Greek governments' deficiency (i.e, irresponsible borrowing which reflects irresponsible lending) has been repeatedly paid by the Greek citizens at a high cost, and the most decisive issue now is to do everything possible to 'end the bleeding'.

Most importantly Krugman (2015b) argues that, in order to avoid a Grexit (refers to Greece's potential withdrawal from the eurozone), Greece needs deep debt restructuring (see also Lagarde's view on the matter in WSJ, 2015). That is, a write-off of a significant portion of its debt; a deal that would lengthen the time over which loans have to be paid back; lowering of interest rates; exchanging part of the debt for GDP-linked bonds. The ECB should act as a lender of last resort and it must provide liquidity immediately. Further, the European Investment Bank should play a more active role in Greece by restoring the inflationary dynamics. Finally, more reasonable budget goals and structural reforms should be demanded by Europe. (Stiglitz 2010, 2015b, c, d, f)

A Grexit from the euro could cause the absolute collapse of the Greek economy. That is, create financial chaos and have catastrophic consequences on its banking system. It might also undermine the credibility of the euro and impose threats on the global economy through contagion risks. An alternative way to exit from the crisis, might be moving towards a dual currency circulation.

However, the authors fear that the collective voice of these three renowned economists will be nothing more than a 'I am the voice of one crying in the wilderness'[42] where the wilderness (or the desert) is the eurozone.

In support of their claims we provide evidence of the negative impacts of the austerity plans on the Greek economy for a period covering 2010-2014. Table 6.2 below presents a brief description of the disastrous consequences that the restrictive policies have had on the Greek economy and society in the previous five years.

The remainder of the Chapter is organized as follows. Section 6.2 reviews the three economists' view (namely De Grauwe, Krugman and Stiglitz) on the European crisis and the Greek issue. Section 6.3 presents our comments, focusing our analysis on the impact that the austerity programs have had on the Greek economy and section 6.4 consists of our concluding remarks.

[42] As it is written in the book of the words of Isaiah the prophet

Figure 6.1 Government deficit as a share of GDP for eurozone countries and euro average 1998-2015 (yearly rate of change)

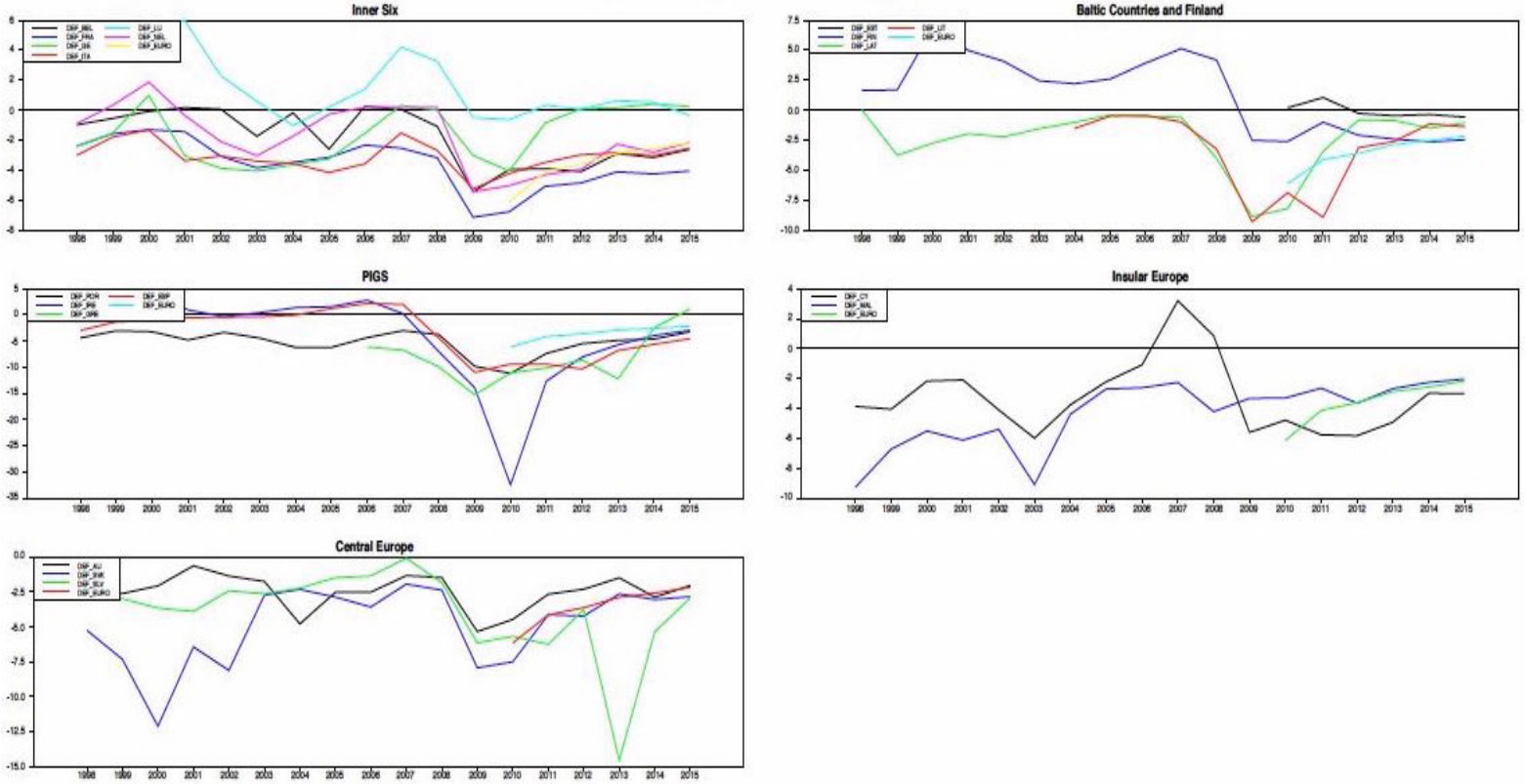


Figure 6.2 Government debt as a share of GDP for eurozone countries and euro average 1998-2015 (yearly rate of change)

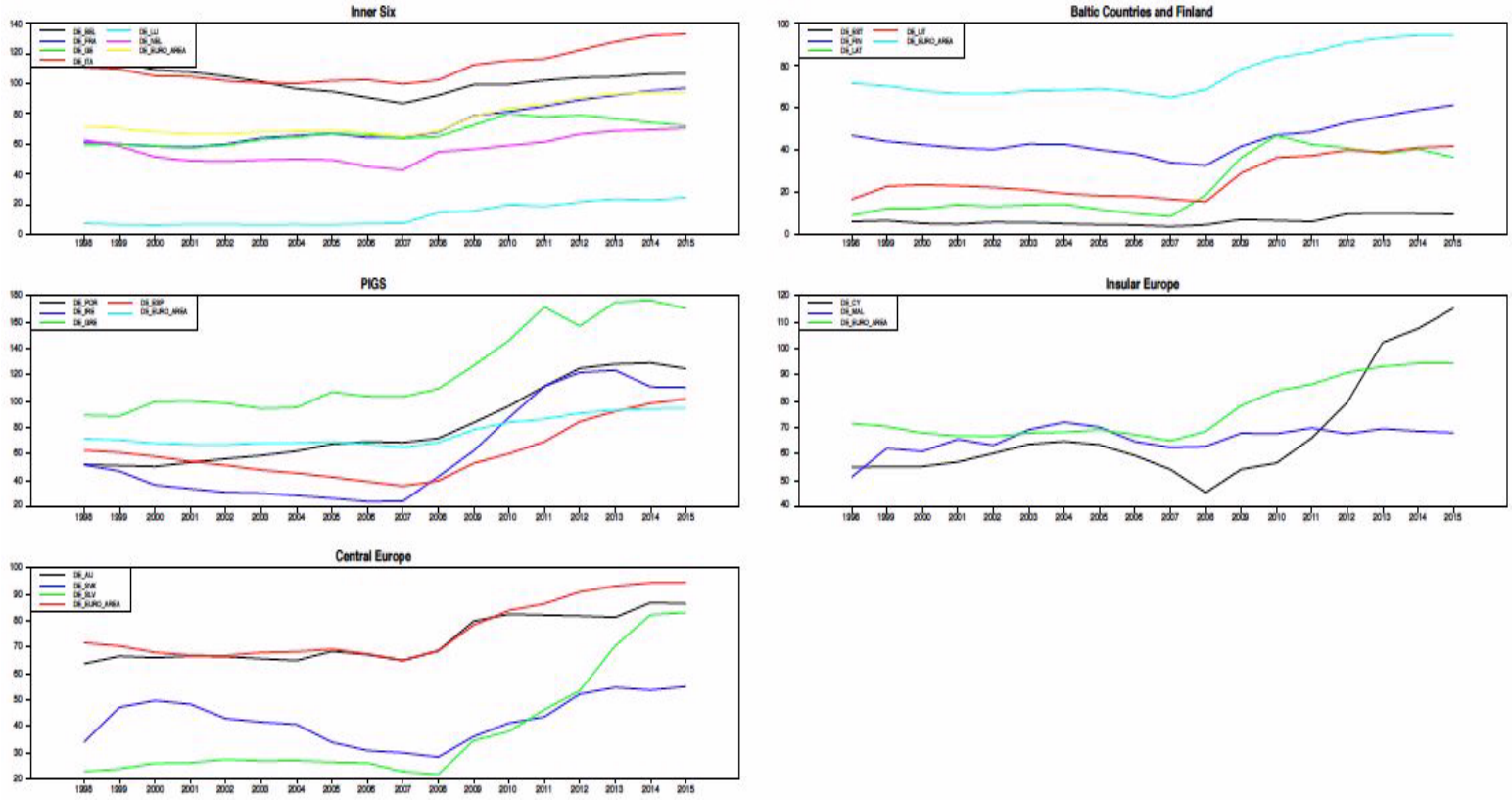


Table 6.1. Notable phrases spoken by the three economists

Paul De Grauwe	Paul Krugman	Joseph Stiglitz
1. For every foolish debtor there must be a foolish creditor	1. Greece did indeed run up too much debt (with a lot of help from irresponsible lenders)	1. The economics behind the program that the troika foisted on Greece five years ago has been abmysal
2. The existing stabilizers...were stripped away from the member-states.This left the member-states naked and fragile	2. What turned Greek debt troubles into catastrophe was Greece's inability to impose fiscal austerity, yes, but offset it with easy money	2. I can think of no depression, ever, that has been so deliberate and had such catastrophic consequences
3. European integration has taken the form of bureaucratic integration as a substitute for political integration	3. Greece's formula for disaster it involved the toxic combination of austerity with hard money	3. The Eurozone was never a very democratic project
4. The euro crisis is not over	4. The euro trapped Greece in an economic straitjacket	4. Greece the sacrificial lamb
	5. These supposed technocrats (the troika officials) are in fact fantasists who have disregarded everything we know about macroeconomics	5. Troika has a criminal responsibility for causing a major recession
	6. Europe's self-styled technocrats are like medieval doctors who insisted on bleeding their patients	6. Europe should at least adopt the principle of 'do no harm'
	7. Greeks have paid for their government's sins many times over. The important thing now is to do whatever it takes to end the bleeding.	

Table 6.2. Impact of austerity policies on the Greek economy

Macroeconomic Indicators
1. Over a period of four years Greek society's wealth was reduced by 20%
2. There was a sharp drop of inflation rates during the period 2010-2015, which put pressure on unemployment rates
3. Consumers' confidence in Greece after 2010 fell sharply, which had a significantly negative impact on private consumption
4. The harmonized unemployment rate amounted in 2015 to 25.5% (more than doubled since 2010) Youth unemployment rate reached 52.4% in 2014
5. After the launch of the first EAP the Greek long-term interest rate (used as a convergence criterion for the EMU) diverged from that of the euro area significantly.
6. The Athens stock market exchange (ASE) is constantly shrinking from 2008
7. After the adoption of the austerity plans credit flow levels reached negative values
8. Foreign direct investment lost almost 60% of its initial value in 2010
9. The credit default swap (CDS) spread (at basis points) is still at high levels
10. Three rating agencies negatively assessed the creditworthiness of the Greek bonds
11. The % of persons whose medical needs were not met (due to the high cost of treatment) almost doubled the period 2010-2014
12. The % of the people that face the risk of poverty and social exclusion increased from around 28 percent in 2010 to 36 percent in 2014
13. Since 2011 Greek society has been faced with an increasing number of total suicides
14. The birth rates drop in the period 2010-2014

Notes: For details see Figure 1 and Figure 3-24 below.

6.2. The Three Economists' View

Paul De Grauwe (on the eurozone crisis)

Debtors and Creditors

De Grauwe (2015) based his arguments on three fundamental axes. The first one supported the idea that the eurozone crisis contributed towards unsustainable government debts that will trouble the euro area further (see Figure 6.2 above), second, the problematic (and hence possibly inefficient) fiscal policies remain at the centre of the continuously soft economic expansion of the eurozone and third, despite the Institutions' efforts at reform, these were not sufficient to address and solve the design failures of the eurozone.

De Grauwe focused on how the Economic and Monetary Union (EMU) is governed. In particular, he distinguishes the eurozone into two parts, namely the countries that belong geographically to the North of Europe (e.g., France, Germany, The Netherlands and Austria) and those belonging to the South of Europe (e.g., Greece, Portugal and Spain).

He points out that the Southern European countries (Ireland as well) are the ones that have accumulated current account deficits in the past (see Figure 6.1 in De Grauwe, 2015). As a result they have become the debtors, and have been hit by sudden liquidity stops and have then been forced to beg the Northern countries (that is, the creditors who have built up current account surpluses) for financial support (see Figure 6.1 above). The direct effect of that was the dominant impact of the creditor countries on the debtor ones and on the eurozone in general. Austerity is the mechanism through which the loans that the reckless creditor nations have extended to the South in the past will be repaid in the future.

However, De Grauwe (2015) is a proponent of the 'symmetric' view that 'for every foolish debtor (a nation who took on too much debt) there must be a foolish creditor (a nation that extended too much

credit)'. Therefore, he argues that not only the debtor nations, but the creditor nations as well, should share the cost of this adjustment. De Grauwe also supports the view that as it happens in the case of banks that are facing the risk of losing part of their loan capital as a consequence of the potential bankruptcy of a borrower the same could apply in the case of the countries-creditors.

Relative unit labour costs

As explained above, the North unwillingly provided funds to the South, but under strict macroeconomic and fiscal conditions. This meant that the debtor countries were obliged to cut spending and to increase taxes. Austerity was the key point for the creditor countries in order to express their solidarity to the debtor ones.

Therefore, that symmetric process, meaning the sharing of responsibilities between debtor and creditor countries, never took place. On the contrary, De Grauwe (2015) stated that debtor countries were indebted to repay in full their loans to the countries-creditors. This asymmetric view led to a series of cutting measures, such as drastic reductions in wages and in prices on the part of debtor countries, which in turn produced deeper recessions. As a result of this 'internal devaluation' the relative unit labour costs (the unit labour cost of a country over the average unit labour cost in the rest of the eurozone) of the debtor countries (that is, of Ireland, Spain, Greece, and to a lesser extend of Portugal and Italy) decreased dramatically (see Figure 6.2 in De Grauwe, 2015). In addition, De Grauwe highlighted the fact that these internal devaluations were very costly in terms of lost output and employment. Consequently, this unilateral absorption of the crisis by the debtor countries developed some deflationary dynamics, which plunged the euro area into a double-dip recession.

Debt ratios

As a result of the 2008 banking crisis the government debt (to GDP) ratios of the debtor countries started to increase. According to De Grauwe (2015) the austerity induced recession just made things even worse, since both the GDP and the government revenues decreased (the latter decline led to higher budget deficits and debts) and, therefore, debt to GDP ratios increased even more. In fact, the more intense the austerity measures were the more resounding was the increase in debt levels, eventually leading to unsustainable debt ratios (see Figure 6.4 in his article, 2015). Thus all these sacrifices (from the Southern countries) were partially blamed for making things worse. Furthermore, De Grauwe provides empirical (cross-section) evidence for the negative impact of austerity (introduced by the IMF as the variable of the fiscal impulse) on the cumulative growth during 2009-2012 (see Figure 6.5, in De Grauwe, 2015).

Finally, in a simulation study (assuming that nominal growth will be equal to the nominal interest rate, and that primary surpluses will be created) De Grauwe (2015, Table 6.1) found that even under these favourable macroeconomic conditions it will take a long time (many decades in fact) for the indebted nations to halve their debt levels and to achieve sustainability.

Design Failures of the eurozone

The third argument that De Grauwe's paper is based on is the design failures of the eurozone and the inadequate attempts to resolve them.

Single interest rate

The existence of a common interest rate (fixed by the ECB) among the euro area members imposed pressure on the countries in recession in contrast to the growing ones, where the interest rate was too low. As pointed out by De Grauwe (2015) the single interest rate that the ECB imposed on all member countries was too low for Spain, Ireland and Greece, whose economies were starting to boom. When inflation also rose in these booming countries the low interest rate aggravated the boom. Those divergent dynamics led to discrepancies in inflation, relative unit labour costs and current accounts (De Grauwe, 2015). The booming economies of the South experienced higher levels of inflation rates and increases

in unit labour costs, which in turn led to large current account deficits. On the other side, Northern countries (who financed the booms in the Southern countries by credit) accumulated current account surpluses.

Lender of last resort

De Grauwe (2015) argued that the elimination of the lender of last resort backing of the member state countries triggered self-fulfilling liquidity crises. These crises (which emerged when booms turned into busts) were caused by a massive outflow of liquidity when investors lost confidence in Greece, Portugal and Spain, and massively sold the government bonds of these countries, pushing interest rates to unsustainably high levels. Then these crises turned into solvency crises. De Grauwe says: 'The governments of the problem countries were forced into instantaneous austerity programmes, by cutting spending and raising taxes. These programmes led to deep recessions, which in turn reduced government revenues even further, forcing these countries to intensify the austerity programmes'. Eventually this led to a deflationary spiral that made the fiscal crisis more intense.

De Grauwe (2015) defends the theory which implies that despite the fact that fundamentals cannot be ignored there is a special role for the central bank, which has to provide liquidity in times of market panic. The role of national stabilizer was undertaken (finally) by the ECB after its decision and the launch of the Outright Monetary Transactions (OMT) on the 6th of September 2012. With this political move the ECB became lender of last resort for banks as well as sovereigns. The beneficial effect of the decision can be seen from Figure 6.5 in De Grauwe (2015), where spreads declined drastically after the announcement of the OMT.

Policy Implications

De Grauwe argues that although the ECB is the 'ultimate guarantor of the sovereign debt in the eurozone' and in this sense has evolved into a central bank such as the Federal Reserve, there is no primacy of the governments of each of the member states over the central bank. De Grauwe (2015) suggests the formation of a eurozone government that will have control over the ECB and will be supported by a European Parliament.

De Grauwe also points out that the EC and the ECB have seen a significant increase in their power since the sovereign debt crisis in the eurozone, without a concomitant increase in their accountability (e.g., the EC can now force countries to raise taxes and reduce spending, without, however, having to bear the political cost of these decisions). De Grauwe highlights the fact that both the EC and ECB with their decisions affect millions of people's welfare. Nevertheless, these people are unable to express their disagreement with such decisions via democratic means such as elections.

De Grauwe (2015) concludes by suggesting that the eurozone should direct its efforts towards a fiscal and political union where a eurozone government supported by a European Parliament will be dominant over the central bank in times of crisis.

Paul Krugman (on the Greek issue)

Numerous times during the EU sovereign debt crisis the Nobel laureate economist Paul Krugman expressed his opinion regarding the failure to tackle the Greek crisis issue by the Institutions. In this paper, we will summarize four of the articles that Krugman wrote in his column in The New York Times.

From Problems and Troubles to a Catastrophe

Even from 2010, when the first signs of the Greek catastrophe that would follow in the coming years unfolded, Krugman stated that Greece was approaching the zero point. According to Krugman (2010), Greece ('a faraway country with an economy roughly the size of greater Miami') is paying the price for

past fiscal irrationality. Yet this view is only one side of the coin, and is by no means the whole story (Krugman, 2015a).

In full alignment with Krugman we argue that Greece (that is, its various Governments) indeed for many years borrowed and spent in excess of the country's capabilities. Although the Greek government was spending beyond its means in the late 2000s since then it has repeatedly cut public spending and raised taxes. However, a restriction of the primary deficit should have occurred by now. On the contrary, the national account statistics have not improved (see Figure 6.5 below in Section 6.3).

Greece's public debt in 2008 was 113 percent of GDP (see: Figure 6.4 in Section 6.3 and Ali et al., 2010). At this point it is worth mentioning that Greece is one of the eurozone countries and these high level government debts were part of the deflationary dynamics that were imposed by the common monetary policy. In any case the Greek debt was at unprecedented levels, yet previous countries confronted similar financial difficulties without entering a crisis. To illustrate this, we will refer to Krugman's (2010) example. In 1946, the post World War II United States, similarly to other countries, was faced with high levels of government debt (equal to 121 percent of GDP; see Ali et al., 2010). In the next decade the ratio of US debt to GDP fell to 62 percent, which was the result of both economic growth (GDP increased more than 70 percent in the period from 1946 to 1956, see Maddison-Project, 2013) and inflation. Nevertheless, this seems to be a utopian scenario for the Greek economy. With negative GDP growth rates in the period 2008-2013 (see Figure 6.3 below, data provided by the World Bank) and participation in a hard currency (euro) that allowed limited space and freedom for progressive and bold monetary policies, the future of the Greek economy is at stake.

In Greece the influx of cheap loans and large amounts of capital into the country as well as it being a member of the eurozone boosted inflation. When the capital inflows (the music as Krugman puts it) stopped Greece was faced with high costs and prices, which were significantly greater than those of the big European economies. Since prices had to come down, Krugman (back in 2010) predicted (correctly) that because of the incoming deflation the debt burden in Greece would worsen, see Figures 6.4 and 6.8 in Section 6.3 below (unlike the US one, which was partly inflated).

He also predicted (again correctly) that as deflation took its toll on growth and employment (as pointed out by Krugman even a G7 country with its own currency like Japan can be trapped in a deflationary vortex) the Greek government would attempt to discipline its debt (indeed today Greek debt is up only 6 percent since 2009, partly because it received some debt relief in 2012) with drastic spending cuts and tax increases, which would further increase the already high unemployment rate (see Figures 12-14 below) and would lead the bond markets to lose confidence (see Figures 6.6 and 6.15 below) and 'push the situation to the brink' (today the Greek debt is over 170 percent of GDP- and still rising- because GDP is down by more than 20 percent; thus austerity probably shrinks the economy faster than it reduces debt). Krugman (2010) argued that with German support (which unfortunately did not materialize) the European countries should have guaranteed Greek debt in exchange for an obligation to undertake harsh fiscal measures. However, in 2015 one member of the troika, the IMF reached the conclusion unilaterally that Greece's debt cannot be repaid. Krugman (2015c) points out that it was Greece's inability, thanks to the euro, to offset fiscal austerity with easy money that turned its debt troubles into a catastrophe. In Krugman's words: 'It was the toxic combination of austerity (drastic fiscal retrenchment) with hard money that resulted in the Greek disaster'. That is, Greece did not have the choice of devaluation or any other monetary policy tool to support its failing economy.

Back in 2010 Krugman also argued that a possible Grexit from the euro (according to him the creation of the common currency was a 'terrible mistake' since Europe did not fulfil the criteria for a prosperous common currency nor the appropriate fiscal and banking union in order to prevent or to confront crises such as the recent one; see Krugman 2015a) would have catastrophic consequences on its banking system. Krugman further highlights the fact that two of the many risks of a Grexit are 'financial chaos and of business hobbled both by banking troubles and by uncertainty over the legal status of debt'. Accordingly, since abandoning the single currency could cause the absolute collapse of the economy, the

Greek government (which is now begging for a standstill on further austerity) has succumbed to creditors' claims for strict austerity plans and structural reforms. In Greece, which did not have the option of a currency devaluation that would have made its exports more competitive and would have broken the cycle of deflation as, for example, in Canada in the 1990s[43], the failed austerity brought a depression and the collapse of the Greek economy. So now, in the words of Krugman, 'we know that even harsher austerity is a dead-end'.

According to Krugman (2015a), the fact that the leftist coalition under Syriza in Greece has acceded to the troika's (the institutions representing creditor interests) ultimatum represents the 'final abandonment of any pretence of Greek independence'. Krugman says that 'the troika officials, these supposed technocrats, are in fact fantasists who have disregarded everything we know about macroeconomics'[44].

Although many analysts used to claim that the adoption of the euro was an irrevocable move, Krugman (2015b) wonders whether a Grexit might work, as in the case of Iceland, where the devaluation of 2008-2009 proved to be extremely successful, or the case of Argentina, which abandoned its one-peso-one-dollar policy in the period 2001-2002. After all, even in the event that Greece receives generous debt relief, leaving the euro might be the only means of escape from the economic depression that the country has faced for five years now. Krugman (2015b) concludes his analysis by saying that the Greek governments' deficiency (i.e., irresponsible borrowing which reflects irresponsible lending) has been repeatedly paid for by the Greek citizens at a high cost, and that the most decisive issue now is to do everything possible to 'end the bleeding'.

Joseph E. Stiglitz (on the Greek issue)

The Austerity Programme

With the outbreak of the Greek crisis, Stiglitz (2010), in an article in The Guardian, castigated the role of the developed countries in Europe towards the Greek issue. In particular, while Greece was criticized severely for falsifying the figures of the national statistics, this did not happen for other countries of Europe when they exceeded the upper limit of deficit as a percentage of GDP established by the Treaty of Maastricht. According to Stiglitz (2010) the Treaty of Maastricht, had already been converted into a two-speed Treaty, one for the strong European countries and one for the weak ones. Although the financial crisis (of 2007-2008) brought to the surface the structural weaknesses of the Greek economy, the large deficit of Greece was partially due to that financial crisis (Greece, like many other countries, was not responsible for causing this global crisis, yet the economy felt the impacts very severely).

After almost five years of austerity experiments on Greece, he revisited the issue with 6 more articles in high volume/traffic newspapers and blogs. According to Stiglitz (2015a) the eurozone appears not to be a very democratic project, and the true nature of the ongoing debt dispute is not about money or debates around robust economic policies but about power (see also De Grauwe, 2015). The program that the troika foisted on Greece for the past five years has been characterized by Stiglitz as abysmal.

Moreover, Stiglitz (2015a, 2015c) alludes to the fact that the implementation of the austerity program, the EAP, economic adjustment programme (Greece had the most significant and rapid fiscal consolidation among the advanced European economies, ruthlessly cutting back on expenditure and raising new revenues) 'deliberately' led to a depression that had long standing effects and 'catastrophic consequences' (see Figure 6.3 for growth and Figures 6.12-6.14 for unemployment rates), and it is already deeper and more prolonged than the Great Depression in the US. Finally, Stiglitz (2015c) points out that without

[43] In the words of Krugman (2015b): 'The truth is that Europe's self-styled technocrats are like medieval doctors who insisted on bleeding their patients — and when their treatment made the patients sicker, demanded even more bleeding.'

[44] Canada in the 1990s, by combining fiscal austerity, drastically reduced interest rates (to encourage private spending) and a currency devaluation programme (to promote exports), managed not only to slash its debt but to maintain growth and reduce unemployment as well.

any of these reforms, Greece grew at a faster rate than the EU beginning in the mid-1990s until the global crisis (4 percent vs 2 percent).

Criticisms

According to Stiglitz (2015e), weaknesses in the design of the euro and the design of the ECB, which is not provided with adequate tools to address unemployment, damage Europe's prospects. It appears that the countries that decided not to be part of the common currency, such as Sweden, seem to be in better condition than those that joined the eurozone, for example, countries like Greece, Portugal and Spain that cannot change economic policies, no matter how harmful they become. Stiglitz argues that the euro is 'poorly designed as in a crisis money flows (for the case of Greece see Figures 6.7, 6.9 and 6.17 below) from the weak country's bank to the strong, leading to divergence' (for the case of Greece see Figure 6.15 below, while for the divergence problem in the eurozone check, among others, Karanasos et al., 2015, Hatgioannides and Karanassou, 2015, and Morana, 2015). Stiglitz (2015d) alludes to the fact that GDP today is lower by 17 percent than the level that it would have been had the soft pattern of European economic growth continued its course.

Greece and other eurozone member countries have turned over their monetary sovereignty to the ECB, which focuses single-mindedly on inflation. As a result, unemployment rose, and insufficient attention was paid to financial stability (Stiglitz, 2015a; see also De Grauwe, 2015). It seems that Greece's destiny is not in her own hands.

According to Stiglitz (2015a) the troika used bad forecasts and models. The troika's demands (e.g., that Greece should achieve a primary budget surplus, excluding interest payments, of 3.5 percent of GDP by 2018) have been condemned by economists around the world, among them Stiglitz, who argues that such demands will lead to unsustainable levels of debt and a deeper downturn. In his words (2015f), the macro-policies demanded by the troika and its incoherent programme will lead to a deeper Greek depression without end, unacceptable levels of unemployment and ever growing inequality. It is a built-in destabilizer. The high unemployment rate will drive down wages and lower Greeks' standard of living even more, possibly leading to even greater economic, social and political chaos (for the case of Greece see Figure 6.20 below). Actually the first two have already arrived whereas the third one is around the corner.

Furthermore, Stiglitz (2010) argues that although Greece is among the poorest of the European family, if Europe had developed a more efficient solidarity and stabilisation framework, then budget deficits in the periphery of Europe might have been smaller and hence easier to manage. For example, in the USA there is a sense of social cohesiveness and, hence, when one part of the country has difficulties, federal spending can be diverted to help those parts that are in need. Unlike the US structural framework, the EU before and even after the introduction of the common currency did not have an overall support mechanism (either financial or structural) in order to protect its economies when they face financial constraints.

In addition, Europe did not adopt the principle of do no 'harm'. As mentioned by Stiglitz (2010; in his article in the Guardian) the ECB announced that it would not accept Greek bonds as collateral and assigned the task of the evaluation of the credit-worthiness of Greek bonds to the rating agencies (see Figures 6.23 and 6.24 below). Additionally, announcements made by the EU leaders exacerbated Greece's problem. A large part of Greece's deficit is the result of the global recession, which revealed the deep-rooted structural problems of the Greek economy. However, European leaders' statements have sent the interest rates Greece has to pay soaring, making it all the more difficult for Greece to tame its deficits (Stiglitz, 2010).

Furthermore, Stiglitz claims that Greece needs debt restructuring. It is an oxymoron that the defeated Germany (after World War II) that received unconditional aid from US with the Marshall Plan (which constituted in real terms the largest financial assistance and debt reduction in world history) now refuses even to discuss such a scenario in the case of Greece (Stiglitz, 2015d). Although some of Greece's debt was restructured, it was too little and not done well. When the crisis began, Greece's debt was about 117

percent of its GDP (see Figure 6.4 below). Today, after restructuring, after a program allegedly designed to increase the sustainability of debt, it stands at 177 percent, (Stiglitz, 2015c).

Stiglitz (2015c) brings up the point that Greece's bailout was not a bailout of the country but of the Western banks, who did not do adequate due diligence. In full agreement with De Grauwe's (2015) arguments, he noted that the lenders 'bear even more responsibility for the current mess than the borrowers'. For example, it is remarkable that almost none of the surprisingly large amount of money loaned to Greece has actually gone there. According to Stiglitz (2015a, c; see also some recent figures published by IMF) 90 percent of it has gone to pay off private sector creditors, including German and French banks. As another example, Goldman Sachs structured irresponsible deals that enabled the Greek government at the time of the Maastricht Treaty to skew the numbers of its debt.

Stiglitz points out that similar austerity programs (and structural reforms) imposed by the IMF on the East Asian countries in the late 1990s had devastating effects. In particular, he stated that 'both before and after the crisis in East Asia, and those in Africa and in Latin America (most recently, in Argentina), these programs failed, turning downturns into recessions, recessions into depressions', Stiglitz 2015f. A prominent example is the case of Indonesia (which surrendered its economic sovereignty), where in 1998 the IMF ruined the country's banking system (see Stiglitz, 2015f).

Negative consequences of the programme

In the last five years the Greeks have managed to transform a large primary deficit into a surplus. This was a great achievement. However, the rapid tightening of the budget deficit threw Greece into a deep recession, and the cost in human suffering has been extremely high. According to Stiglitz's experience there has been no other intentional recession that resulted in such destructive results. There is a 25 percent decline in the country's GDP, and Greece's rate of unemployment has reached its peak of 25 percent (with youth unemployment rate exceeding 50 percent), see also the analysis in Section 3 and Figures 12-14 below.

Moreover, as pointed out by Stiglitz, these types of policies (e.g., tax hikes and pension cuts) have done so much to increase inequality in so many advanced countries (see also Hatgioannides and Karanassou, 2015). Despite the fact that the IMF has warned of the dangers that the high taxation might impose, yet in Greece the troika insisted on imposing high taxes even at low income levels. A mistaken tax policy can help destroy an economy. Although the requirement is intended to reduce tax evasion, in the case of Greece it will destroy small business (Stiglitz, 2015f).

The aforementioned major negative consequences are some of many of the austerity programmes. Most importantly, Stiglitz mentions that 'special interests in the rest of Europe and some within Greece itself have taken advantage of the troika to push their own interests at the expense of ordinary Greek citizens and the country's overall economy' (Stiglitz, 2015f). Stiglitz highlighted the fact that as a result, Greece might end up as a depleted country - one that has sold off all of its assets, and whose bright young people have emigrated.

What has to be done

The solution of the 'Greek problem' according to Stiglitz might lie in the following points.

Stiglitz (2010) claims that Europe should re-examine the short-run budgetary targets (meaning more reasonable primary budget surplus targets, that is the imbalance between government revenues and expenditure) it sets for Greece in terms of the structural deficit. In particular, more reasonable budget goals, such as a 'primary surplus' of 1 percent, and reasonable structural reforms should be demanded by Europe. No country can sustain levels of primary surpluses as high as 3.5 percent for a long period of time without deepening the recession and causing social and political unrest.

Stiglitz (2015b, c, f) indicates that Greece needs deep debt restructuring, that is, a write-off of a significant portion of Greece's debt (estimated to be worth close to $300 billion in bailouts), or at least a

deal that would lengthen the time over which loans have to be paid back (even the IMF, i.e., its current managing director Christine Lagarde, is calling for deep debt restructuring).

An alternative scenario of debt restructuring, proposed by Stiglitz (2015c, d), is either lowering interest rates or exchanging part of the debt for GDP-linked bonds, which would pay more in case Greece recovered. Such an exchange lines up the incentives of debtors and creditors (unlike the current system, where Germany benefits from the weaknesses in Greece; see also De Grauwe, 2015).

Furthermore, the European Investment Bank should undertake countercyclical investments in the country and offset the deflationary impacts of the austerity programmes (e.g., the budget cuts). In general it should play a more active role in Greece by restoring the inflationary dynamics. The provision of such support might lower interest rates, and help the country achieve budgetary balance (Stiglitz, 2010).

Stiglitz (2015c) also suggests that the ECB should act as a lender of last resort and he argues that it must provide liquidity immediately (see also De Grauwe, 2015). That is, it should offer the stimulus money that two successive Greek governments have been requesting.

Grexit

During an interview in TIME magazine, Stiglitz (2015b) called attention to the fact that there is no way to predict the long-run consequences of Greece abandoning the euro. A Grexit might undermine the credibility of the euro and impose threats on the global economy through contagion risks. If the Greek economy recovers after abandoning the euro, this may trigger intense anti-euro politics. If, on the other hand, the Greek economy collapses outside the euro, then there will be a failed state on the edge of Europe, and that is when the geopolitics will become very ugly, Stiglitz (2015b).

In an economy which is globalized to such an extent it is difficult to know all the linkages, and thus safe predictions related to the connections between events and institutions are most probably impossible. For example, many countries of Eastern Europe are still heavily dependent on Greek banks, and in the case of the bad scenario, that is, those banks collapsing, the EU will face the risk of a financial turmoil that could easily be transmitted to the rest of the world economy (Stiglitz, 2015d).

Parallel Currency (and the similarities with Argentina)

Stiglitz (2015e) points out that an alternative way to exit the crisis might be moving towards a dual currency circulation, using both the euro and a 'Greek euro', a currency that would be tradable only within the country's own banking system.

Argentina (Campos et al., 2012 and Campos et al., 2015, among others, present a detailed analysis of economic growth in Argentina) and others have shown how this can be done. In particular, the government would recapitalize the banks using the newly issued currency, extend the capital controls, limit withdrawals from banks, and promote money transfers within the banking system from one party to another (Stiglitz, 2015d). Despite the fact that every country is different there are, however, some astonishing resemblances between the two countries (Argentina and Greece). Both countries were being choked by austerity as well as (under the IMF programs) experiencing rising unemployment, poverty, and immense suffering (Stiglitz, 2015d).

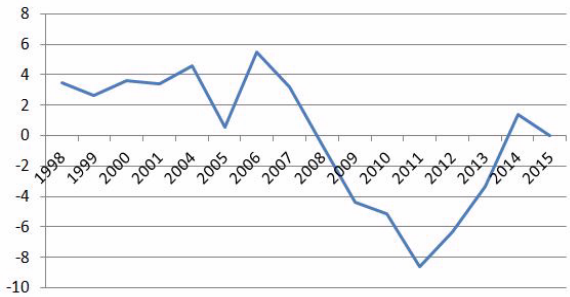
6.3. A Comment: The Greek Economy after Five Years of Austerity

The outbreak of the crisis in 2008 found the Greek economy already crumbling. Figure 6.3 below shows the steep decline of GDP per capita growth in 2008 (-0.65 percent) after a period (1998-2007) with a benign macroeconomic environment, with an average growth rate of +3.38 percent [for example

the GDP of North Greece and Aegean Islands was similar to that of Croatia and Cameroon in 2008 (namely 60,600 and 23,300 million euros respectively) while in 2012 it was similar to that of Slovenia and Equatorial Guinea (around 47,500 and 18,100 million euros respectively)]. It is noteworthy that in 2008 the gross general government debt (see Figure 6.4 below) reached its highest level (112.9 percent of GDP) since the restoration of democracy in 1974. After the condemnation of Greece by the EC because of misrepresentation of its national statistical data, the newly elected socialist government was forced (by the events) to revise the estimations regarding the level of general government deficit (notably Eurostat reports data related to government deficit for Greece after 2011 see Figure 6.5 below) from 5 to 7.7 percent for 2008 and from 3.7 (the figure predicted by the previous government some months earlier) to 12.5 percent for the year 2009. Already, since October 2009, the 10-year government bond yields started to rise (see Figure 6.6 below). From Figure 6.5, we can notice that when the Greek Prime Minister (PM) George Papandreou called on his EU partners and the IMF to provide financial assistance (23^{rd} April 2010), the long term government bond yields reached levels around 8 percent and after that the rates followed a rising pattern. The economic calvary of Greece had just begun.

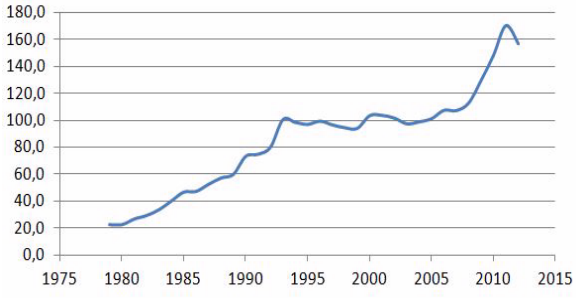
For five years (2010-2015), Greece implemented endless austerity (solidarity) measures that had disastrous effects (see Krugman and Stiglitz above) on its economy. In this section we will try to present the consequences that the five years of restrictive policies had on the Greek economy and on society in general.

Figure 6.3. GDP per capita growth (% change) for Greece, annual data 1998-2015



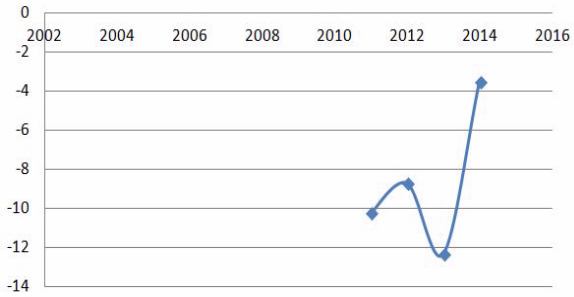
Source: World Bank

Figure 6.4. Gross general government debt (% of GDP), annual data 1979-2012



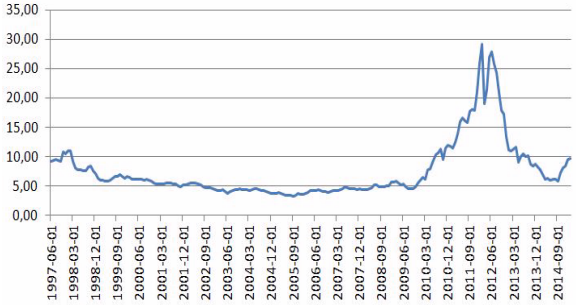
Source: Ali et al. (2010)

Figure 6.5. General government deficit (% of GDP), annual data 2011-2013



Source: Eurostat

Figure 6.6. Long-Term Government Bond Yields: 10-year for Greece, monthly data 1997:06-2015:02



Source: OECD

Macroeconomic indicators

Gross domestic product

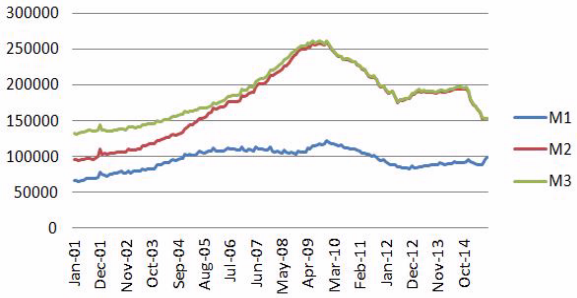
After the announcement of the referral to the support mechanism by the ex Greek PM George Papandreou and the implementation of strict fiscal measures by the subsequent governments, the macroeconomic indicators of the Greek economy do not seem to have improved. In particular, GDP per capita growth (see Figure 6.3 above) shrank on average by 5.85 percent in the period 2010-2013 and from 21,900 (in 2010) to around 18,100 (in 2013) US dollars (at constant 2005 prices, see World Bank, 2015). In 2014, the Greek economy displayed some signs of improvement (the GDP per capita increased from 18,100 in 2013 to 18,400 US dollars in 2014), though at significantly lower levels than that of the pre-crisis period. Similarly, the country's GDP fell from 299.6 billion US dollars in 2010 to 238.5 billion US dollars in 2014 (World Bank, 2015). Hence, over a period of four years Greek society's wealth was reduced by 20 percent. Stiglitz (2015a) cannot recall any other depression (like Greece's) that resulted in such a devastating impact.

Monetary aggregates (M1, M2 and M3) and inflation rates

Monetary aggregates are very important tools for the ECB. By adjusting them the central bank can control inflation. Too much money in an economy could lead to higher inflation and vice versa. Hence, central banks often use this macroeconomic tool to promote economic expansion and increase GDP growth at the cost of a simultaneous increase in the inflation rates. But a problem that arises very often is which one of the three measurements (M1, M2, and M3) is the most appropriate for the central banks in order to affect key indicators of the economy. Mishkin (2009) argued that we do not know exactly which of the money supply indicators is the most accurate. Hence if M1, M2 and M3 follow a parallel performance then we could use one of the three, in order to develop the appropriate economic policies and predictions for the future. Figure 6.7 reports the monetary aggregates (M1, M2 and M3) for Greece from 2001 to 2015. The data show a downward trend, especially for M2 and M3 aggregates [and hence a decrease in deposits (M2), which in turn caused a lack of liquidity in the Greek economy and recapitalization issues for the Greek banks] after 2010 and the launch of the economic adjustment program (EAP) imposed by the troika.

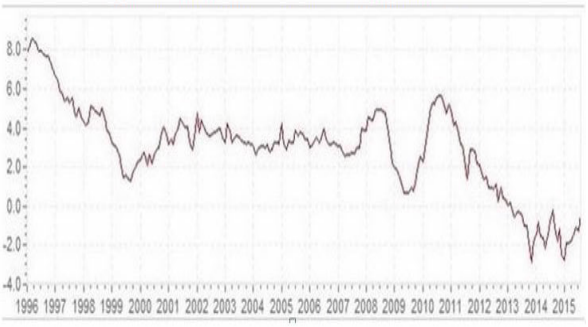
Since the level of inflation is directly affected my monetary aggregates, the Greek economy faced a decreasing trend of inflation rates after 2010 and negative ones from 2013 and onwards. This sharp drop of inflation rates during the period 2010-2015 might be due to three reasons: firstly because of a reduction in money supply (in Greece a reduction of money supply took place, see Figure 6.7), secondly due to lower credit (see Figure 6.9 below) and thirdly because of reduced consumer spending (after 2010 private consumption fell, see Figure 6.10 below). In the last three years, deflation put pressure on unemployment rates (see below for further details), transforming a recession into a depression (see Krugman 2015a).

Figure 6.7. Monetary aggregates (M1,M2 and M3), monthly data 2001-2015



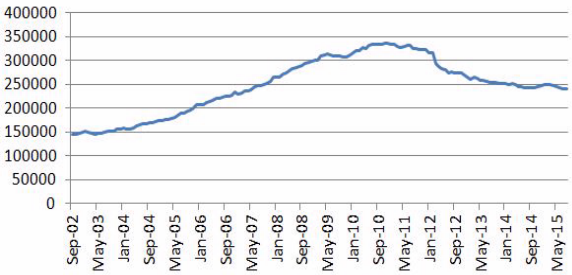
Source: Bank of Greece

Figure 6.8. Inflation rates for Greece, annual data 1996-2015



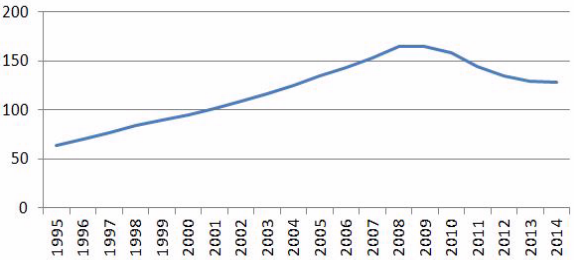
Source: Inflation.eu

Figure 6.9. Credit to domestic public and private sectors by domestic Monetary Financial Institutions (million euros), monthly data 2002-2015



Source: Bank of Greece

Figure 6.10. Private Final Consumption Expenditure in Greece (billion euros), annual data 1995-2014

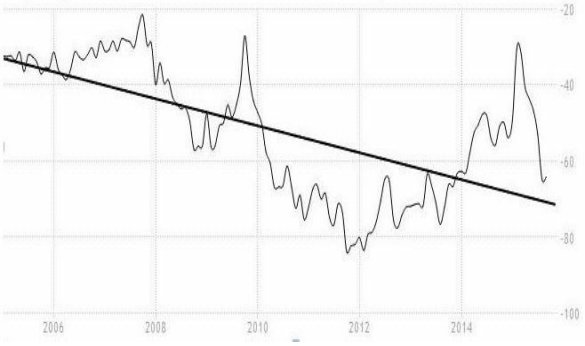


Source: OECD

Consumer confidence index

Figure 6.11 (European Commission, 2015) below reports the level of the trust that consumers have towards the Greek economy. The importance of this statistic lies in the fact that consumers are more willing to spend money since they feel more certain about their financial and career prospects. The trend (dashed line) shows that the consumers' confidence in Greece after 2010 fell sharply, which had a significantly negative impact on private consumption (see Figure 6.10 above).

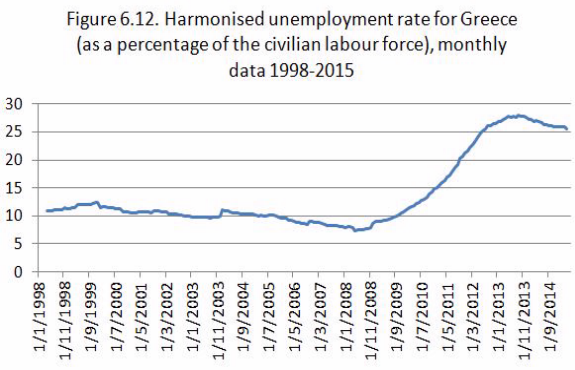
Figure 6.11. Consumer confidence index for Greece, annual data 2006-2015



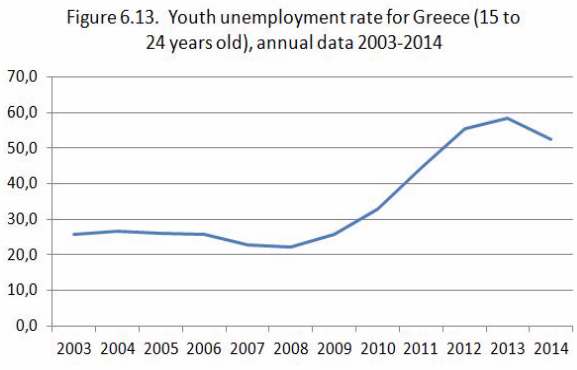
Source: European Commission

Unemployment rates

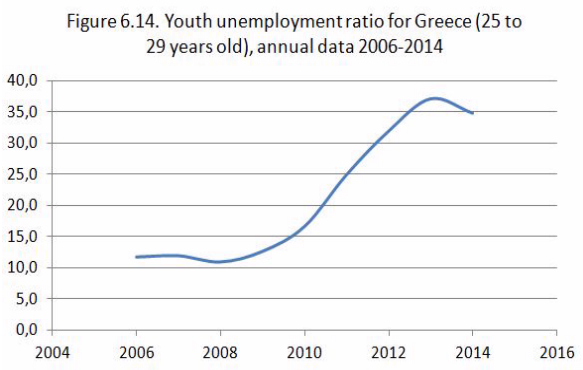
The effects of the crisis were even more severe for unemployment rates. The harmonized unemployment rate (as a percentage of the civilian labour force), see Figure 6.12 below, increased after 2010 and amounted to 25.5 percent in 2015 (it more than doubled after 2010) according to Eurostat projections. Hence, despite the measures that the Greek government adopted after the proposals of the troika under the first and second EAP, Greece shows the highest unemployment rates in the EU (according to Eurostat). Even more remarkable is the youth unemployment rate (the group of unemployed persons aged between 15 and 24) for Greece (see Figure 6.13 below), reaching 52.4 percent in 2014 and reflecting how difficult it is for the young people to find a job. However, due to the fact that many young people are studying full-time and are therefore neither working nor looking for a job (so they are not included in the workforce, which is used as the denominator for calculating the unemployment rate), for this reason, youth unemployment ratios are estimated as well (the share of unemployed for the whole population). In particular, the youth unemployment ratio for the ages between 15 and 24 rose from 9.9 percent in 2010 to 14.7 percent in 2014 and for the ages from 25 to 29 years old the unemployment ratio rose from 16.7 percent in 2010 to 34.9 percent in 2014 (see Figure 6.14 below). The latter show how difficult it is for the most active population (young people) to find a job in Greece.



Source: Eurostat



Source: Eurostat

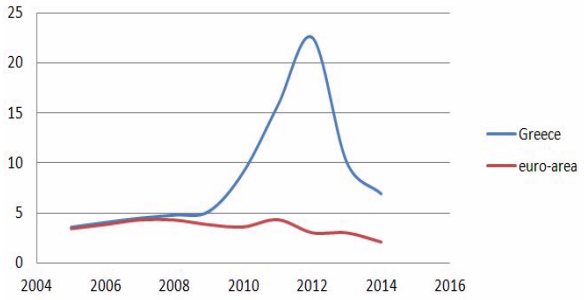


Source: Eurostat

Maastrict criterion interest rates

Interestingly, despite the fiscal consolidation of the previous years (2010-2014) the Greek economy seems to have diverged even more from the EMU countries. Maastricht criterion bond yields are long-term interest rates, used as a convergence criterion for the EMU, based on the Treaty of Maastricht (Eurostat, 2015). Figure 6.15 below clearly shows that after the launch of the first EAP for Greece in 2010 the Greek long-term interest rate diverged from that of the euro area significantly.

Figure 6.15. Maastricht criterion bond yields for Greece, annual data 2005-2014

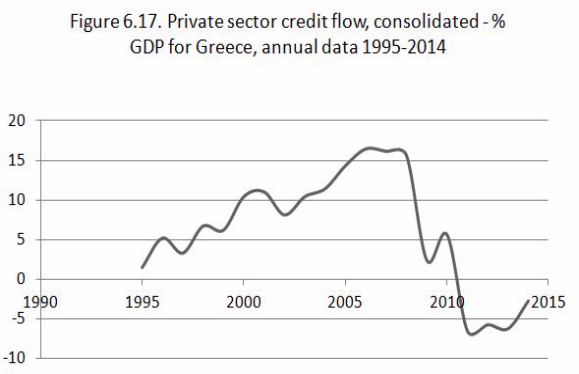


Source: Eurostat

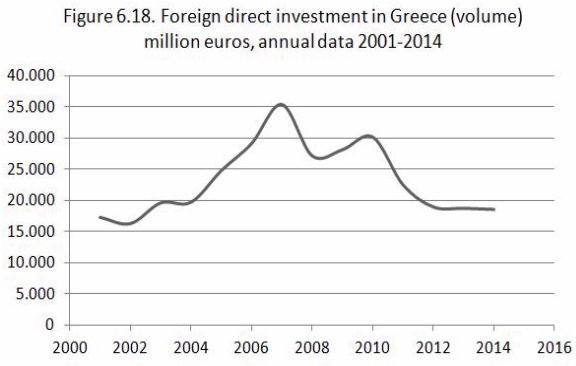
Athens stock exchange (ASE), private sector credit flow and foreign direct investment (FDI)

Stock markets can very often be used as a barometer of future business and consumer confidence. In particular, positive stock market returns can be interpreted as an indicator of the development of business investment as well as a trace of greater consumer expenditure in the future. In Figure 6.16 below, the Athens stock market exchange (ASE) is constantly shrinking from 2008 (the outbreak of the financial crisis) and onwards (during the 1^{st}, 2^{nd} and 3^{rd} EAP of Greece). The fall of the ASE reflects the economic instability and insecurity that was dominant after five years of austerity. In addition, Figure 6.17 reports the level of private sector credit flow as a share of GDP from 1995 to 2014. Since the financial crisis of 2008 (when the credit flow started decreasing), and especially after the adoption of the austerity plans by the Greek government, credit flow levels reached negative values, suggesting that during the period 2010-2014 businesses operated in a very tight liquidity environment since credit institutions were extremely unwilling to fund them. Similarly, according to the Bank of Greece (2015), foreign direct investment (in millions of euros) continuously diminished after 2010 (and the launch of the austerity plans imposed by the troika) by losing almost 60% of its initial value in 2010 (see Figure 6.18 below).

Source: Athens stock exchange (ASE)



Source: Eurostat

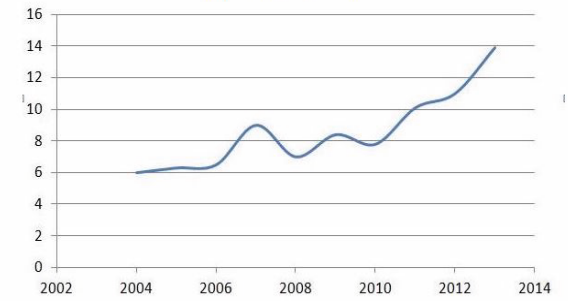


Source: Bank of Greece

Healthcare access, poverty risks, suicides and birth rates

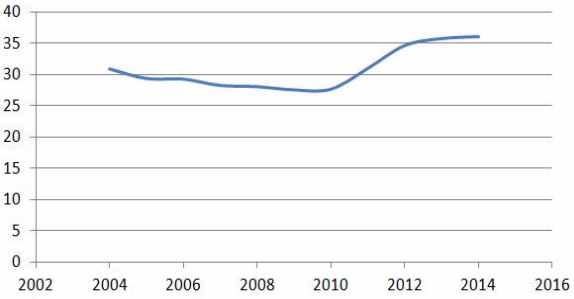
Figure 6.19 below reports the self-reported unmet needs for medical examinations (including all ages and both male and female, as a share of total visits). The reason that these needs were not met was that the healthcare service was too expensive for them. It is clear that the restrictive policies that were employed in Greece after 2010 did not leave the health sector unaffected. The percentage of the persons whose medical needs were not met due to the high cost of treatment increased from 8 percent in 2010 to 14 percent in 2014. Hence, the citizens' access to health services was limited further during the period 2010-2014. Ever more remarkable is the increase in the rate of the people at risk of poverty or social exclusion (as a share of the total population). From Figure 6.20, the percentage of the people that face the risk of poverty and social exclusion increased from around 28 percent in 2010 to 36 percent in 2014, demonstrating the serious social consequences of the austerity program. As far as the number of suicides is concerned, Branas et al. (2015) argued that since the beginning of the austerity measures in 2011 Greek society has been faced with an increasing number of total suicides, marking the negative (unintended) impacts that these policies might have had on the mental health of the people. Similarly, birth rates (the average annual number of births during a year per 1,000 persons in the population at midyear, see CIA World Factbook, 2015) started diminishing even from 2004, though this drop became even steeper after the financial crisis of 2008 and in the period 2010-2014 (the period of the Greek sovereign debt crisis, see Figure 6.21).

Figure 6.19. Self-reported unmet needs for medical examination by sex, age, detailed reason and income quintile for Greece-% of visits, annual data 2002-2014
Main reason: too expensive



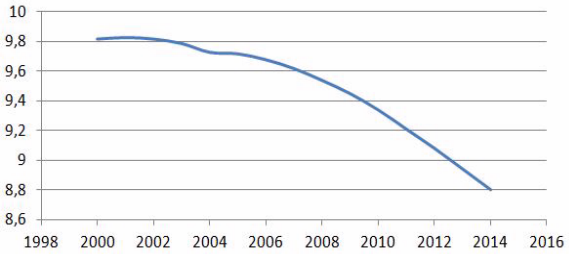
Source: Eurostat

Figure 6.20. People at risk of poverty or social exclusion - % of total population, annual data 2004-2014



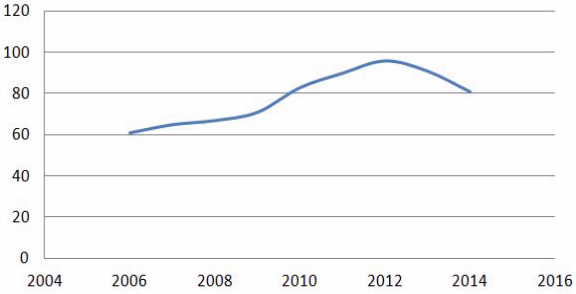
Source: Eurostat

Figure 6.21. Birth rate (births/1,000 population) for Greece, annual data 2000-2014



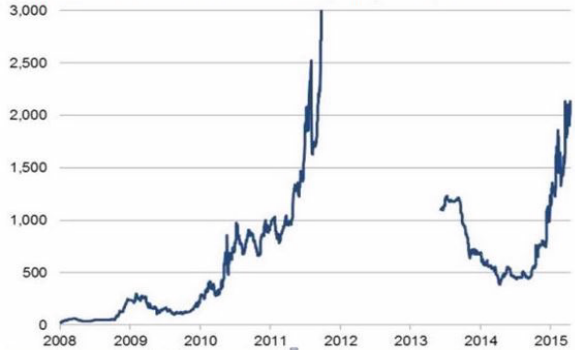
Source: CIA World Factbook

Figure 6.22. Global competitiveness index for Greece, annual data 2006-2014



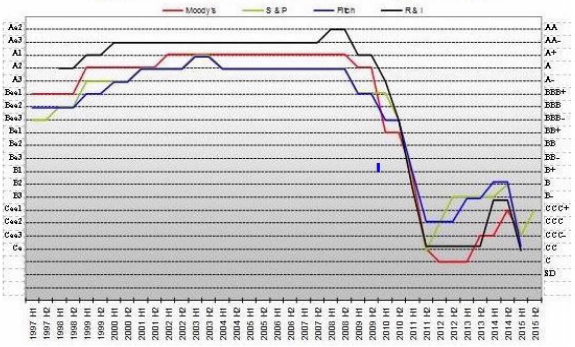
Source: World Economic Forum

Figure 6.23. Credit default swap spread, basis points for Greece



Source: Markit

Figure 6.24. Evolution of credit rating of Greece



Source: PDMA

6.4. Conclusions

In this Section we will further discuss and summarize our results. Since the Greek economy's integration in the EAP in 2010, much has been written and said about the necessity and efficiency of these programs. Among them are the three economists Paul De Grauwe, Paul Krugman and Joseph Stiglitz.

In particular, De Grauwe argued, first that the euro area crisis contributed towards unsustainable government debts, second, the ill-designed fiscal policies remain at the centre of the continuously weakened economic expansion of the zone and third despite the Institutions' efforts for reforms, these were not sufficient to address and solve the design failures of the eurozone. All the parties are responsible for the imbalances that existed between the euro area countries, 'for every foolish debtor there must be a foolish creditor' (De Grauwe, 2015).

Krugman, with a series of articles, illustrates the incomplete tackling of the Greek crisis by the Institutions and that the creation of the euro was a 'terrible mistake' (see Krugman 2015a). He pointed out that with negative GDP growth rates in the period 2008-2013 and participation in a hard currency (euro) that allowed limited space and freedom for progressive and bold monetary policies, the future of the Greek economy is at stake. Krugman (2010) argued that with German support (which unfortunately did not materialize) the European countries should have guaranteed Greek debt in exchange for an obligation to undertake harsh fiscal measures. According to Krugman (2015a), the fact that the leftist coalition under Syriza in Greece has acceded to the troika's (the institutions representing creditor interests) ultimatum represents the 'final abandonment of any pretence of Greek independence'. He says that 'the troika officials, these supposed technocrats, are in fact fantasists who have disregarded everything we know about macroeconomics'. Krugman (2015b) wonders whether a Grexit might work, as in the case of Argentina, which abandoned its one-peso-one-dollar policy in the period 2001-2002.

Stiglitz (2010) argues that although Greece is among the poorest of the European family, if Europe had developed a more efficient solidarity and stabilisation framework, then budget deficits in the periphery of Europe might have been smaller and hence easier to manage. In addition, Europe did not adopt the principle of do no 'harm'. For example, announcements made by the EU leaders exacerbated Greece's problem. Stiglitz (2015c) brings up the point that Greece's bailout was not a bailout of the country but of the Western banks, who did not do adequate due diligence. In full agreement with De Grauwe's (2015) arguments, Stiglitz noted that the lenders 'bear even more responsibility for the current mess than the borrowers'. Moreover, despite the fact that the IMF has warned of the dangers that the high taxation might impose, yet in Greece the troika insisted on imposing high taxes even at low income levels. Stiglitz (2015f) points out that Although the requirement is intended to reduce tax evasion, in the case of Greece it will destroy small business. Finally, Stiglitz (2015e) points out that an alternative way to exit the crisis might be moving towards a dual currency circulation. Argentina and others have shown how this can be done. Despite the fact that every country is different there are, however, some astonishing resemblances between the two countries. Both countries were being choked by austerity as well as (under the IMF programs) experiencing rising unemployment, poverty, and immense suffering (Stiglitz, 2015d).

In support of their claims, we provide nineteen socioeconomic indicators that show the deterioration of the Greek economy and the difficulties faced by society during the five years of austerity measures. At the same time, since much has been written about the problem of competitiveness of the Greek Economy, the latest ranking lists reveal that little has been achieved in this field (see Figure 6.22 above). In particular, after five years of restrictive policies the position of the Greek economy in the global rankings does not seem to have improved dramatically. In addition, the credit default swap (CDS) spread (at basis points) is still at high levels (see Figure 6.23 above), just above the dam of two thousand basis points, suggesting that the risk of a credit event is too high (the cost of insuring against a Greek default). Verifying the lack of competitiveness and the high risk of bankruptcy of the Greek economy the Big Three rating agencies [namely, Standard & Poor's (S&P), Moody's and Fitch and the Rating and Investment Information Inc. (R&I)] negatively assessed the creditworthiness of the bonds issued by the Greek government (see Figure 6.24 above) in the period covering 2009-2015.

Chapter 7

Measuring Inflation Persistence: A Time-Varying GARCH-in-mean Approach

7.1. Introduction

The detrimental effect of inflation in various fields of the economy such as economic growth and unemployment is the mainstream among the monetary policy makers. Consistent with the aforementioned statement most of the European Union (EU) countries and especially the ones that belong to the eurozone area were characterized by inflation targeting policies before and mainly after the introduction of the common currency. However, according to Fischer and Modigliani (1978) the real effects of inflation vary depending on the institutional structure of the economy and whether or not the inflation is anticipated.

One of the main goals of each central bank is to maintain price stability. For instance, the European Central Bank (ECB) defines the latter as the year on year increase in the HCPI (Harmonised Consumer Price Index for the Euro area) of just below 2%. The same policies apply and in the case of the Federal Reserve Bank (of the United States of America, FRB) statutory mandate. But what is the significance of price stability? ECB argues that under price stability consumers rationally spend their money, conduct investments and distribute their resources. In addition, with low inflation, lower real interest rates are observed, which in turn promotes investment. Due to the fact that the nominal interest rate is fixed for all the eurozone countries by the ECB, stable (or alternatively less volatile) inflation rates (at a rate just below 2%) set the pillars for a benign macroeconomic environment. Furthermore, price stability neutralizes the potential negative implications of inflation and deflation (among others) on the tax and social security systems, promotes financial stability as well as defends a fairer distribution of wealth and income.

Contrary (to price stability) high inflation volatility or higher price level uncertainty, imposes upward pressure on long term risk premia, extra hedging costs due to inflation risks, and unfair distribution of wealth. Consequently high volatility undermines economic growth regardless of whether inflation levels remain low or not. It worth mentioning that before the establishment of the Exchange Rate Mechanism (ERM) by the European Economic Community in 1979 and until 1986, many countries' inflation rates (among others France, Italy, The Netherlands, Austria and Denmark, see Figure A1 in the Appendix) experienced high variability. This might be attributed to the oil crises of the early and late 1970s, which were characterized by high levels of inflation. Although after 1986 inflation levels decreased, despite the launch of the ERM many euro-area countries inflation rates still displayed divergent behaviour (Karanasos et al., 2015).

In this Chapter we analyze the properties of inflation rates and their volatilities among countries that belong to the Inner Six group, namely France, Italy and The Netherlands and countries being a part of the Outer Seven group namely Austria and Denmark. The first group adopted the European Economic Community (EEC) while the latter the European Free Trade Association (EFTA). Austria joined the EEC after the 1995 enlargement of the EU. Contrary to the studies examined so far we investigate whether or not the inflation rate and its volatility of each individual country displayed time-varying characteristics. For this purpose we employ quarterly inflation rates over a period 1960-2013.

Then by applying the Bai-Perron breakpoint technique we detect five breaks that reflected among others the oil crises of the early and late 1970s respectively. The results from the various power ARCH processes with structural breaks and with or without in-mean effects indicated that both the conditional means and variances displayed time-varying characteristics. With respect to the relationship between

inflation and its uncertainty, our results suggest that there is a time-varying link. In addition for the countries belonging to the Inner Six group (namely France, Italy and Netherlands) the in-mean effect is positive, whereas that of the countries belonging to the Outer Seven group (namely Austria and Denmark) is negative. Also we find negative and significant leverage effects for France and Italy whereas for Denmark (a country not a member of the common currency) positive asymmetric effects were displayed. Unlike the previous studies that model the conditional variance, we model the power transformed conditional variance. In particular, in the majority of the cases this is fixed and equal to 1.20.

The remainder of the Chapter is organized as follows. Section 7.2 reviews the previous literature on the topic. Sections 7.3 describes the data and the estimated structural breaks. Section 7.4 provides details for our econometric methodology. In Section 7.5 we report the empirical results. Section 7.6 concludes and suggests directions for future research.

7.2. Literature Review

Inflation persistence attracted much of attention, particularly in the United States, nevertheless those studies' conclusions seem to deviate significantly. The aforementioned studies could be separated into two (methodological) groups, depending on how they measure persistence.

Unit root tests

Studies in the first group are based on the order of integration as the measure of inflation persistence. In particular by implementing unit root tests these studies categorize the inflation process as either an I(0) or I(1) process. More specifically MacDonald and Murphy(1989) argued that for the U.S. inflation rate over a period from 1955 to 1986 there is a strong evidence for non-stationary I(1) behaviour. Similarly, Evans and Wachtel (1993) cited that the monthly U.S.inflation rate from 1978 to 1992 seemed to be an I(1) process. In contrast, Rose (1988) suggested that monthly U.S. inflation from 1947 to 1986 was an I(0) process. Brunner and Hess (1993) found that the inflation is an I(1) process since 1960s, whereas before that time it was an I(0) one. Other studies on the topic include Barsky (1987), Ball and Cecchetti (1990), Kim(1993), and Culver and Papell (1997).

AR model based measures

The second group of research focuses on autoregressive model-based measures, such as the LARR (largest autoregressive root) and the SARC (sum of the autoregressive coefficients). For instance, Taylor (2000) estimated both the LARR and the SARC models and found that the US inflation persistence was significantly higher before the Volcker-Greenspan period (namely 1979-1987 and 1987-2006 accordingly). Similarly, Levin and Piger (2003) by applying the SARC model suggested that high inflation persistence was not an immanent feature of industrial economies during the period covering 1984-2002. In the contrast, Batini (2002) using the SARC argued that the inflation persistence of the Euro area changed slightly in the past thirty years.

Changes over time in the dynamics of inflation persistence

To the best of our knowledge, the volume of the studies that investigated the variations in the dynamics of inflation persistence are quite limited. Cogley and Sargent (2002, 2005) estimated a Bayesian state-space VAR model of inflation dynamics and provided evidence of how inflation persistence in the United States evolved over a period from 1948 to 2000. By employing the normalized spectrum of inflation at frequency zero as the measurement of inflation persistence they suggested that inflation persistence increased during the 1970s and decreased in the 1980s and 1990s. In antithesis, Stock (2001) commenting on the results provided by Cogley and Sargent (2002) and by estimating the LARR (with rolling window estimation methods) he argued that inflation persistence in the US the last forty years was more or less stable. In the spirit of the aforementioned studies, Pivetta and Reis (2007) examined the US inflation persistence covering a period from 1947 to 2001. To do so they estimated both the LARR and the SARC

under the Bayesian and rolling window estimation framework. Their results indicated that inflation persistence in the US was high and roughly invariable during the period under consideration. Noriega and Ramos-Francia (2009) showed that the US inflation persistence was high during the 'Great Inflation' era of 1970s, then reduced during 1984 and remained stationary till 2009. Finally, Mumtaz and Surico (2012) employing a dynamic factor model, they find that the reduced inflation persistence of the 1980s is a 'common' characteristic in the majority of the industrial economies.

7.3. Data and Structural Breaks

In this Chapter we study the stochastic properties of inflation rates for five EU countries and in particular three from the Inner Six group, namely France, Italy and The Netherlands and two from the Outer Seven group, namely Austria and Denmark over a period from 1960Q2 to 2013Q4 (see Table 7.1 below). The only exception is the case of Denmark where data were available from 1967Q2 to 2013Q4. The main data source is Datastream. The data we employ consist of quarterly log-differences of the Consumer Price Index (CPI), $log(CPI_t/CPI_{t-1})$, for each individual country (see Figures 7.1 and 7.2 below).

Figure 7.1 Quarter on quarter inflation rates for countries belonging to the Inner Six group, 1960Q3-2013Q4

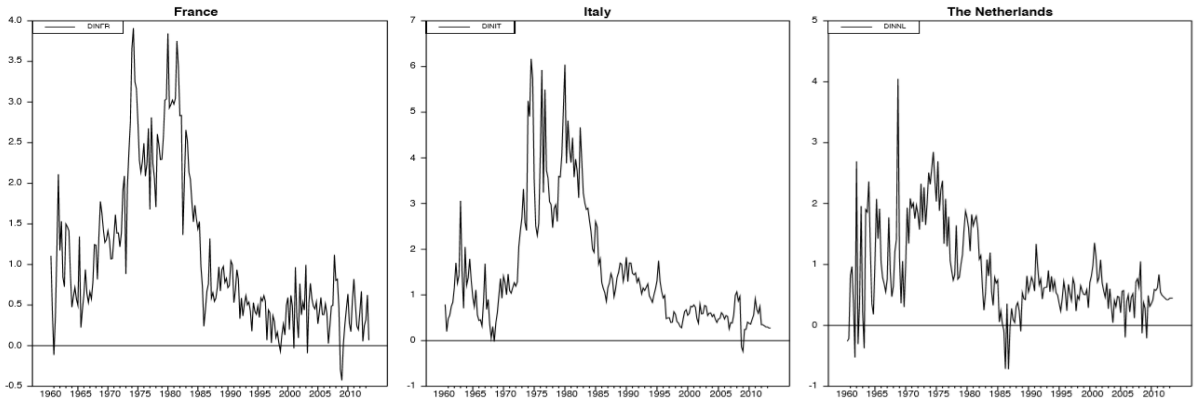


Figure 7.2 Quarter on quarter inflation rates for countries belonging to the Outer Seven group, 1960Q3-2013Q4

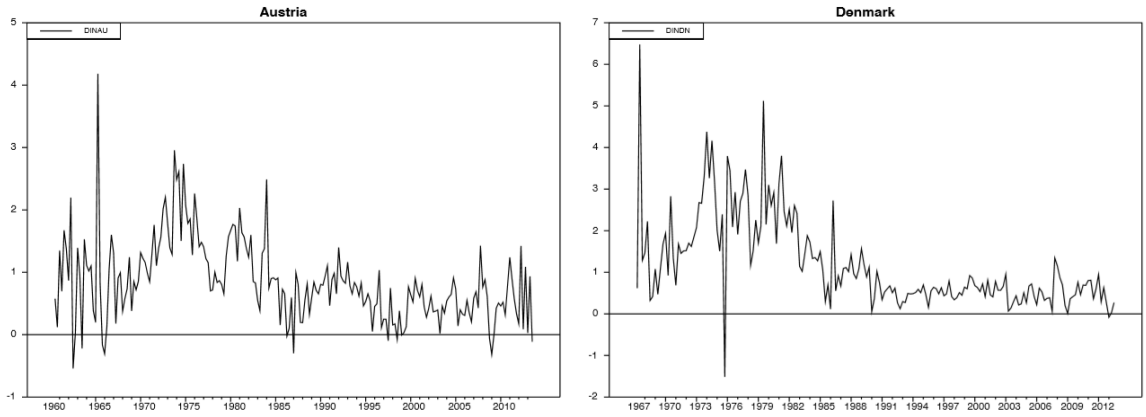


Table 7.1. Classification of European countries

Category 1 Inner Six	France, Italy and The Netherlands
Category 2 Outer Seven	Austria and Denmark

From the Figures 7.1 and 7.2 above, and A.7.1 in the Appendix we can notice that the inflation rates and their squared estimates (an approximation of volatility) is higher during the period 1960-1980. After that point the level of inflation rates and their volatility start to diminish through time as we approach the introduction of the common currency in 1999 and even more over the period 2000-2013. One potential reason why inflation rates experienced shrinkage of such extent might be the early participation of the aforementioned countries in the Exchange Rate Mechanism (ERM). Among others Karanasos et al. (2015) argued that countries that belonged to the narrow ERM (since 1979) saw their inflation rates decreasing with much faster pace than countries belonging to the wider core of the ERM.

An analysis of breakpoints was conducted for each series of the inflation rates (Table 7.2 below). The reasons behind the breaks in Table 7.2 will be explained (where it is possible) using the dates of past events. The dates in bold indicate breaks for which, at least one dummy variable is significant in either the mean or the variance equation of each inflation rate series (see models in Section 7.4 below). In the breakpoint analysis below, we will focus on the significant breaks.

Structural Breaks

By applying the Bai-Perron (2003) breakpoint estimation procedure on inflation rates we identify five breaks during the sample period. Furthermore, there are several cases where the breaks are either identical or very close to one another, which clearly shows the significant impact that some economic events had on the inflation rates under consideration. The main findings support that the Merger Treaty of the 1965, the general strikes of 1968 in many countries (including France), the early and late 1970s oil crises, the global economic crisis of the early 1980s (1980-1982), the adoption of the Spinelli draft (that was the draft Treaty on the establishment of the European Union) by the European parliament in the first quarter of 1984, the signing of the Schengen Agreement, the strengthening measures (towards the EMS) that the Committee of Governors of the Central Banks undertook (during the second and third quarter of 1985), the fall of the Berlin Wall in 1989Q1 and the rejoining of the Italian lira with the ERM, are captured in the majority of the inflation rates.

Table 7.2. The break points (inflation rates)

	1^{st} Break	2^{nd} Break	3^{rd} Break	4^{th} Break	5^{th} Break
	Inner Six group				
France	**1968Q2**	**1973Q2**	$1979Q2$	**1982Q2**	$1985Q2$
Italy	**1972Q2**	**1973Q4**	**1974Q4**	**1984Q1**	**1996Q2**
The Netherlands	$1968Q3$	**1968Q4**	**1970Q1**	**1976Q1**	**1982Q2**
	Outer Seven group				
Austria	**1965Q1**	**1965Q2**	**1971Q2**	**1976Q2**	**1984Q1**
Denmark	**1973Q1**	**1975Q3**	**1975Q4**	**1982Q4**	**1989Q4**

Notes: The dates in bold indicate breakdates for which, at least one dummy variable is significant in both the mean and variance equation (see Section 4 below) of each inflation rate series (for example in the case of France of the 1982Q2 breakpoint , the φ_l^4 and α^4 coefficients are significant).

7.4. Econometric Framework

In this Section, for the five countries inflation rates, we will estimate the autoregresssive power ARCH models and with or without in-mean effects (hereafter AR-PARCH and AR-PARCH-M) allowing the conditional means and the variances to switch across the breakpoints. For applications (including inflation) of the various types of GARCH or PARCH models (see, among others, Baillie et al., 1996; Conrad and Karanasos, 2010; Conrad and Karanasos 2015; Karanasos et al., 2014; Karanasos et al.; 2015 and the references therein).

Let y_t denote the inflation rate at time t and define its mean equation as:

$$y_t = \varphi_0 + \sum_{l=1}^{4}(\varphi_l y_{t-l} + \sum_{\tau=1}^{5}\varphi_l^{\tau} D_t^{\tau})y_{t-l} + (\lambda + \sum_{\tau=1}^{5}\lambda^{\tau} D^{\tau})\sigma_t^{\delta} + \varepsilon_t, \tag{7.1}$$

where $\varepsilon_t \,|\Omega_{t-1} \sim N(0, \sigma_t^2)$ is the innovation, which is conditionally (as of time $t-1$) normally distributed with zero mean and conditional variance σ_t^2. The λ denotes the in-mean parameter, that it captures the impact of the inflation rate uncertainty on the inflation. D_t^{τ} are dummy variables defined as 0 in the period before each break and 1 after the break. The breakpoints for each country are given in Table 7.2 above. In addition σ_t^2 is specified as a PARCH$(1,1)$ process (a model developed by Ding et al., 1993):

$$\sigma_t^{\delta} = \omega + \alpha f(\varepsilon_{t-1}) + (\beta + \sum_{\tau=1}^{5}\beta^{\tau} D_t^{\tau})\sigma_{t-1}^{\delta},^{45} \tag{7.2}$$

with

$$f(\varepsilon_{t-1}) = (\mid \varepsilon_{t-1} \mid + \gamma\varepsilon_{t-1})^{\delta}$$

where α and β denote the ARCH and GARCH parameters, γ is the leverage coefficient and δ is the power term. We also tried dummies on the two constants (ϕ and ω) however they were not statistically significant and hence we omitted them. The 'persistence' in the conditional variance, in the absence of breaks, is given by $c = \alpha k + \beta$, where $k = \frac{1}{\sqrt{\pi}}[(1-\gamma_l)^{\delta} + (1+\gamma_l)^{\delta}]2^{(\delta/2-1)}\Gamma(\frac{\delta+1}{2})$ under normality (see Karanasos and Kim, 2006).

[45] Only for the case of France the conditional variance receives the following form. $\sigma_t^{\delta} = \omega + \alpha f(\varepsilon_{t-1}) + \alpha^4 D_t^4 \mid \varepsilon_{t-1} \mid^{\delta} + (\beta + \sum_{\tau=1}^{5}\beta^{\tau} D_t^{\tau})\sigma_{t-1}^{\delta}$

7.5. Empirical Results

Tables 7.3 to 7.7 below reports the baseline results provided by the conditional maximum likelihood estimates of the GARCH and (P)ARCH models with or without in-mean effects,[46] allowing the conditional means and variances to switch across the breakpoints [see Eq. (7.1) and (7.2) above] identified by the Bai and Perron procedure. More specifically, columns two and five report the standard GARCH and (P)ARCH processes. Columns three and six report the in-mean models and columns four and seven report the results for the in-mean models with breaks in the in-mean parameter. Moreover, the tests for remaining serial correlation suggest that all the models for each individual country seem to be well-specified since there is no remaining autocorrelation in either the standardized residuals or squared standardized residuals at 5% statistical significance level. In the case of the two constants ϕ and ω (see Tables 7.3 to 7.7 below) the effects of the breaks are insignificant in all the cases, whereas the power parameter δ is fixed, and for all the models (apart from the case of Italy where δ is 0.80, see the sixth column of Table 7.4 below), equal to 1.2 (different from either one or two). Perhaps it is on the same level among the countries, due to their participation in the EU, their common currency (apart from the case of Denmark) and the resulting monetary integration.

France

The principal findings for France (see Table 7.3 below) indicate that the autoregressive coefficients display two breaks in the first (1968Q2) and fourth (1982Q2) break respectively. Similarly the ARCH parameter (α) is shown to be time-varying across one break in all cases, 1982Q2. With regards to the GARCH parameter (β), it exhibits a significant time-varying pattern across the first break (1968Q2) for the GARCH models (in 2 out of the 3 models, see columns 7.3 and 7.4 of Table 7.3 below). As far as the in-mean effect (λ) is concerned, this is positive and significant in all the cases apart from the last model (see column seven of Table 3 below) and shows either one or two breaks (depending on the model) during the first (1968Q2) and the fourth break (1982Q2). Finally, with respect to leverage effects (γ), there is a significant and negative effect only in one case, that is model 6 (see column seven of Table 7.3).

Italy and Netherlands

The conditional mean of Italy shows that a time-varying pattern exists across all breaks (for models 1, 2 and 4, see Table 7.4 below) while the conditional variance displays significant breaks only for the β parameter with one significant break in all cases and during the second (1973Q4, see model 6), fourth (1984Q1, see models 1, 4 and 5), and fifth (1996Q2, see models 2 and 3) one. Significant and negative asymmetric effects are observed in all the three (P)ARCH specifications (see columns five, six and seven of Table 4 below), while the in-mean parameter is positive and significant only in one case (see the sixth column of Table 7.4). Finally regarding the in-mean coefficient (λ) we detect one significant break for the model 3 across the fifth breakpoint whereas for the model 6 we detect an additional break across the second breakpoint.

With regards to The Netherlands, results from the conditional mean (see Table 7.5 below) show that time-varying characteristics exhibited across the second, third and fourth break. In contrast ARCH parameter has not such characteristics, since no significant breaks were detected, whereas the dynamics of the GARCH parameter show time-varying pattern across one break in all the cases. As far as the γ and λ coefficients are concerned there is no significant effect. However, the in-mean parameter becomes significant after the third break (1970Q1, see columns four and seven of Table 7.5 below).

Austria and Denmark

Table 7.6 below reports the results for the inflation rate of Austria. The parameters of the mean equation show time-varying characteristics in all models across one break for the models 1, 3, 4 and 6 and

[46] In order to distinguish the general PARCH model from a version in which δ is fixed (but not necessarily equal to two) we refer to the latter as (P)ARCH.

two breaks for the models 2 and 5. As far as the conditional variance is concerned, in all the cases the ARCH parameter shows no significant breaks whereas for the GARCH parameter only one break seems to impact the inflation rate of Austria. The in-mean parameter (λ) is positive and significant in all cases (except for the model 6), while displaying either two or three breaks. The asymmetry coefficient is not significant in all cases.

The baseline results for Denmark (see Table 7.7 below) show that the autoregressive coefficients experience two (for the GARCH models across the fourth and fifth breakpoint) and three (for the PARCH models) significant breaks. With respect to the conditional volatility there is a time-varying behaviour only for the β parameter (in the case of α there are no significant breaks) across either one (for models 1, 5 and 6) or two (for models 2 and 3) breaks. With regards to the asymmetry parameters, they are positive and significant for the three PARCH models and insignificant for the case of the GARCH models. Finally, the in-mean effect shows time-varying dynamics across either one or two breaks.

The Effect of Inflation Uncertainty on Inflation

From Tables 7.3 to 7.7 first notice that the in-mean parameter in all cases\countries is affected by the breaks.

In the case of France (see model 3 of Table 7.3 below) the in-mean effect in the period preceding all the breaks is positive (+4.45) providing evidence in favor of the Cukierman and Meltzer (1986) hypothesis. That effect increases to 7.74 after the general strikes that occurred in France in May 1968 (and caused serious problems to the government of General Charles de Gaulle) and then displays a decline to 6.31 (though in higher levels than in the period preceding all the breaks) after the global economic crisis of the early 1980s.

In the case of Italy the effect of inflation uncertainty on inflation rate is positive but insignificant (see model 6 of Table 7.4 below) the period before the breaks. However, this impact becomes significant and positive (+2.32) after the oil cricis of 1973 and then declines sharply to 0.25 after the readmission of the Italian lira in ERM in 1996. Similarly, the case of Netherlands exhibits no significant in-mean effects the period preceding all the breaks (see model 6 of Table 7.5 below), it becomes significant and positive (+1.37) after the end of the 'wage explosion period' in Netherlands (this took place in 1970) and then shows a drastic decline to 0.12 after the oil crisis of the early 1970s.

With respect to the countries that belong to the Outer Seven group and in particular Austria, the effect of inflation uncertainty on inflation is positive though insignificant before the introduction of the breaks (see model 6 of Table 7.6 below). After the Merger Treaty of the 1965 it is significant and negative (-0.45), later it displays a steep increase to +2.30 in the onset of the international monetary crisis of 1971 (when Austria's central bank stopped the currency trading) and finally it experiences a sharp decline to -1.10 after the oil crisis of the early 1970s.

In the case of Denmark the in-mean size effect the period preceding all the breaks is positive and significant (+1.24) providing evidence in favor of the Cukierman-Meltzer hypothesis (see model 6 of Table 7.7. below). After the economic recession of 1973-1975 (with high unemployment and inflation rates), the impact of inflation uncertainty on inflation declined to 0.35, and it declined further to -0.77 after the global economic crisis of the early 1980s.

At this point it is worth mentioning that for the countries belonging to the Inner Six group (namely France, Italy and Netherlands) the in-mean effect is positive, whereas that of the countries belonging to the Outer Seven group (namely Austria and Denmark) is negative.

Table 7.3. The estimated univariate models allowing for breaks in the mean and in the variance for France

coefficients	GARCH(1,1)	GARCH-M	GARCH-M^d	(P)ARCH	(P)ARCH-M	(P)ARCH-M^d
	(1)	(2)	(3)	(4)	(5)	(6)
Mean Equation						
φ_0	0.23^{***} (5.59)	0.002 (0.02)	-0.14 (-0.73)	0.24^{***} (6.08)	0.20^{***} (4.41)	0.26^{***} (5.54)
φ_1	0.71^{***} (13.97)	0.58^{***} (9.50)	0.50^{***} (7.31)	0.71^{***} (14.81)	0.65^{***} (12.08)	0.61^{***} (9.47)
φ_l^1	0.14^{***} (2.74) $_{l=3}$	0.13^{***} (2.44) $_{l=3}$	0.02 (0.28) $_{l=2}$	0.13^{***} (2.85) $_{l=3}$	0.14^{***} (3.41) $_{l=3}$	0.18^{***} (4.17) $_{l=3}$
φ_l^4	-0.32^{***} (-5.25) $_{l=1}$	-0.26^{***} (-3.47) $_{l=1}$	-0.20^{**} (-2.51) $_{l=1}$	-0.32^{***} (-5.34) $_{l=1}$	-0.29^{***} (-4.35) $_{l=1}$	-0.18^{***} (-2.76) $_{l=1}$
λ	–	3.46^{**} (2.31)	4.75^{**} (2.32)	–	0.76^{***} (1.70)	0.74 (1.24)
λ^1	–	–	2.99^{***} (2.35)	–	–	–
λ^4	–	–	-1.43^{**} (-1.67)	–	–	-1.62^{***} (-2.87)
Variance Equation						
ω	0.02^{**} (1.83)	0.005^{***} (3.39)	0.004^{***} (3.32)	0.07^{***} (2.44)	0.06^{***} (2.43)	0.08^{***} (4.65)
α	0.38^{*} (1.61)	0.05^{**} (2.19)	0.04^{***} (2.48)	0.36^{**} (2.29)	0.39^{***} (2.59)	0.45^{***} (3.77)
β	0.54^{**} (2.20)	0.90^{***} (28.18)	0.91^{***} (44.21)	0.49^{***} (2.47)	0.57^{***} (3.14)	0.46^{***} (4.13)
α^4	-0.33^{*} (-1.60)	-0.05^{***} (-2.60)	-0.04^{***} (-2.37)	-0.30^{**} (-2.22)	-0.21^{*} (-1.66)	-0.24^{**} (-2.13)
β^1	0.09 (0.89)	0.05^{***} (2.41)	0.03^{**} (2.10)	–	–	–
β^2	–	–	–	0.14 (1.48)	0.08 (0.85)	0.09 (1.15)
δ	–	–	–	1.20	1.20	1.20
γ	–	–	–	–	-0.16 (-1.45)	-0.21^{**} (-2.03)
LB(3)	0.21 (0.98)	0.18 (0.98)	1.39 (0.71)	0.44 (0.93)	0.73 (0.87)	0.37 (0.94)
MCL(3)	6.90 (0.08)	11.01 (0.02)	3.65 (0.06)	6.43 (0.09)	3.15 (0.08)	7.36 (0.06)

Notes: Table reports parameter estimates for the following model:

Mean Equation: $y_t = \varphi_0 + \sum_{l=1}^{4} \varphi_l y_{t-l} + \sum_{\tau=1}^{5} \varphi_l^{\tau} D_t^{\tau} y_{t-l} + \lambda \sigma_t^{\delta} + \sum_{\tau=1}^{5} \lambda^{\tau} D^{\tau} \sigma_t^{\delta} + \varepsilon_t$

Variance Equation: $\sigma_t^{\delta} = \omega + \alpha(\mid \varepsilon_{t-1} \mid + \gamma \varepsilon_{t-1})^{\delta} + \alpha^4 D_t^4 \mid \varepsilon_{t-1} \mid^{\delta} + (\beta + \sum_{\tau=1}^{5} \beta^{\tau} D_t^{\tau}) \sigma_{t-1}^{\delta}$

The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of three lags on the standardized and squared standardized residuals, respectively (p-values reported in brackets). l denotes number of lags.

***,**,*, indicates significance at the $1\%, 5\%, 10\%$, level respectively.

Table 7.4 The estimated univariate models allowing for breaks in the mean and in the variance for Italy

coefficients	GARCH(1,1)	GARCH-M	GARCH-M^d	(P)ARCH	(P)ARCH-M	(P)ARCH-M^d
	(1)	(2)	(3)	(4)	(5)	(6)
Mean Equation						
φ_0	0.29^{***} (5.68)	0.27^{***} (5.60)	0.37^{***} (4.79)	0.27^{***} (6.09)	0.24^{***} (6.43)	0.25^{***} (7.17)
φ_1	0.66^{***} (12.24)	0.62^{***} (8.90)	0.62^{***} (8.39)	0.71^{***} (14.15)	0.65^{***} (11.51)	0.76^{***} (9.69)
φ_l^1	0.39^{***} (4.08) $_{l=3}$	0.45^{***} (4.08) $_{l=3}$	0.40^{***} (3.43) $_{l=3}$	0.36^{***} (3.94) $_{l=3}$	0.21 (1.46) $_{l=3}$	0.40^{***} (2.37) $_{l=2}$
φ_l^2	0.21^{*} (1.75) $_{l=3}$	0.20^{*} (1.62) $_{l=3}$	0.22^{*} (1.69) $_{l=3}$	0.22^{*} (1.70) $_{l=3}$	0.44^{***} (2.66) $_{l=3}$	–
φ_l^3	-0.37^{***} (-3.21) $_{l=3}$	-0.37^{***} (-3.21) $_{l=3}$	-0.39^{***} (-3.45) $_{l=3}$	-0.34^{***} (-3.49) $_{l=3}$	-0.54^{***} (-4.34) $_{l=3}$	-0.37^{**} (-2.25) $_{l=2}$
φ_l^4	-0.15^{***} (-3.14) $_{l=3}$	-0.12^{**} (-2.18) $_{l=3}$	–	-0.19^{***} (-5.59) $_{l=3}$	–	–
φ_l^5	-0.28^{***} (-4.18) $_{l=3}$	-0.30^{***} (-5.15) $_{l=3}$	-0.40^{***} (-5.03) $_{l=3}$	-0.21^{***} (-3.88) $_{l=3}$	-0.21^{***} (-3.92) $_{l=3}$	-0.26^{***} (-5.65) $_{l=2}$
λ	–	-0.02 (-0.10)	-0.06 (-0.18)	–	0.44^{**} (2.18)	0.13 (0.37)
λ^2	–	–	0.07 (0.20)	–	–	2.32^{**} (2.20)
λ^5	–	–	-3.04^{***} (-2.50)	–	–	-2.07^{**} (-2.08)
Variance Equation						
ω	0.03^{***} (3.85)	0.03^{***} (3.33)	0.02^{*} (1.66)	0.009^{***} (3.47)	0.04^{**} (2.15)	0.02^{***} (2.53)
α	0.37^{*} (1.83)	0.36^{**} (2.28)	0.26^{**} (2.33)	0.69^{***} (3.80)	0.26^{***} (3.76)	0.37^{***} (3.65)
β	0.62^{***} (4.96)	0.64^{***} (6.40)	0.70^{***} (9.42)	0.53^{***} (6.16)	0.85^{***} (17.83)	0.85^{***} (14.92)
β^2	–	–	–	–	–	-0.14^{**} (-2.07)
β^3	–	-0.02 (-0.29)	–	–	–	–
β^4	-0.60^{***} (-4.33)	-0.26 (-1.41)	-0.25 (-1.22)	-0.46^{***} (-3.57)	-0.10^{***} (-2.32)	-0.03 (-0.47)
β^5	–	-0.46^{***} (-2.51)	-0.48^{**} (-1.92)	–	-0.006 (-0.16)	–
δ	–	–	–	1.20	0.80	1.20
γ	–	–	–	-0.46^{***} (-2.94)	-0.29^{***} (-3.83)	-0.48^{***} (-4.27)
LB(3)	7.45 (0.06)	6.01 (0.11)	4.26 (0.23)	8.37 (0.04)	4.02 (0.26)	8.53 (0.04)
MCL(3)	0.17 (0.98)	1.05 (0.78)	2.74 (0.43)	0.44 (0.93)	1.04 (0.79)	0.90 (0.83)

Notes: Table reports parameter estimates for the following model:

Mean Equation: $y_t = \varphi_0 + \sum_{l=1}^{4} \varphi_l y_{t-l} + \sum_{\tau=1}^{5} \varphi_l^\tau D_t^\tau y_{t-l} + \lambda \sigma_t^\delta + \sum_{\tau=1}^{5} \lambda^\tau D^\tau \sigma_t^\delta + \varepsilon_t$

Variance Equation: $\sigma_t^\delta = \omega + \alpha(|\varepsilon_{t-1}| + \gamma \varepsilon_{t-1})^\delta + \alpha^4 D_t^4 |\varepsilon_{t-1}|^\delta + (\beta + \sum_{\tau=1}^{5} \beta^\tau D_t^\tau)\sigma_{t-1}^\delta$

The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of three lags on the standardized and squared standardized residuals, respectively (p-values reported in brackets). l denotes number of lags.

***,**,*, indicates significance at the $1\%, 5\%, 10\%$, level respectively.

Table 7.5 The estimated univariate models allowing for breaks in the mean and in the variance for Netherlands

coefficients	GARCH(1,1)	GARCH-M	GARCH-M^d	(P)ARCH	(P)ARCH-M	(P)ARCH-M^d
	(1)	(2)	(3)	(4)	(5)	(6)
Mean Equation						
φ_0	0.25^{***} (5.18)	0.22^{***} (4.13)	0.22^{***} (3.95)	0.25^{***} (5.29)	0.24^{***} (4.71)	0.21^{***} (4.38)
φ_1	0.17 (1.07)	–	–	0.11 (0.81)	0.06 (0.37)	–
φ_2	–	0.31^{***} (4.64)	0.32^{***} (4.67)	–	–	0.36^{***} (4.76)
φ_3	0.45^{***} (6.90)	0.28^{***} (4.37)	0.29^{***} (4.77)	0.47^{***} (7.47)	0.46^{***} (7.19)	0.27^{***} (4.46)
φ_l^2	0.27^{***} (1.68) $_{l=1}$	0.32^{***} (4.08) $_{l=1}$	0.20^{***} (2.63) $_{l=1}$	0.31^{**} (2.20) $_{l=1}$	0.37^{**} (2.18) $_{l=1}$	0.18^{***} (2.49) $_{l=1}$
φ_l^3	-0.15^{***} (−3.06) $_{l=1}$	-0.14^{***} (−2.23) $_{l=1}$	–	-0.16^{***} (−3.07) $_{l=1}$	0.10 (−0.61) $_{l=1}$	–
φ_l^4	-0.22^{***} (−3.46) $_{l=2}$	-0.21^{***} (−2.97) $_{l=2}$	-0.24^{***} (−3.45) $_{l=2}$	-0.22^{***} (−3.63) $_{l=3}$	-0.21^{***} (−3.70) $_{l=3}$	-0.24^{***} (−3.58) $_{l=2}$
λ	–	0.06 (0.49)	−0.07 (−0.63)	–	0.10 (0.61)	−0.04 (−0.30)
λ^3	–	–	1.07^{**} (2.11)	–	–	1.37^{***} (2.43)
λ^4	–	–	-1.10^{**} (−2.22)	–	–	-1.25^{***} (−2.47)
Variance Equation						
ω	0.03^{**} (2.12)	0.03^{***} (2.61)	0.03^{***} (2.74)	0.06^{**} (2.18)	0.06^{**} (2.16)	0.06^{**} (2.16)
α	0.24^{**} (2.32)	0.39^{***} (3.26)	0.42^{***} (3.42)	0.29^{***} (2.15)	0.29^{**} (2.21)	0.41^{***} (3.70)
β	0.74^{***} (12.74)	0.60^{***} (6.92)	0.57^{***} (6.34)	0.77^{***} (8.47)	0.78^{***} (8.94)	0.65^{***} (7.38)
β^3	-0.37^{***} (−2.84)	–	–	-0.25^{***} (−2.60)	-0.24^{***} (−2.56)	–
β^5	–	-0.31^{***} (−2.34)	-0.33^{***} (−2.50)	–	–	-0.17^{*} (−1.18)
δ	–	–	–	1.20	1.20	1.20
γ	–	–	–	−0.04 (−0.36)	−0.05 (−0.42)	−0.16 (−1.41)
LB(3)	6.56 (0.08)	1.65 (0.65)	1.51 (0.68)	5.75 (0.12)	5.51 (0.14)	0.92 (0.82)
MCL(3)	1.14 (0.76)	1.58 (0.66)	1.66 (0.64)	1.57 (0.66)	1.49 (0.68)	1.68 (0.64)

Notes: Table reports parameter estimates for the following model:

Mean Equation: $y_t = \varphi_0 + \sum_{l=1}^{4} \varphi_l y_{t-l} + \sum_{\tau=1}^{5} \varphi_l^{\tau} D_t^{\tau} y_{t-l} + \lambda \sigma_t^{\delta} + \sum_{\tau=1}^{5} \lambda^{\tau} D^{\tau} \sigma_t^{\delta} + \varepsilon_t$

Variance Equation: $\sigma_t^{\delta} = \omega + \alpha(|\varepsilon_{t-1}| + \gamma \varepsilon_{t-1})^{\delta} + \alpha^4 D_t^4 |\varepsilon_{t-1}|^{\delta} + (\beta + \sum_{\tau=1}^{5} \beta^{\tau} D_t^{\tau}) \sigma_{t-1}^{\delta}$

The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of three lags on the standardized and squared standardized residuals, respectively (p-values reported in brackets). l denotes number of lags.

***,**,*, indicates significance at the $1\%, 5\%, 10\%$, level respectively.

Table 7.6 The estimated univariate models allowing for breaks in the mean and in the variance for Austria

coefficients	GARCH(1,1)	GARCH-M	GARCH-M^d	(P)ARCH	(P)ARCH-M	(P)ARCH-M^d
	(1)	(2)	(3)	(4)	(5)	(6)
Mean Equation						
φ_0	0.14^{***} (2.82)	0.21^{***} (3.29)	0.35^{***} (3.53)	0.15^{***} (2.98)	0.17^{***} (2.50)	0.32^{***} (4.11)
φ_2	0.25^{***} (3.02)	–	0.28^{***} (3.87)	0.21^{***} (2.94)	–	0.26^{***} (4.73)
φ_3	0.16^{**} (1.96)	0.20^{***} (2.55)	–	0.18^{***} (2.69)	0.19^{***} (2.62)	–
φ_4	0.14^{**} (2.06)	0.16^{***} (2.49)	0.11^{*} (1.68)	0.13^{**} (2.18)	0.15^{***} (2.37)	0.14^{***} (2.73)
φ_l^1	0.28^{***} (3.45) $_{l=1}$	–	–	0.29^{***} (4.18) $_{l=1}$	–	–
φ_l^2	–	–	0.32^{***} (4.50) $_{l=1}$	–	–	0.22^{***} (4.05) $_{l=1}$
φ_l^3	–	0.46^{***} (4.55) $_{l=2}$	–	–	0.46^{***} (4.85) $_{l=2}$	–
φ_l^4	–	-0.20^{***} (2.52) $_{l=2}$	–	–	-0.15^{**} (−1.89) $_{l=2}$	–
λ	–	0.32^{***} (1.54)	1.02^{***} (4.84)	–	0.53^{**} (1.97)	0.11 (0.88)
λ^1	–	–	-0.99^{***} (3.85)	–	–	-0.45^{***} (−2.36)
λ^3	–	–	–	–	–	2.75^{***} (3.93)
λ^4	–	–	–	–	–	-3.40^{***} (−5.56)
λ^5	–	–	-1.39^{***} (−2.56)	–	–	–
Variance Equation						
ω	0.03^{*} (1.79)	0.12^{***} (3.31)	0.03^{***} (2.76)	0.05^{***} (3.40)	0.25^{***} (2.93)	0.14^{***} (2.54)
α	0.21^{**} (2.26)	0.23^{*} (1.66)	0.20^{***} (3.01)	0.20^{***} (4.33)	0.26^{***} (2.39)	0.36^{***} (3.33)
β	0.76^{***} (9.53)	0.70^{***} (6.66)	0.71^{***} (9.51)	0.77^{***} (37.28)	0.54^{***} (3.66)	0.60^{***} (5.47)
β^3	–	−0.26 (−1.33)	–	–	−0.21 (−1.16)	-0.31^{***} (−2.34)
β^4	–	-0.46^{***} (−2.39)	–	–	-0.35^{***} (−2.26)	
β^5	-0.15^{*} (−1.66)	–	-0.14^{*} (−1.68)	-0.08^{**} (−2.06)	–	–
δ	–	–	–	1.20	1.20	1.20
γ	–	–	–	–	−0.04 (−0.39)	0.19 (1.44)
LB(4)	1.77 (0.78)	10.57 (0.03)	1.68 (0.79)	1.47 (0.83)	9.95 (0.04)	4.02 (0.40)
MCL(4)	0.70 (0.95)	1.28 (0.86)	2.39 (0.66)	0.88 (0.92)	2.59 (0.63)	0.21 (0.99)

Notes: Table reports parameter estimates for the following model:

Mean Equation: $y_t = \varphi_0 + \sum_{l=1}^{4} \varphi_l y_{t-l} + \sum_{\tau=1}^{5} \varphi_l^\tau D_t^\tau y_{t-l} + \lambda\sigma_t^\delta + \sum_{\tau=1}^{5} \lambda^\tau D^\tau \sigma_t^\delta + \varepsilon_t$

Variance Equation: $\sigma_t^\delta = \omega + \alpha(|\ \varepsilon_{t-1}| + \gamma\varepsilon_{t-1})^\delta + \alpha^4 D_t^4 |\ \varepsilon_{t-1}|^\delta + (\beta + \sum_{\tau=1}^{5} \beta^\tau D_t^\tau)\sigma_{t-1}^\delta$

The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of four lags on the standardized and squared standardized residuals, respectively (p-values reported in brackets). l denotes number of lags.

***,**,*, indicates significance at the $1\%, 5\%, 10\%$, level respectively.

Table 7.7. The estimated univariate models allowing for breaks in the mean and in the variance for Denmark

coefficients	GARCH(1,1)	GARCH-M	GARCH-M^d	(P)ARCH	(P)ARCH-M	(P)ARCH-M^d
	(1)	(2)	(3)	(4)	(5)	(6)
Mean Equation						
φ_0	0.31^{***} (5.48)	0.22^{***} (3.24)	0.38^{***} (3.63)	0.38^{***} (5.72)	0.49^{***} (8.88)	0.39^{***} (9.51)
φ_1	0.59^{***} (9.96)	0.14 (1.30)	0.12 (1.11)	–	0.64^{***} (8.56)	–
φ_2	–	–	–	0.13^{**} (2.12)	–	0.04 (1.36)
φ_3	0.28^{***} (8.55)	0.12^{***} (2.09)	0.15^{***} (2.38)	0.21^{***} (3.60)	–	0.22^{***} (5.00)
φ_l^1	–	–	–	0.61^{***} (6.85) $_{l=1}$	0.24^{***} (3.10) $_{l=1}$	-0.09 (-1.15) $_{l=3}$
φ_l^2	–	–	–	-0.26^{***} (-2.95) $_{l=1}$	–	0.22^{**} (1.98) $_{l=1}$
φ_l^4	-0.17^{**} (-1.97) $_{l=1}$	-0.28^{***} (-2.09) $_{l=1}$	-0.28^{**} (-2.03) $_{l=1}$	-0.02 (-0.32) $_{l=1}$	-0.28^{***} (-4.45) $_{l=1}$	0.35^{*} (1.75) $_{l=1}$
φ_l^5	-0.29^{***} (-3.10) $_{l=1}$	0.41^{**} (2.21) $_{l=1}$	0.42^{**} (2.26) $_{l=1}$	-0.38^{***} (-4.46) $_{l=1}$	-0.51^{***} (-6.97) $_{l=1}$	-0.41^{***} (-8.47) $_{l=1}$
λ	–	1.58^{***} (3.80)	1.13^{**} (1.99)	–	-0.10^{*} (-1.64)	1.24^{***} (4.25)
λ^1	–	–	0.26 (0.56)	–	–	–
λ^3	–	–	–	–	–	-0.89^{***} (3.22)
λ^4	–	–	–	–	–	-1.12^{***} (-4.73)
λ^5	–	–	-2.95^{*} (-1.72)	–	–	–
Variance Equation						
ω	0.04^{***} (2.42)	0.03^{***} (3.11)	0.03^{***} (2.24)	0.03^{**} (2.10)	0.07^{***} (3.03)	0.07^{***} (2.88)
α	0.59^{***} (3.53)	0.06^{**} (2.44)	0.08^{**} (2.18)	0.13^{*} (1.72)	0.38^{***} (2.95)	0.37^{***} (9.49)
β	0.24^{*} (1.70)	0.91^{***} (44.55)	0.90^{***} (37.08)	0.82^{***} (16.47)	0.46^{***} (4.12)	0.48^{***} (4.22)
β^1	0.39^{***} (3.08)	–	–	–	0.20^{**} (2.19)	0.25^{**} (2.01)
β^4	–	–	–	-0.48^{***} (-3.61)	-0.37^{***} (-3.99)	-0.40^{***} (-2.83)
β^5	-0.62^{***} (-3.22)	-0.52^{***} (-3.47)	-0.45^{***} (-2.61)	–	–	–
δ	–	–	–	1.20	1.20	1.20
γ	–	–	–	0.35^{***} (2.99)	0.29^{**} (1.92)	0.20^{*} (1.85)
LB(3)	2.16 (0.54)	3.37 (0.33)	3.66 (0.30)	3.82 (0.28)	7.99 (0.05)	1.10 (0.77)
MCL(3)	3.58 (0.31)	2.37 (0.49)	3.48 (0.32)	8.18 (0.04)	7.95 (0.05)	2.03 (0.56)

Notes: Table reports parameter estimates for the following model:

Mean Equation: $y_t = \varphi_0 + \sum_{l=1}^{4} \varphi_l y_{t-l} + \sum_{\tau=1}^{5} \varphi_l^\tau D_t^\tau y_{t-l} + \lambda \sigma_t^\delta + \sum_{\tau=1}^{5} \lambda^\tau D^\tau \sigma_t^\delta + \varepsilon_t$

Variance Equation: $\sigma_t^\delta = \omega + \alpha(|\ \varepsilon_{t-1}| + \gamma \varepsilon_{t-1})^\delta + \alpha^4 D_t^4 |\ \varepsilon_{t-1}|^\delta + (\beta + \sum_{\tau=1}^{5} \beta^\tau D_t^\tau)\sigma_{t-1}^\delta$

The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of three lags on the standardized and squared standardized residuals, respectively (p-values reported in brackets).

***,** ,* , indicates significance at the $1\%, 5\%, 10\%$, level respectively.

7.6. Conclusions

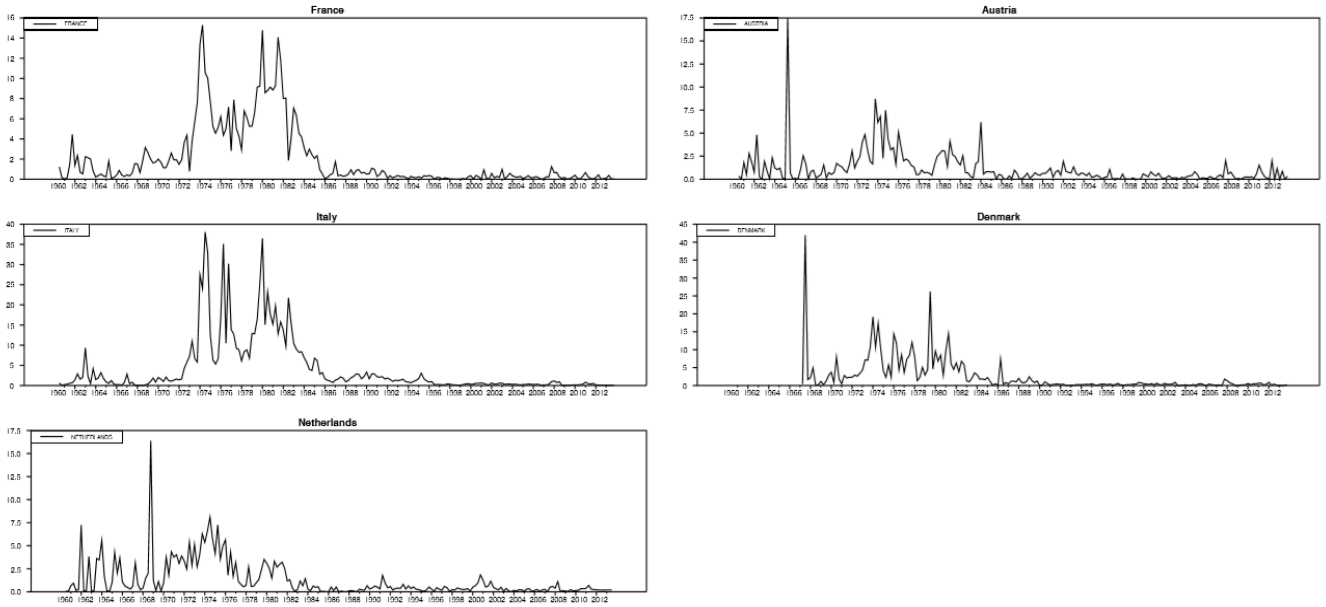
This study has provided evidence about the properties of inflation rates and their volatilities for five EU countries over a long period of time 1960-2013. Using quarterly data we first detected five breaks (employing the Bai-Perron estimation technique) for each of the inflation rates series, which we associate mainly to the Merger Treaty of the 1965, the oil crises of 1970s, the global economic crisis of the early 1980s, the launch of the ERM in 1979 and the adoption of the Spinelli draft in the first quarter of 1984. Having obtained the breaks we then apply various PARCH models with or without in-mean effects on the inflation rates allowing the conditional means and variances to switch across the breakpoints identified by the Bai and Perron procedure.

With respect to the conditional mean and volatility, our results detect time-varying dynamics, which could be attributed mainly to the oil crises of 1970s and the launch of the ERM. As far as the power parameter is concerned, this is fixed and different from either one or two. In addition we detect (the period preceding all the breaks) a positive impact of the inflation uncertainty on inflation rates for the case of France, Austria and Denmark and to a less extent in Italy, whereas there are negative asymmetric effects for some of the countries.

However, although the breakpoint analysis did not capture the impact of the recent financial and EU sovereign-debt crises, in addition of abrupt breaks it could also be tested the time-varying behaviour of inflation rates by employing a smooth transition GARCH (where the transition variable could be either the financial or the EU crisis) model allowing for breaks in both the conditional mean and the volatility. Finally a forecasting analysis of inflation rates are among the issues we feel future research should try to address.

Appendix 7

Figure A.7.1. Quarter on quarter squared inflation rates, 1960Q1-2013Q4



Chapter 8

Modelling and Forecasting Commodity Volatilities During the Global Financial Crisis: A time-varying Coefficient Approach

8.1. Introduction

The recent global financial crisis of 2007-2008 and the EU sovereign debt crisis (2009-present) are targeted by many researchers and policy makers. The main cause for that is due to the shocks that the aforementioned crises imposed on many sectors of the economy, including the financial markets. These shocks introduced structural changes among others in commodity returns, hence it would be crucial, before any analysis, to take into account the potential presence of such breaks both in the mean and in the variance of a time series. During the global financial crisis overall the commodity prices and their volatility increased. Baffes (2011) argued that the commodity market faced a boom in prices that was one of the longest and broadest of the post world war II period. However, despite the fact that booms in commodity prices occurred previously during the Korean war (1950-1953) and the oil crisis of the 1970s, the recent one, described by the World Bank as the most notable commodity price boom of the previous century, displayed three main differences. According to Baffes (2011), first the surge affected the commodity prices of agriculture, energies and metals at the same time. Second high inflation rates were not observed, as in the case of the oil crisis of the 1970s and third it coincided with the outbreak of the crises in equity and real estate markets.

Lin and Martin (2011) argued that the latest financial crisis has its roots (among others) in the progressive deregulation of the financial sector since the 1980s, change in the global way of conducting investments and accumulating money (savings), the U.S. dotcom bubble in 2001, as well as malfunction of the modern financial centres. Caballero et al. (2008) argued that high prices of commodities and in particular that of gold and oil were among the driving forces of the financial crisis of 2007-2008. Nissanke (2012) stated that the linkage between commodity and financial markets played the role of a fast transmission channel of the crisis to the developing countries.

Yet, despite the fact that commodity markets played a prominent role during the financial crisis, there is little research on whether or not commodity stochastic properties were affected by the crisis. Vivian and Wohar (2012), Sensoy (2013) and Shalini and Prasanna (2015) are to the best of our knowledge the only studies that have investigated the effect of the 2007-2008 crisis on the volatility returns, albeit only on spot price data.

In this Chapter we analyze how the stochastic properties of different commodity time series, and in particular that of grains (namely wheat, corn and oats), metals (platinum), energies (namely rbob, heating oil, wti and natural gas), softs (cocoa, coffee, sugar and orange juice) and soya complex (namely soybean, soymeal and soyoil) groups, have been impacted by the recent financial and EU sovereign debt crisis as well as conducting a forecasting analysis under the spectral method, which to the best of our knowledge is the first time that such a technique has been applied in commodity series. Contrary to the studies examined so far we employ an Autoregressive (AR) power ARCH (PARCH) model, allowing for breaks both in the mean and in the variance processes using mapped data introduced by Margaronis et al. (2014, 2015).

Hence, we believe that this study can further our understanding of the significance of the two crises on the commodity returns mainly because of three considerations. Firstly, we study 15 different daily observed commodity prices covering a period from January 2007 to April 2012 for the grains, metals, softs and soya complex groups and from January 2008 to January 2012 for the energies group. Secondly

applying the Bai-Perron (2003) breakpoint technique we were able to identify five breaks for each series of returns and their variances (squared returns), which were associated with previous economic events of great significance. The majority of the breaks (both in the mean and in the variance) reflected the financial and EU sovereign debt crisis (see Section 8.3 below for a thorough breakpoint analysis).

Then having obtained the breaks we estimated the AR(1)-PARCH(1,1) models for each commodity, allowing the conditional means and variances to switch across the breakpoints identified by the Bai and Perron procedure. The estimated models show overall that there is a time-varying behaviour of the conditional mean and variance parameters in the case of grains, energies (with the exception of natural gas, which does not show significant breaks in the mean equation) and softs (not in the case of the conditional mean of coffee and sugar) respectively. In contrast, metals and soya complex show no time-varying characteristics in the conditional mean, whereas they experience significant breaks in the variance equation.

Finally, we conduct a forecasting analysis using spectral techniques (in both mapped and unmapped data) for approximately two months ahead in the case of grains, metals, softs and soya complex and for six months in the case of energies (with the exception of wti). First we find that regardless of whether the data for each commodity series are mapped or unmapped the trend (blue line in Figures below) is roughly the same. The only exception is that of wheat, platinum and heating oil, where slight differences were observed between the mapped and unmapped forecasts. The estimated predictions (for the forecasting period, Figures 8.3-8.7) show that the prices of corn remained almost stable while for wti and orange juice the prices decreased further, though slightly. In the case of natural gas and coffee overall the prices experienced significant deflationary pressures, whereas that of sugar initially decreased and then started rising. As far as the prices of oats, rbob, cocoa, soybean, soymeal and soyoil are concerned, they showed an upward trend. To verify the accuracy of our forecasting analysis we compared our prediction with the actual prices at that time and we found that the trends of the prices of each commodity series are very similar.

The remainder of the Chapter is organized as follows. Section 8.2 reviews the previous literature on the topic. Sections 8.3 and 8.4 describe the data and structural breaks, and the econometric framework employed respectively. In the next Section we report the empirical results. The last Section summarizes and concludes.

8.2. Literature Review

Quite a few studies have addressed the stochastic properties of the commodity returns. Plourde and Watkins (1998) compared the change in the prices of oil and widely used non oil commodities. Implementing parametric and non-parametric techniques they found that changes in oil prices are more volatile than the majority of the remaining non-oil commodities. McMillan and Speight (2001) studied the conditional volatility using daily data of six non-ferrous metals [from the London Metal Exchange (LME)] over the period 1972-1995. The results indicate that a model of conditional volatility that takes into consideration the short and long-run effects of volatility is superior to the standard model of conditional volatility which is extensively used in modelling the volatility of financial markets. In particular, the principal findings show the significance of this kind of decomposition, between short and long-run effects. McKenzie et al. (2001), considering daily futures prices from the LME roughly from 1989 to 1997, attempted to examine the capacity of the power GARCH process to model efficiently the characteristics of metals' (in their case) volatility. By applying with or without asymmetry PGARCH models they find that asymmetric effects of the LME futures data are in general absent. Furthermore, in contrast with stock market data, APGARCH models do not seem to interpret the futures data under consideration satisfactorily.

Fong and See (2001), using daily data over 1992-1997 from Goldman Sachs Commodity Index (including energies, precious metals, grains and soya complex), focused on the modelling issues of the conditional variance of futures returns. For the purposes of their study they utilized an econometric approach, which

allows for abrupt changes or regime sifts in the volatility. Their results among others indicated strong evidence of regime changes in the conditional mean and variance. Jin and Frechette (2004) tested whether or not fractional integration exists in the volatility of agricultural futures prices. The baseline findings exhibited strong long term dependence. Tully and Lucey (2007) were the first to apply an asymmetric power model to gold. They argued that the best fit for the gold data was found under the PGARCH model. Moreover, they concluded that in the majority of the cases the US dollar is the prominent macroeconomic indicator that impacts on gold.

Similarly, Hammoudeh and Yuan (2008) examined the volatility characteristics of three metals, namely gold, silver and copper. By employing three different GARCH models they found among others that the volatility persistence between gold and silver is roughly the same but greater than that of copper. In addition, the asymmetric parameter is significant only for the case of copper while previous oil shocks do not affect gold, silver and copper respectively. Watkins and McAleer (2008) attempted to calculate and forecast the volatility for daily returns (on the future prices) of two metals (aluminium and copper). To do so they employed a rolling autoregressive GARCH model. Their findings suggest that despite the fact that volatility in returns did not certainly increase, the conditional volatility of the metals under consideration displayed time-varying characteristics when analyzed over a long horizon. In terms of the forecasting, results indicate that most of the forecast errors are positive and small, while some large (in absolute magnitude) negative forecast errors exist, though few.

Cheong (2009) studied the time-varying volatility of wti and Europe Brent spot prices respectively. The results covering a period from January 1993 to December 2008 (daily frequency) under the various GARCH processes suggested first that long persistence volatility in the wti is greater than in the Brent and second in the case of wti depreciation and appreciation shocks have a very similar effect on the wti's volatility. Third, asymmetric effects were found in Brent and fourth the evaluation of both the estimation and diagnostic procedures favoured the APARCH model. Frank and Garcia (2009) showed that the consideration of a structural break in the 1970s affected the results on the agricultural future markets. Additionally, unlike the rest of the literature they find limited evidence of time-varying risk premium. Hammoudeh et al. (2010), utilizing daily closing spot prices for four precious commodities (from January 1999 to November 2007), tried to analyze among others their conditional volatility. The principal findings of the Vector GARCH model showed that there are significant short and long-run dependencies and interdependencies on news and past volatility.

In their analysis Choi and Hammoudeh (2010) incorporated weekly data for the closing spot prices of wti oil, Brent oil, gold, silver and copper over a period from January 1990 to May 2006. For testing their hypothesis they use two Markov-switching GARCH models. One of their main conclusions stressed that commodities' volatility persistence behaves in a disparate way to financial and geopolitical crises. Jacks et al. (2011) attempted to address whether or not commodity price volatility has increased since 1700. Their analysis reached the conclusion [using a GARCH model as a robustness check] that commodity price volatility did not increase over time (since 1700). Vivian and Wohar (2012) employed daily spot price data from January 1985 to July 2010 and a GARCH process in order to model volatility of a broad range of commodities and four indices. Their results indicate that even in the presence of structural breaks the volatility persistence of commodities remains at high levels. Arouri et al. (2012) explored the properties of long-memory returns and the volatility of four precious metals (including platinum) as well as the existence of structural breaks. The findings under parametric and semi-parametric techniques revealed strong evidence of long range dependence in the conditional return and volatility of the precious metals under examination, which is better captured by a dual long-memory process.

8.3. Data and Structural Breaks

In this Chapter we use daily mapped data on various commodity futures prices covering a period from January 3^{rd} 2007 to April 27^{th} 2012 for the grains (namely wheat, corn and oats) metals (platinum), softs (cocoa, coffee, sugar and orange juice) and soya complex (namely soybean, soymeal and soyoil) groups (see Figure 8.1 below) while for the energies group namely rbob, heating oil, wti[47] and natural gas the period covers from January 3^{rd} 2008 to 17^{th} January 2012 (except for the case of wti, where data end on July 2010, see Figure 8.2 below). The sources of the unmapped data included Datastream and Bloomberg. The data were introduced by Margaronis et al. (2014, 2015) and involved the use of a program in order to conduct the mapping procedure. The input of that particular program was the entire set of front month futures contracts. The next stage takes each contract's last price and lines it up by date to the price of the second month contract. Due to the fact that the program uses a counter for both the price and date series, mapping occurs when the counters (of price and date) coincide on the day of expiry. In the final stage the front and the second month prices on that date are lined up and this happens across the entire data set (see also Karanasos et al., 2015 for further details). Finally, the data we employ in the (P)ARCH models consist of daily log-differences of the futures prices, $(\log p_t - \log p_{t-1})$ where p_t represents the commodities futures prices at time t.

[47] RBOB and WTI stand for Reformulated gasoline Blend stock for Oxygen Blending and West Texas Intermediate respectively.

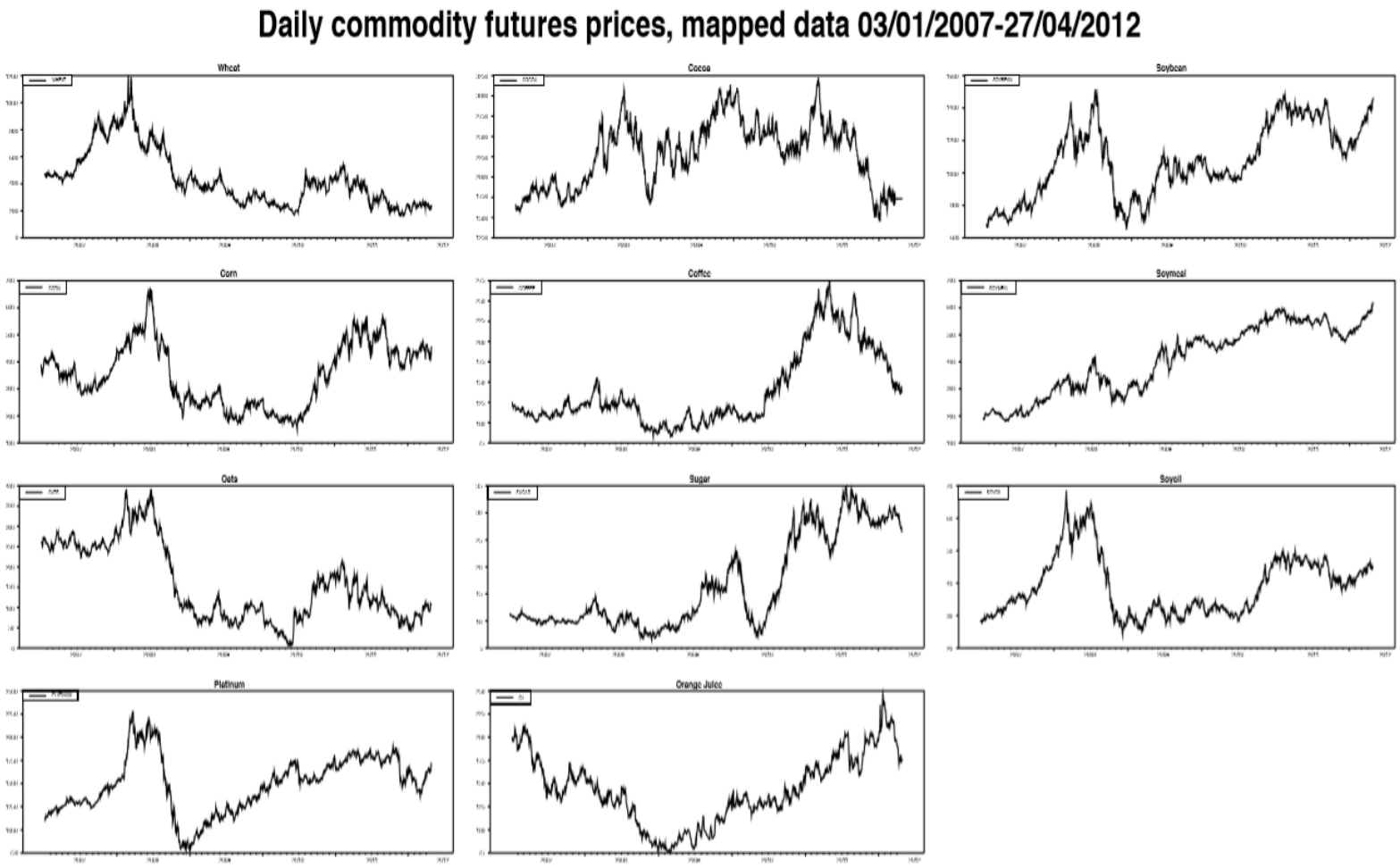


Figure 8.1. Futures prices for grains, metals, softs and soya complex groups

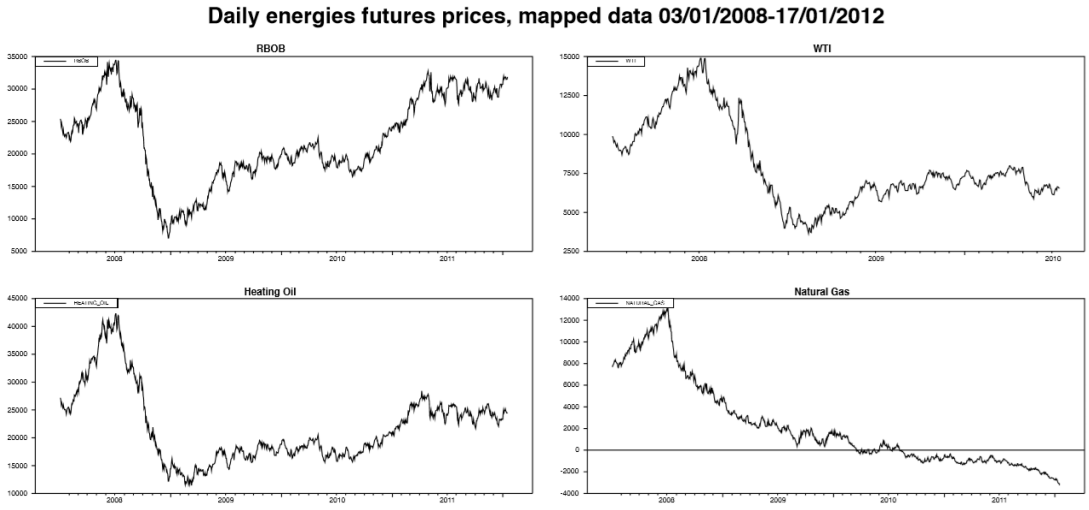


Figure 8.2. Futures Prices for Energies Group

An analysis of breakpoints was conducted for each series of commodities returns (Table 8.1 below) and squared returns (Table 8.2 below) respectively. The breakpoints are detailed in the two tables shown (Table 8.1 and 8.2) and, using the dates of past events, the reasons behind the breaks will be explained where possible. The dates in bold indicate break dates for which at least one dummy variable (see the PARCH models in Section 8.5) is significant in either the mean or the variance equation of each commodity series [for instance for wheat 12/03/2008 breakpoint φ_1^1 is significant (see Tables 8.1 and 8.3 below)]. In the following breakpoint analysis we will focus on the significant break dates.

Structural breaks

By applying the Bai-Perron breakpoint estimation procedure on commodity and squared commodity returns we identify five breaks during the sample period. Furthermore, there are several cases where the breaks are either identical or very close to one another, which clearly shows the significant impact that some economic events had on the commodities returns under consideration. The main finding supports the idea that the financial crisis of 2007-2008, and the European sovereign-debt crisis that followed are reflected in all commodity returns and squared returns series (see Table 8.1 and 8.2). However, despite the sharp down-turn in prices during 2008 and early 2009 in most of the series, prices began to rise again from late 2009 to mid-2010 (a resounding exception is the case of natural gas, where prices continued to fall since 2008, causing significant problems in exporting countries such as Russia).

8.3.1. Grains

Breaks in the Mean

Wheat

The wheat time series saw a significant break during the first couple of weeks of March 2008 (see Table 8.1). The specific date in question is between the emergency 75 basis point rate cut the Federal Reserve made allowing stocks to recover, and the JP Morgan Chase offer to buy Bear Stearns for just $2 per share, sparking controversy with shareholders, which caused the offer to be revised to $10 per share and a loan from the Federal Reserve. The reason for this was the previous day's losses, which were the steepest losses since 9/11. Additionally, the first week of March saw HSBC have a credit crisis loss of

$17 billion, manufacturing activity hitting a five year low and the collapse of a significant hedge fund called Peloton Capital. These are all significant events that had an impact on demand and consumer confidence, which might explain the break in the wheat price seen in the analysis.

The wheat time series also experienced one break in the first couple of weeks of June 2010. In late May the Congressional Budget released a study describing the Federal Reserve's plans of action in order to stabilize financial markets while also detailing the subsidies provided by the Federal Reserve to financial institutions. This essentially summarized the bailout money provided by the Federal Reserve during the crisis (to date), while also detailing where the Federal Reserve would again provide subsidies. This allowed the markets to adjust to the report set out by the Federal Reserve, so once again consumer confidence as well as all financial institutions' confidence was affected significantly. Summarizing the bailout money in a report allowed all to see the total bailout packages given and what future bailouts could be comprised of. Hence, the wheat market might see significant changes in demand due to significant financial reports such as this. Despite the report not being directly influential in the wheat market, the amount of wheat traded via financial institutions is a significant portion, and the demand is essentially set by the consumers, whose confidence would be negatively affected by such a report.

Corn

As far as the corn time series is concerned the first break took place in early June 2008 (see Table 8.1 below). On June 5^{th} 2008 Bond Insurers ratings were downgraded from AAA to AA by Standard and Poors'. This would have an impact on the corn price because once again consumer confidence would decrease and the same domino effect explained previously would occur. Additionally, on June 9^{th} 2008 the average price of gasoline in the US increased to $4 per gallon. This would have a huge impact on consumer confidence as one of the key commodities used for transport (whether it is of people themselves or of the commodities such as grains) increased significantly in price, which would in turn, yet inadvertently, cause a decrease in demand for commodities such as corn. The behaviour of the corn time series might then be affected, causing the break seen.

The corn time series also saw a significant break in the mean during the first days of December 2008. In the beginning of December 2008, the National Bureau of Economic Research finds that the US economy was officially in recession. Reports such as this have a significant impact on consumer confidence as well as altering the investment goals of financial institutions, which are very active in the trading of grains. This would also affect the demand and confidence of consumers, which could therefore have a significant effect on the price behaviour of grains such as corn. Additionally, the days succeeding the first few days of December 2008 saw the Federal Reserve cut interest rates by 75 base points to 0.25%. This would be able to alter economic confidence and make both financial institutions and consumers change their behaviour as well. The lowering of rates signals an economic crisis but its purpose is to allow for cheaper borrowing, which can inject confidence into the economy (or at least begin to shed some light in a crisis), which in turn might affect the price behaviour of grains due to the knock-on effect similar to that explained earlier.

Oats

The beginning of 2010 saw Greece run into financial problems and the EU pledge its support. The crisis in Greece has caused a huge change in consumer confidence worldwide due the exposure of the banking sector, which causes knock on effects into other markets. Additionally, Greece itself produces grains including oats (2nd largest European producer), and the crisis might have had an impacted on the production of grains within Greece, hence possibly introducing the break seen in the time series (8th January 2010, see Table 8.1).

Breaks in the Variance

Wheat

From Table 8.2, the first break in the variance for wheat is towards the end of February 2008. This is likely due to a lag from the oil price, which reached new highs shortly before the displayed break. Oil and its derivatives are used in the production, transportation and general supply of grains, thus possibly affecting the price of the latter. The second significant break for wheat (16/11/2010) appeared in the wake of high temperatures (in the summer of 2010, Russia experienced the highest temperatures that recorded in the last 130 years) that struck Russia, leading to a drop in Russia's grain crop (the Russian Federation is the 4^{th} biggest wheat producer in the world according to the FAOSTAT, 2015) and to the international grain price increase. In responce, the Russian government, in an attempt to protect local consumers and meat producers, imposed a grain export ban that boosted the international grain prices even higher. With this move, Russia and other exporters created an environment where price spikes and general instability were even more probable in the future (see Welton, 2011).

Corn

Regarding the corn time series, a break is observed towards the middle of September 2008, where the Lehman Brothers collapse occurred. The reason this might have had an impact on the corn price is due to the effect on the economic, and hence consumer confidence world-wide, as one of the largest investment banks in the world went bankrupt. Interestingly, the second break for the squared returns for corn (30/01/2009) occurred shortly after the US Treasury purchased a large tranche of stock from US banks, which would alter economic confidence by increasing uncertainty in the financial markets.

Oats

As far as the breaks in the squared returns of oats are concerned (see Table 8.2), the Bai-Perron test identifies three significant break dates, namely October 3^{rd} 2008, March 15^{th} 2010 and August 2^{nd} 2010. October 2^{nd} 2008 saw the US Senate pass their bailout bill, which would increase stability within the world economy though the economic confidence would still be uncertain due to the need for government intervention in the private sector and this might be a very good explanation for the first break seen in the Oats squared returns. This is again due to consumer confidence being impacted, hence affecting demand for grains. The other breaks that occurred, are not directly linked to events but they might be the result of lags from past events or simple demand and supply issues, especially in the grains market, where farming factors such as weather and crop yields are significant.

8.3.2. Metals

The platinum time series did not show significant breaks in the mean equation throughout the period (see Table 8.1). Metals are non-consumable and recyclable and in the case of precious metals, they can be considered reserve currencies. These are probably the reasons why the metals time series saw no significant breaks in their time series. In the case of breaks in the variance (Table 8.2), where the squared returns are utilized, the platinum series experiences two breaks. One occurred in late August 2008 and shortly before the Fannie Mae, Freddie Mac and Ginnie Mae takeover by the Federal Reserve Bank (FRB) and the other in early January 2009, when the FRB began purchasing mortgage backed securities guaranteed by the same companies. This may be explained by the use of precious metals in times of financial turmoil as reserve currencies, where a sudden surge of demand for them is manifested as confidence in other securities falls.

8.3.3. Energies

Breaks in the Mean

Interestingly both rbob and wti have a break on the exact same day (24^{th} December 2008). The week leading up to this date saw the biggest fall in the stock markets with a number of banks (including the FRB) either decreasing their rates or defaulting. Furthermore, Bank of America announced huge job cuts after its takeover of Merril Lynch and Japan approved a massive budget to help finance its fiscal stimulus program. The US Treasury also unveiled a bailout for General Motors. All these events affected consumer confidence and as economic confidence changed so too did the demands of consumers. The energy markets especially experience varying demand as seasons change and heating demands alter as well as transport and demand for other goods and services which require energy commodities to be manufactured or taken to the point of sale. These reasons may all, partly or singly, be the reason for the breaks seen for both rbob and wti at the end of December 2008.

It is also interesting to see that both rbob and heating oil have a break on the same day (11^{th} June 2009, see Table 8.1). The day before the break global oil consumption fell for the first time since 1993 according to BP's global energy outlook, while Japan's economy showed a record rate of decline. The drop in global oil consumption would certainly have an impact on the price behaviour and is likely to be the cause for the break for both rbob and heating oil. In addition, it is a period prior to summer months whereby demand for heating would fall as the winter months are over and households no longer need to consume as much energy for heating purposes. The latter combined with the declines in Japan (a significant economic power and thus consumer of energy) could cause significant behavioural changes in the energy market as consumer and economic confidence varies and uncertainty looms.

Moreover, for heating oil there is a break in the mean on August 28^{th} 2010, most likely caused by the end of the summer season and the forecasts for the brutal winters to come in the Americas. This would cause abnormal demand for heating oil by homeowners in order to heat their homes as the winters slowly become longer and colder. Wti also experiences a break in the time series in the middle of July 2008 (see Table 8.1) as two days prior to the break, crude oil reached an all-time high, which would certainly cause consumers to lose confidence and increase the uncertainty as prices of necessities slowly became higher and higher, taking away from what consumers could spend on luxuries and non-discretionary spending. In the case of natural gas there are no significant breaks in the mean equation of the PARCH model.

Breaks in the Variance

RBOB and Heating Oil

From Table 8.2, there is a break in the variance for rbob on August 10^{th} 2011. Just some days before the civil war in Syria (oil producer among others) escalated with the creation of the anti-government Free Syrian Army (FSA). The worsening situation in Syria and in Libya led to a deterioration in the sensitive area of the Middle East (which is a significant source of oil extraction) and increased the political instability in the region. Finally, seasonalities in the behaviour of rbob (for example the end of the summer and the beginning of the winter) might be responsible for the break seen in early August. As far as heating oil is concerned, there is a break in the variance, which took place on the same day that the G-20 Summit agreed to commit $1.1 trillion to the IMF to assist emerging economies in crisis (2^{nd} April 2009). This may have involved pledging capital to economies with oil reserves and the ability to refine it to heating oil, altering supply dynamics. However, more likely, the break is due to the end of the harsh winter and the changing demand for the commodity.

WTI

The break seen for wti on the 22^{nd} May 2008 (see Table 8.2) for the squared returns occurred days after consumer sentiment was measured to have hit a 28 year low. This would have an impact on the demand for crude oil significantly as consumer confidence is essentially what drives the demand, and

hence the price of oil despite its price inelasticity. The second break for wti took place at the end of September 2009 when the Treasury Department began to wind down its government support initiative, meaning that the protection of the government for large financial institutions decreased. This would have an impact on economic stability and confidence although the break may also be due to the looming of winter and changing demand for oil for heating purposes.

Natural Gas

In the case of Natural Gas, there are two significant break dates; one on the 9^{th} of October 2008 and one on the 26^{th} of February 2009 (see Table 8.2). The first break occurred during the worst week for the stock market in 75 years, meaning economic confidence and stability would be at a historically low level, hence affecting demand for consumables such as natural gas. Additionally, another factor that might explain the break in early October of 2008 could be the start of the winter months in Europe, where natural gas is used for household heating. The second break (26^{th} of February 2009) took place when the Federal Deposit Insurance Corporation (FDIC) announced its list of 'problem banks', as well as huge losses being announced by Fannie Mae. Once more the economic confidence would be affected by these two events. Finally, the end of February marks the end of the harsh winter in many parts of Europe, where natural gas is used to heat households, adding a reason that might explain the displayed break.

8.3.4. Softs

Breaks in the Mean

Cocoa

The Cocoa time series sees a break on the 24^{th} of June 2008 (see Table 8.1 below). No major events occurred around this period. However, the price of gasoline reached all-time highs shortly before this date, so perhaps that extra cost (since gasoline is used in the transportation of cocoa) filtered through to the cocoa market with a slight lag causing the break. The second break occurred on the 20^{th} of July 2011. In particular after the end of the political crisis in the Ivory Coast (the biggest producer of cocoa beans worldwide) prices of cocoa started falling. However, cocoa prices recorded an upward movement during the period covering late June until mid July 2011. The reason for this might be the unfavourable outlook regarding the size of the cocoa production in the following crop year 2011/2012 and statements in support of supply deficit (ICCO, 2012).

Orange Juice

The orange juice time series has three breaks,that is the 21^{st} of July 2008, 29^{th} of June 2009 and on the 8^{th} of January 2010. The orange juice price is highly volatile due to its low daily contract volumes and is also very sensitive to weather conditions and crop disease or illness. Seasons changes might cause the breaks seen, while bad weather conditions and significant fruit disease to the oranges, for instance on the 8^{th} of January 2010 caused a massive increase in price (spike). These are likely to be the same reasons for the rest of the breaks seen in Table 8.1 and for the breaks in Table 8.2 for the squared returns (see Table 8.2 dates in bold for orange juice). Coffee and Sugar do not show any significant breaks in the mean equation of the PARCH models.

Breaks in the Variance

Cocoa, Coffee and Sugar all have breaks in the same month for their squared returns (March 2008, see Table 8.2). During that period Bear Stearns was taken over by JP Morgan for a fraction of its previous year's price. A recession is beginning to become more and more evident and consumer and economic confidence as well as stability started to decrease. Prior to this month (March 2008) a number of events leading to instability and the lag of the markets for the softs (which are perishable consumables) may have caused the discrepancy in the break dates. This would happen simply due to demand changes.

The second cocoa break in the variance (28^{th} of October 2008) took place a couple of weeks after the announcement of the Troubled Asset Relief Program (TARP) and the placing of $250 billion into the U.S. banking sector in an attempt to address the subprime mortgage crisis. This would inadvertently have an impact on the price of all commodities in some way as the financial institutions in question account for significant volumes of commodities such as cocoa. Cocoa's third break (15^{th} of October 2009) happened a day after the US stock market recovery above 10,000, suggesting the beginning of a recovery.

As far as the second break for sugar is concerned (19/12/2008, see Table 8.2 below) it might be due to a range of reasons as events in December 2008 could have all had an impact on all commodities. A number of significant economic events ranging from new announcements to financial reforms occurred, all of which could have caused the break in sugar.

8.3.5. Soya Complex

The soy complex saw no significant breaks for the returns (see Table 8.1), but when the squared returns were considered, a number of breaks occurred (see Table 8.2).

The first break for soybean on the 14^{th} of June 2007 happened shortly after large banks began to show signs of instability and profit warnings and given their involvement in the trading of soy contracts, it is clear that the volumes for such perishable commodities may be adversely affected, hence having an impact on their demand and price. The second break on the 31^{st} of July 2008 took place shortly after consumer sentiment was measured to be the lowest in 28 years, which would have an impact on demand for goods (and services) involving the soybean industry. Additionally, gasoline reached $4 per gallon so machinery and vehicles used to process and transport soybeans would become more expensive to run, altering price due to cost changes.

For soymeal, breaks are seen on the 29^{th} of May 2007 and on the 29^{th} of October 2008, shortly after the issues began in the banking sector in the U.S. and the worst week for the stock market in 75 years respectively. This would of course have an impact on price behaviour of commodities as many of the contracts traded, are traded by large financial institutions.

In the case of the soyoil three breaks are observed on the 27^{th} of February 2008, 12^{th} of January 2009 and 17^{th} of August 2009, where unemployment rates were on the rise, many institutions were downgraded, China's exports began to decline, various announcements were being made by the Federal Reserve, IMF and US Treasury and contingency plans by these organizations were announced and implemented. Soyoil and soymeal are also derivatives of soybean, suggesting that ultimately the soybean price behaviour will have an impact on that of the other two. This may, however, be with a lag due to the possibility of storage, differences in processing and of course differing demand and supply conditions.

Table 8.1. The Break Points (Commodity Returns)

	1^{st} Break	2^{nd} Break	3^{rd} Break	4^{th} Break	5^{th} Break
Grains					
Wheat	**12/03/2008**	05/12/2008	**09/06/2010**	09/02/2011	29/06/2011
Corn	**07/07/2008**	**08/12/2008**	03/06/2009	30/06/2010	01/03/2011
Oats	04/07/2008	20/02/2009	**08/01/2010**	28/05/2010	15/10/2010
Metals					
Platinum	03/09/2007	05/03/2008	24/07/2008	12/12/2008	12/05/2009
Energies					
RBOB	14/07/2008	**24/12/2008**	**11/06/2009**	24/08/2010	29/04/2011
Heating Oil	14/07/2008	24/12/2008	**11/06/2009**	**24/08/2010**	08/04/2011
WTI	**14/07/2008**	**24/12/2008**	20/05/2009	07/10/2009	24/02/2010
Natural Gas	22/05/2008	09/10/2008	26/02/2009	16/07/2009	03/12/2009
Softs					
Cocoa	**24/06/2008**	12/11/2008	03/04/2009	**20/07/2011**	09/12/2011
Coffee	02/07/2008	05/12/2008	01/06/2009	07/06/2010	09/03/2011
Sugar	03/03/2008	05/12/2008	06/01/2010	03/06/2010	09/11/2010
Orange Juice	26/06/2007	**21/07/2008**	31/12/2008	**29/06/2009**	**08/01/2010**
Soya Complex					
Soybean	04/07/2008	05/12/2008	11/06/2009	22/07/2011	09/12/2011
Soymeal	30/07/2007	11/07/2008	05/12/2008	11/06/2009	09/12/2011
Soyoil	02/07/2008	05/12/2008	02/06/2009	06/07/2010	31/12/2010

Notes: The dates in bold indicate breakdates for which at least one dummy variable is significant in the mean equation (see Section 5 below) of each commodity series (for instance for wheat 12/03/2008 breakpoint φ_1^1 is significant).

Table 8.2. The Break Points (Squared Commodity Returns)

	1^{st} Break	2^{nd} Break	3^{rd} Break	4^{th} Break	5^{th} Break
Grains					
Wheat	**22/02/2008**	29/06/2010	**16/11/2010**	05/05/2011	11/10/2011
Corn	**12/09/2008**	**30/01/2009**	30/06/2009	17/11/2009	11//10/2011
Oats	**03/10/2008**	**15/03/2010**	**02/08/2010**	21/02/2011	16/11/2011
Metals					
Platinum	06/02/2008	**20/08/2008**	**07/01/2009**	12/07/2010	10/11/2011
Energies					
RBOB	12/09/2008	02/04/2009	30/09/2009	14/03/2011	**10/08/2011**
Heating Oil	26/09/2008	**02/04/2009**	16/11/2009	30/03/2011	18/08/2011
WTI	**22/05/2008**	09/10/2008	02/04/2009	**30/09/2009**	24/02/2010
Natural Gas	22/05/2008	**09/10/2008**	**26/02/2009**	16/07/2009	03/12/2009
Softs					
Cocoa	**12/03/2008**	**28/10/2008**	08/04/2009	**15/10/2009**	08/12/2011
Coffee	**05/03/2008**	16/11/2009	09/06/2010	18/11/2010	08/09/2011
Sugar	**03/03/2008**	**19/12/2008**	02/02/2010	22/06/2010	18/03/2011
Orange Juice	**26/07/2008**	**05/02/2009**	**03/07/2009**	13/01/2010	09/12/2011
Soya Complex					
Soybean	**14/06/2007**	03/03/2008	**31/07/2008**	12/01/2009	15/09/2009
Soymeal	**29/05/2007**	16/10/2007	05/03/2008	**29/10/2008**	15/09/2009
Soyoil	**27/02/2008**	12/08/2008	**12/01/2009**	**17/08/2009**	18/03/2011

Notes: The dates in bold indicate breakdates for which, at least one dummy variable is significant in the variance equation (see Section 5 below) of each commodity series (for instance for wheat 22/02/2008 breakpoint α^1 is significant).

8.4. Econometric Framework

In this Section, for the different commodity returns, we will estimate AR power ARCH models (hereafter AR-PARCH) with structural breaks (for applications of the asymmetric PARCH models see among others, Karanasos and Kim, 2006 and for other applications of GARCH models with structural breaks see Karanasos et al., 2014 and the references therein).

Let commodity returns be denoted by $y_t = (\log p_t - \log p_{t-1})x100$, where p_t is the commodity futures price at time t, and define its mean equation as:

$$y_t = \varphi_0 + \sum_{\tau=1}^{3} \varphi_0^\tau D_t^\tau + \varphi_1 y_{t-1} + \sum_{\tau=1}^{5} \varphi_1^\tau D_t^\tau y_{t-1} + \varepsilon_t, \tag{8.1}$$

where $\varepsilon_t \,|\Omega_{t-1} \sim N(0, \sigma_t^2)$ is the innovation, which is conditionally (as of time $t-1$) normally distributed with zero mean and conditional variance σ_t^2. D_t^τ are dummy variables defined as 0 in the period before each break and 1 after the break. The breakpoints $\tau = 1, 2, .., 5$ are given in Tables 8.1 and 8.2 above. In addition σ_t^δ is specified as a PARCH$(1,1)$ process (a model developed by Ding et al., 1993):

$$\sigma_t^\delta = \omega + \alpha(\mid \varepsilon_{t-1} \mid + \gamma\varepsilon_{t-1})^\delta + \sum_{\tau=1}^{4} \alpha^\tau D_t^\tau \mid \varepsilon_{t-1} \mid^\delta + (\beta + \sum_{\tau=1}^{4} \beta^\tau D_t^\tau)\sigma_{t-1}^\delta, \tag{8.2}$$

where α and β denote the ARCH and GARCH parameters, γ is the leverage coefficient and δ is the power term. The 'persistence' in the conditional variance, in the absence of breaks, is given by $c = \alpha k + \beta$, where $k = \frac{1}{\sqrt{\pi}}[(1-\gamma_l)^\delta + (1+\gamma_l)^\delta]2^{(\delta/2-1)}\Gamma(\frac{\delta+1}{2})$ under normality (see Karanasos and Kim, 2006).

8.5. Empirical Results

Tables 8.3 to 8.7 below report the baseline results provided by the conditional maximum likelihood estimates of the (P)ARCH(1,1) model[48] allowing the conditional means and variances to switch across the breakpoints [see Eq. (1) and (2) above] identified by the Bai and Perron (2003) procedure. Moreover, the tests for remaining serial correlation suggest that all the models seem to be well-specified since there is no remaining autocorrelation in either the standardized residuals or squared standardized residuals at the 5% statistical significance level. In the case of the two constants ϕ_0, and ω (see Table 8.5 below) the effects of breaks are insignificant in all the cases, with the exception of the conditional mean equation of the energies futures returns (rbob and wti), whereas for the autoregressive coefficients there seems to exist a statistically significant impact of the breaks in most of the cases.

8.5.1. Grains

Table 3 reports the principal results retrieved from the AR(1)-(P)ARCH(1,1) models with breaks both in the mean and the variance for grains (namely wheat, corn and oats). In particular, the autoregressive parameters of the mean equation show time-varying characteristics across either one (in the case of oats) or two (in the case of wheat and corn) breaks. As far as the conditional variance is concerned, the ARCH parameter (α) shows that there is a significant impact of one break in the case of wheat and corn, while there is no time-varying behaviour for the oats. As far as the GARCH parameter (β) is concerned, one break seems to have an impact on wheat whereas we observe three breaks in the case of corn and oats respectively. The asymmetry parameter displays significant and positive leverage effects when corn and oats are under examination, while for wheat the asymmetric term did not have a significant impact, and hence is omitted from the model. Finally, the power parameter δ is fixed, and for all three cases, equal to 1.2. The reason for this may be explained by the similarities between the grains in their storage costs and methods of growth and harvesting[49].

8.5.2. Metals

Table 8.4 shows the results obtained from the estimated model with breaks both in the mean and the variance for metals and in particular platinum. First, notice that the parameters of the mean equation indicate no time-varying behaviour. Second, the conditional variance shows time-varying characteristics in both ARCH and GARCH parameters, with one and two breaks respectively. Third, leverage effects do not seem to have a significant impact on platinum since the γ parameter (see Table 8.4 below) was insignificant and hence omitted. Concluding, the power parameter δ is fixed and equal to 1.6.

8.5.3. Energies

Table 8.5 presents the results indicated from the AR(1)-(P)ARCH(1,1) models with breaks both in the mean and the variance for rbob, heating oil, wti and natural gas. In the case of the conditional mean two breaks are significant for the constant (φ_0) of the rbob and wti, whereas for the autoregressive coefficients of heating oil there seems to exist statistical significance of two breaks. In contrast, natural gas does not show any significant breaks in the mean equation. Regarding the variance equation, one break seems to affect the ARCH parameters of the rbob and heating oil while for the GARCH parameter there is a time-varying behaviour of rbob and wti, and natural gas across one and two breaks respectively. In the case of heating oil there is no significant break for the β coefficient. Asymmetry does not impose any effect in all the cases (and hence is excluded from the models), while δ is fixed, and different from either two or unity (with the exception of the rbob). There are similarities between rbob and wti, with

[48] In order to distinguish the general PARCH model from a version in which δ is fixed (but not necessarily equal to two) we refer to the latter as (P)ARCH.

[49] For the three cases, that is for the three estimated AR(1)-(P)ARCH(1,1) models with breaks both in the mean and the variance, we also calculate the time varying estimated persistence of the three commodity returns and compare it with the one without breaks (results not reported).

heating oil also being very similar in some cases. The liquid form of rbob, heating oil and wti make their storage needs very similar. The gaseous form of natural gas, on the other hand, makes its storage far more challenging; this suggests that supply shocks may be far more likely for natural gas, not to mention its extraction, for which the same issue applies.

8.5.4. Softs

Results from the estimated models with breaks both in the mean and the variance for cocoa, coffee, sugar and orange juice are presented in Table 8.6 below. Cocoa and orange juice show one and three significant breaks in the conditional mean respectively, while coffee and sugar do not experience time-varying behaviour. The ARCH parameter in the conditional variance displays two (for sugar) and one (for cocoa and orange juice) breaks respectively; in the case of coffee there is no time-varying behaviour for the α parameter. Also notice that the ARCH parameter in cocoa becomes significant after the fourth break (15/10/2009). Similarly, the GARCH parameter demonstrates a significant impact of three breaks for cocoa, two for sugar and orange juice and one break for coffee. The power δ is fixed and equal to either 1.2, $1,4$, or 2.0 (see sugar and orange juice). Finally, only orange juice seems to show significant (negative) asymmetric effects. The differences between the softs may be attributed to the fact that all of them have very different uses and supply and demand characteristics. Orange juice especially is almost a pure weather derivative due to its dependence on Florida weather (where most of the supply comes from) and disease in the area for the trees. Coffee and sugar, however, have more similar uses in the market as well as processing procedures. Cocoa's production differs to that of the others, although it is far more similar to coffee and sugar than orange juice. Cocoa's use in the production of chocolate, though, which is not consumed as much in its raw form as coffee and sugar are, could explain the differences in the results.

8.5.5. Soya Complex

Table 8.7 below reports the results produced by the AR(1)-(P)ARCH(1,1) models with breaks both in the mean and the variance for soybean, soymeal and soyoil. In all the three cases, the conditional means do not show any significant breaks. As far as the variance equation is concerned, the α exhibits time-varying characteristics across two breaks only in the case of soybean (soymeal and soyoil do not have significant ARCH breaks). The β parameter displays no significant effect of breaks on soybean, whereas there are significant effects across one and two breaks for soymeal and soyoil respectively. The power δ is fixed and equal to either 1.3, $1,6$, or 2.12, while the asymmetry parameter is significant only in the case of soybean. The similarities are expected to be due to the fact that both soymeal and soyoil are derived from soybean so their supply is completely dependent on the latter. The differences may be due to the dissimilarities in application of the commodities, with soymeal being used in livestock feed whereas the other two have more of a consumer dependent demand.

Table 8.3. The Estimated Univariate (P)ARCH(1,1)
Allowing for Breaks in the Mean and in the Variance

	Grains		
	Wheat	Corn	Oats
Mean Equation			
φ_0	-0.0002 (-0.23)	0.002^{*} (1.66)	-0.001 (-1.02)
φ_1	0.14^{***} (279)	–	–
φ_1^1	-0.28^{***} (-4.32)	-0.01^{***} (-4.11)	–
φ_1^2	–	0.01^{***} (3.67)	–
φ_1^3	0.15^{***} (2.43)	–	0.16^{***} (3.79)
Variance Equation			
ω	0.003^{***} (2.70)	0.002^{***} (5.39)	0.002^{***} (3.61)
α	0.03^{*} (1.78)	0.08^{**} (1.76)	0.04^{**} (2.01)
β	0.70^{***} (7.08)	0.69^{***} (11.93)	0.68^{***} (9.58)
α^1	–	-0.03 (-0.62)	–
α^2	0.07^{***} (2.65)	-0.07^{***} (-2.38)	–
β^1	0.13^{***} (2.46)	0.14^{***} (3.21)	0.17^{***} (3.48)
β^2	–	–	0.03^{**} (1.89)
β^3	–	0.04^{**} (2.26)	-0.04^{**} (-2.07)
β^4	–	-0.04^{***} (-3.13)	
δ	1.20	1.20	1.20
γ	–	0.17^{***} (5.87)	0.15^{***} (5.71)
$LB(1)$	0.16 [0.69]	0.49 [0.49]	2.88 [0.09]
$MCL(1)$	1.56 [0.21]	0.07 [0.79]	1.54 [0.21]

Notes: Table reports parameter estimates for the following model:
$y_t = \phi_0 + \sum_{\tau=1}^{3} \phi_0^{\tau} D_t^{\tau} + \varphi_1 y_{t-1} + \sum_{\tau=1}^{5} \varphi_1^{\tau} D_t^{\tau} y_{t-1} + \varepsilon_t$
$\sigma_t^{\delta} = \omega + \alpha(|\varepsilon_{t-1}| + \gamma\varepsilon_{t-1})^{\delta} + \sum_{\tau=1}^{4} \alpha^{\tau} D_t^{\tau} |\varepsilon_{t-1}|^{\delta} + (\beta + \sum_{\tau=1}^{4} \beta^{\tau} D_t^{\tau})\sigma_{t-1}^{\delta}$
The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of one lag on the standardized and squared standardized residuals, respectively (p-values reported in brackets).
***,**,*, indicates significance at the 1%, 5%, 10% level respectively.

Table 8.4. The Estimated Univariate (P)ARCH(1,1)
Allowing for Breaks in the Mean and in the Variance

	Metals
	Platinum
Mean Equation	
φ_0	0.001^{***}
	(2.62)
φ_1	0.11^{***}
	(3.75)
Variance Equation	
ω	0.0001^{***}
	(3.58)
α	0.17^{***}
	(3.68)
β	0.83^{***}
	(22.07)
α^2	-0.09^{**}
	(-1.97)
β^2	0.10^{***}
	(2.77)
β^3	-0.03^{***}
	(-2.83)
δ	1.60
$LB(1)$	0.09
	[0.75]
$MCL(1)$	0.83
	[0.36]

Notes: Table reports parameter estimates for the following model:
$y_t = \phi_0 + \sum_{\tau=1}^{3} \phi_0^{\tau} D_t^{\tau} + \varphi_1 y_{t-1} + \sum_{\tau=1}^{5} \varphi_1^{\tau} D_t^{\tau} y_{t-1} + \varepsilon_t$
$\sigma_t^{\delta} = \omega + \alpha(\mid \varepsilon_{t-1} \mid + \gamma \varepsilon_{t-1})^{\delta} + \sum_{\tau=1}^{4} \alpha^{\tau} D_t^{\tau} \mid \varepsilon_{t-1} \mid^{\delta} + (\beta + \sum_{\tau=1}^{4} \beta^{\tau} D_t^{\tau}) \sigma_{t-1}^{\delta}$
The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of one lag on the standardized and squared standardized residuals, respectively (p-values reported in brackets).
$^{***}, ^{**}, ^{*}$, indicates significance at the 1%, 5%, 10% level respectively.

Table 8.5. The Estimated Univariate (P)ARCH(1,1)
Allowing for Breaks in the Mean and in the Variance

	Energies			
	RBOB	Heating Oil	WTI	Natural Gas
Mean Equation				
φ_0	-0.001 (-0.56)	0.001 (0.77)	0.004^{**} (2.05)	-0.002 (-1.05)
φ_0^1	–	–	-0.01^{***} (-3.55)	–
φ_0^2	0.01^{***} (2.37)	–	0.01^{***} (2.93)	–
φ_0^3	-0.01^{**} (-2.07)	–	–	–
φ_1^3	–	0.13^{***} (2.46)	–	–
φ_1^4	–	-0.18^{**} (-2.31)	–	–
Variance Equation				
ω	0.0001^{**} (1.85)	0.0001^{**} (2.07)	0.0003^{***} (2.41)	0.004^{***} (3.77)
α	0.07^{***} (3.76)	0.03^{**} (2.31)	0.08^{***} (3.48)	0.18^{***} (5.22)
β	0.92^{***} (43.97)	0.96^{***} (62.68)	0.85^{***} (19.10)	0.50^{***} (4.74)
α^2	–	-0.01^{**} (-2.12)	–	–
α^4	-0.06^{***} (-2.52)	–	–	–
β^1	–	–	0.05^{**} (1.94)	–
β^2	–	–	–	0.15^{**} (2.84)
β^3	–	–	–	0.16^{**} (2.70)
β^4	0.04^{**} (2.08)	–	-0.05^{**} (-2.25)	–
δ	2.00	1.55	1.42	1.30
$LB(1)$	0.30 [0.58]	0.21 [0.65]	0.10 [0.75]	2.40 [0.12]
$MCL(1)$	2.28 [0.13]	0.11 [0.74]	0.001 [0.97]	3.31 [0.07]

Notes: Table reports parameter estimates for the following model:
$y_t = \phi_0 + \sum_{\tau=1}^{3} \phi_0^\tau D_t^\tau + \varphi_1 y_{t-1} + \sum_{\tau=1}^{5} \varphi_1^\tau D_t^\tau y_{t-1} + \varepsilon_t$
$\sigma_t^\delta = \omega + \alpha(\mid \varepsilon_{t-1} \mid + \gamma \varepsilon_{t-1})^\delta + \sum_{\tau=1}^{4} \alpha^\tau D_t^\tau \mid \varepsilon_{t-1} \mid^\delta + (\beta + \sum_{\tau=1}^{4} \beta^\tau D_t^\tau)\sigma_{t-1}^\delta$
The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of one lag on the standardized and squared standardized residuals, respectively (p-values reported in brackets).
***,**,*, indicates significance at the 1%, 5%, 10% level respectively.

Table 8.6. The Estimated Univariate (P)ARCH(1,1)
Allowing for Breaks in the Mean and in the Variance

	Softs			
	Cocoa	Coffee	Sugar	Orange Juice
Mean Equation				
φ_0	0.0003 (0.63)	-0.0001 (-0.14)	0.0001 (0.20)	0.0001 (0.15)
φ_1^2	–	–	–	0.15^{***} (2.39)
φ_1^4	0.19^{***} (2.88)	–	–	0.27^{***} (2.65)
φ_1^5	–	–	–	-0.32^{***} (-3.62)
Variance Equation				
ω	0.001^{**} (2.93)	0.001 (1.28)	0.0001 (0.33)	0.0001^{***} (3.33)
α	0.004 (0.20)	0.07^{**} (2.27)	0.07^{***} (3.27)	0.16^{***} (2.82)
β	0.61^{***} (3.46)	0.88^{***} (16.27)	0.94^{***} (55.39)	0.56^{***} (4.53)
α^1	–	-0.04 (-1.19)	-0.07^{***} (-2.62)	–
α^2	–	–	0.04^{***} (2.40)	–
α^3	–	–	–	0.12^{***} (2.18)
α^4	0.11^{***} (2.85)	–	–	–
β^1	0.22^{**} (2.06)	0.05^{**} (2.03)	0.07^{**} (3.35)	0.13^{***} (2.29)
β^2	–	–	-0.04^{***} (-2.79)	-0.23^{***} (-3.48)
β^3	-0.05^{**} (-1.85)	–	–	–
β^4	-0.12^{***} (-3.08)	–	–	–
δ	1.40	1.20	2.00	2.00
γ	–	–	–	-0.15^{***} (-2.66)
$LB(1)$	0.28 $[0.59]$	0.31 $[0.57]$	0.39 $[0.53]$	0.02 $[0.90]$
$MCL(1)$	0.61 $[0.44]$	0.06 $[0.80]$	2.58 $[0.11]$	0.63 $[0.43]$

Notes: Table reports parameter estimates for the following model:
$y_t = \phi_0 + \sum_{\tau=1}^{3} \phi_0^\tau D_t^\tau + \varphi_1 y_{t-1} + \sum_{\tau=1}^{5} \varphi_1^\tau D_t^\tau y_{t-1} + \varepsilon_t$
$\sigma_t^\delta = \omega + \alpha(|\varepsilon_{t-1}| + \gamma\varepsilon_{t-1})^\delta + \sum_{\tau=1}^{4} \alpha^\tau D_t^\tau |\varepsilon_{t-1}|^\delta + (\beta + \sum_{\tau=1}^{4} \beta^\tau D_t^\tau)\sigma_{t-1}^\delta$
The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of one lag on the standardized and squared standardized residuals, respectively (p-values reported in brackets).
$^{***}, ^{**}, ^{*}$, indicates significance at the 1%, $5\%, 10\%$ level respectively.

Table 8.7. The Estimated Univariate (P)ARCH(1,1)
Allowing for Breaks in the Mean and in the Variance

	Soya Complex		
	Soybean	Soymeal	Soyoil
Mean Equation			
φ_0	0.001^{**} (2.06)	0.001^{**} (2.18)	0.001^{***} (2.70)
Variance Equation			
ω	0.00001^{***} (2.63)	0.00001^{***} (2.68)	0.00002^{**} (2.04)
α	0.04^{**} (2.29)	0.06^{***} (4.46)	0.06^{***} (4.01)
β	0.93^{***} (75.54)	0.95^{***} (76.54)	0.74^{***} (6.96)
α^1	0.02^{*} (1.73)	–	–
α^3	-0.01^{*} (−1.78)	–	–
β^1	–	–	0.16^{*} (1.81)
β^4	–	-0.01^{***} (−2.71)	-0.09^{**} (−1.98)
δ	1.30	1.60	2.12
γ	0.03^{**} (1.96)	–	–
$LB(1)$	0.26 [0.61]	0.09 [0.75]	0.10 [0.75]
$MCL(1)$	1.33 [0.25]	0.004 [0.95]	0.52 [0.47]

Notes: Table reports parameter estimates for the following model:
$y_t = \phi_0 + \sum_{\tau=1}^{3} \phi_0^{\tau} D_t^{\tau} + \varphi_1 y_{t-1} + \sum_{\tau=1}^{5} \varphi_1^{\tau} D_t^{\tau} y_{t-1} + \varepsilon_t$
$\sigma_t^{\delta} = \omega + \alpha(\mid \varepsilon_{t-1} \mid + \gamma \varepsilon_{t-1})^{\delta} + \sum_{\tau=1}^{4} \alpha^{\tau} D_t^{\tau} \mid \varepsilon_{t-1} \mid^{\delta} + (\beta + \sum_{\tau=1}^{4} \beta^{\tau} D_t^{\tau}) \sigma_{t-1}^{\delta}$
The number in parentheses represent t-statistics. LB and MCL represent Ljung-Box and McLeod-Li tests for serial correlations of one lag on the standardized and squared standardized residuals, respectively (p-values reported in brackets).
$^{***}, ^{**}, ^{*}$, indicates significance at the 1%, $5\%, 10\%$ level respectively.

8.5.6. Forecasting Using Spectral Techniques

In this section we employ spectral techniques in order to forecast the commodity prices of our study (to the best of our knowledge, this is the first time that forecasting using spectral techniques has been employed in commodity prices data). In particular we implement an algorithm suggested by Geweke and Porter-Hudak (1983). The basis of the method is the moving average representation:

$$Y_t = c(L)\varepsilon_t,$$

where $c(L) = 1 - c_1 L - ... - c_p L^p$ is polynomial in L of order p, $c(0) = 1$ and ε is fundamental for Y. Spectral techniques permit us to compute an estimate of the Fourier transform of c, which in turn can be employed to compute forecasts. In this study we will attempt to forecast the prices of grains, metals, softs and soya complex groups from 30^{th} of April 2012 (end of our original dataset) to 29^{th} of June of 2012 or for 45 steps ahead. In the case of energies we will forecast the price for 117 steps ahead after the end of our original dataset is 18^{th} of January 2012, except from wti, where forecasting will take place from 19^{th} of July 2010 to 31^{st} of August 2010. The reason behind the choice of that period (end of June 2012) lies in the fact that during the first quarter of 2012 the United Kingdom (UK) announced

a negative growth rate for a second consecutive time, formally entering a recession, while the euro zone showed negative growth rates for three consecutive quarters (2011Q4 to 2012Q2) after the recession of 2009. It would be only some months later when the euro zone would experience a double dip recession. Hence it would be interesting to investigate whether or not the forecasting technique would be able to capture the effects of this negative economic atmosphere that dominated the European economy on the US commodity prices.

During the period under consideration (daily data covering a period from January 2007 to April 2012) the commodity prices went through many variations due to the global financial and the EU sovereign debt crisis of 2007-2008 and 2009-present respectively. Hence employment of forecasting methods that are not sensitive to dynamic variations such as the aforementioned is a vital stage of the estimation procedure. Therefore, taking into consideration the properties of the spectral forecasting method, the latter could be considered as an appropriate technique for the forecasting of the commodity prices.

Figures 8.3 to 8.7 below display the history and the forecast for each of both the mapped and unmapped commodity prices. First notice that regardless of whether the data for each commodity are mapped or unmapped the trend (blue line in Figures below) is roughly the same. The only exception is that of wheat, platinum and heating oil where slight differences were observed between the mapped and unmapped forecasts. Specifying the results, in the case of corn the predicted prices remain almost stable while for wti and orange juice the prices decrease further, though slightly. In the case of natural gas and coffee overall the prices experienced significant deflationary dynamics, meaning that they followed a continuous negative trend whereas in the case of sugar prices, initially decreased and then started rising. In contrast the prediction for oats, rbob, cocoa, soybean, soymeal and soyoil displayed an upward trend. To check the validity of our results and the accuracy of the forecasting algorithm we compared the predicted prices (for the unmapped data) with those of the actual prices during the period under examination and we found that the way they behave (both predicted and actual series) is very similar. Hence spectral methods could be a reliable tool for predicting the future prices of commodities.

Figure 8.3. History and Forecast for Grains (Mapped and Unmapped Data)

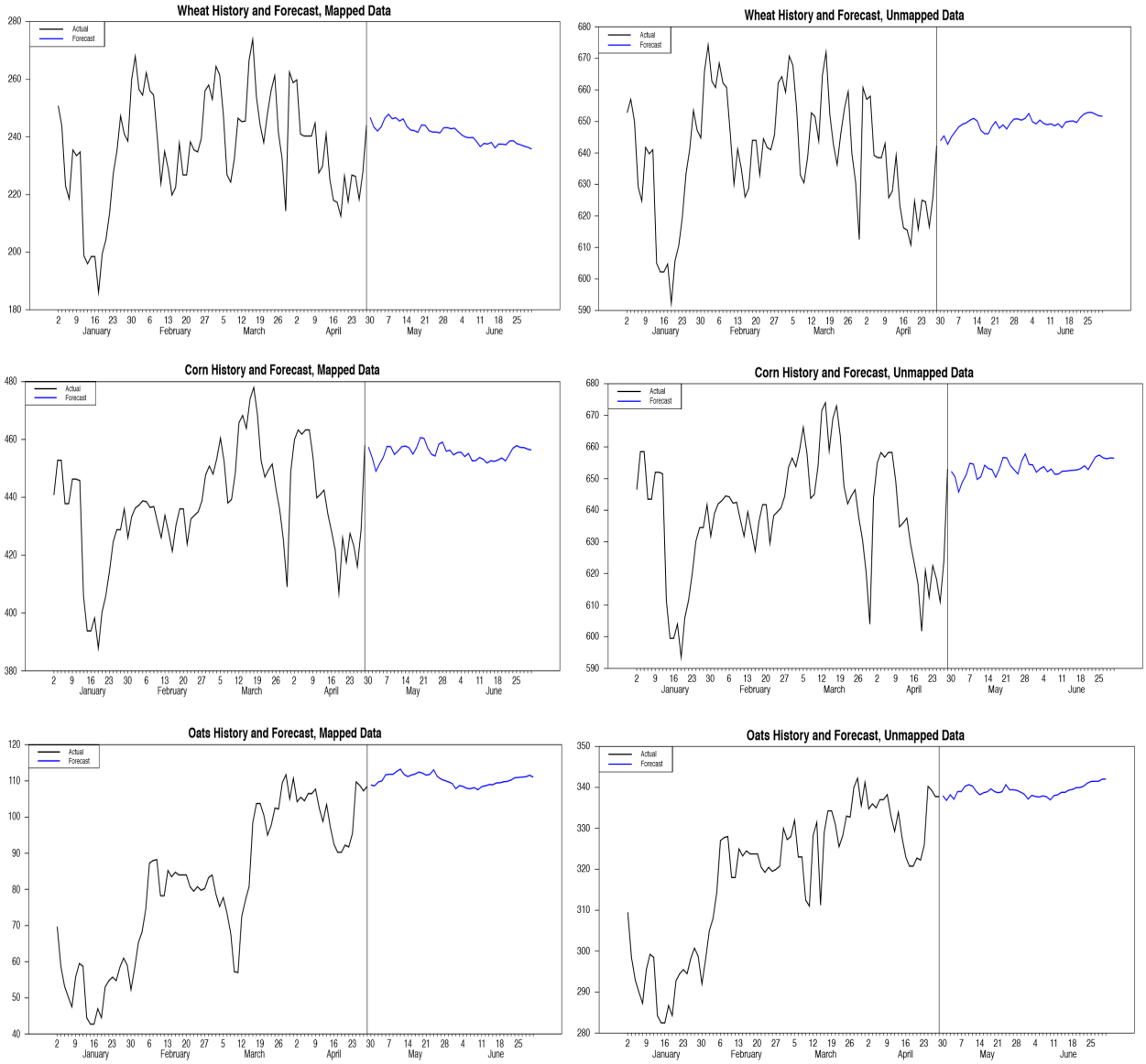


Figure 8.4. History and Forecast for Metals (Mapped and Unmapped Data)

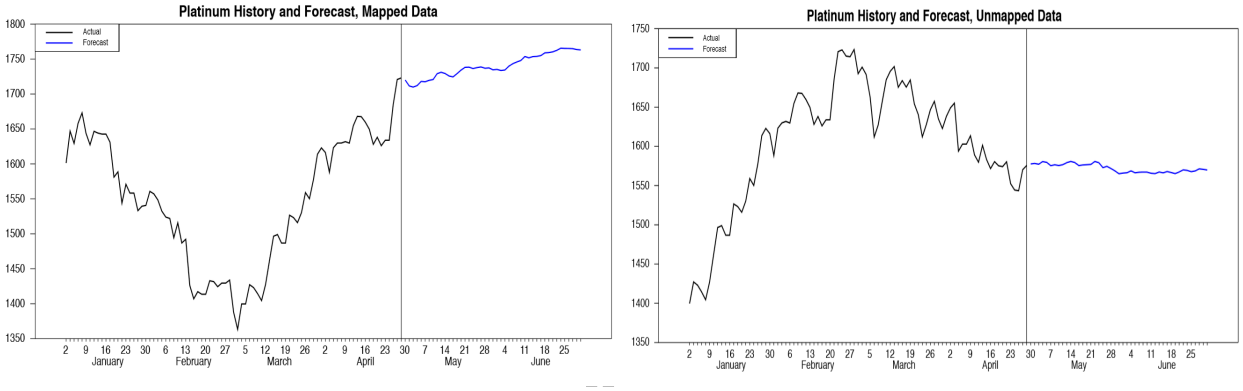
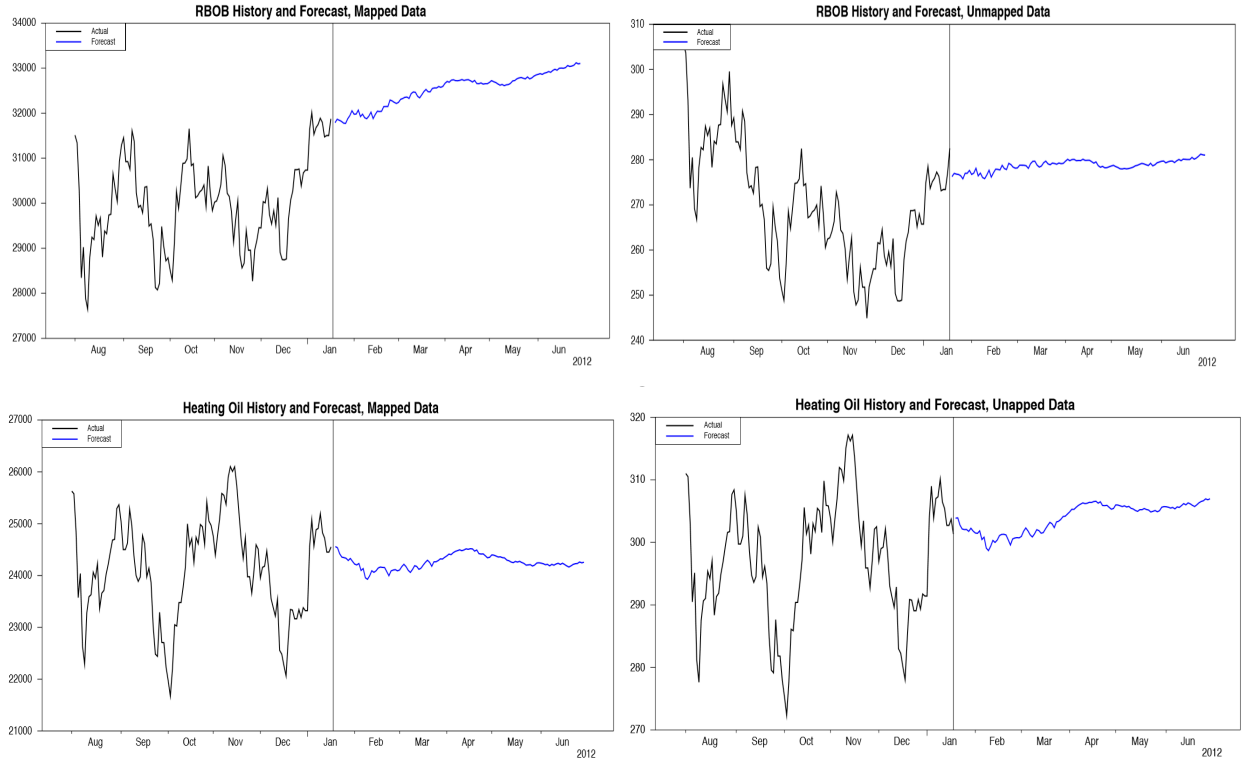
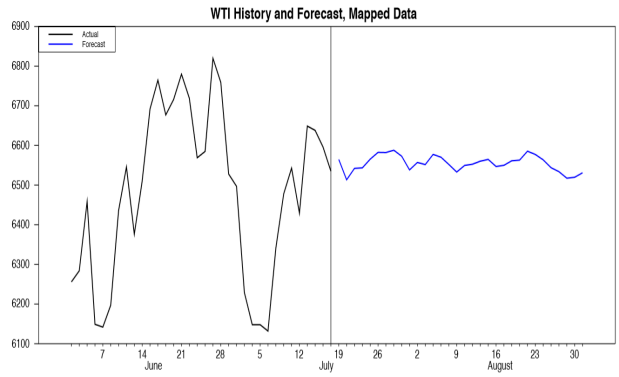
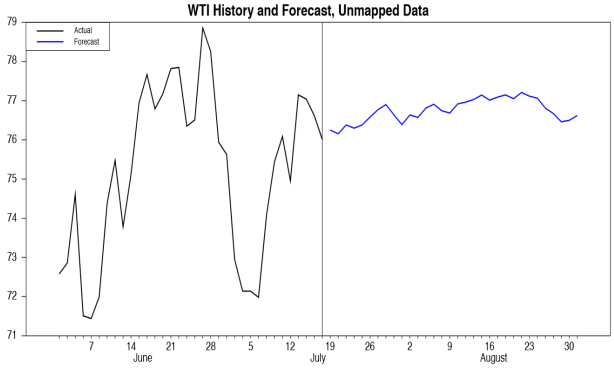
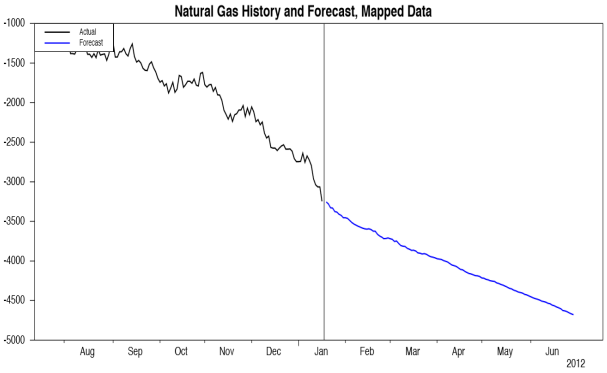


Figure 8.5. History and Forecast for Energies (Mapped and Unmapped Data)




WTI History and Forecast, Mapped Data
Actual
Forecast
6900
6800
6700
6600
6500
6400
6300
6200
6100
7
14
21
28
5
12
19
26
2
9
16
23
30
June
July
August


WTI History and Forecast, Unmapped Data
Actual
Forecast
79
78
77
76
75
74
73
72
71
7
14
21
28
5
12
19
26
2
9
16
23
30
June
July
August


Natural Gas History and Forecast, Mapped Data
Actual
Forecast
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2012

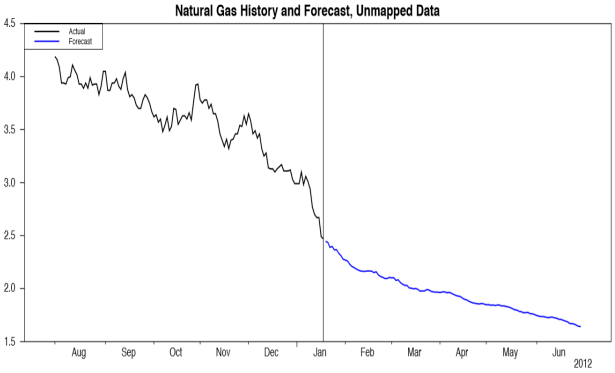
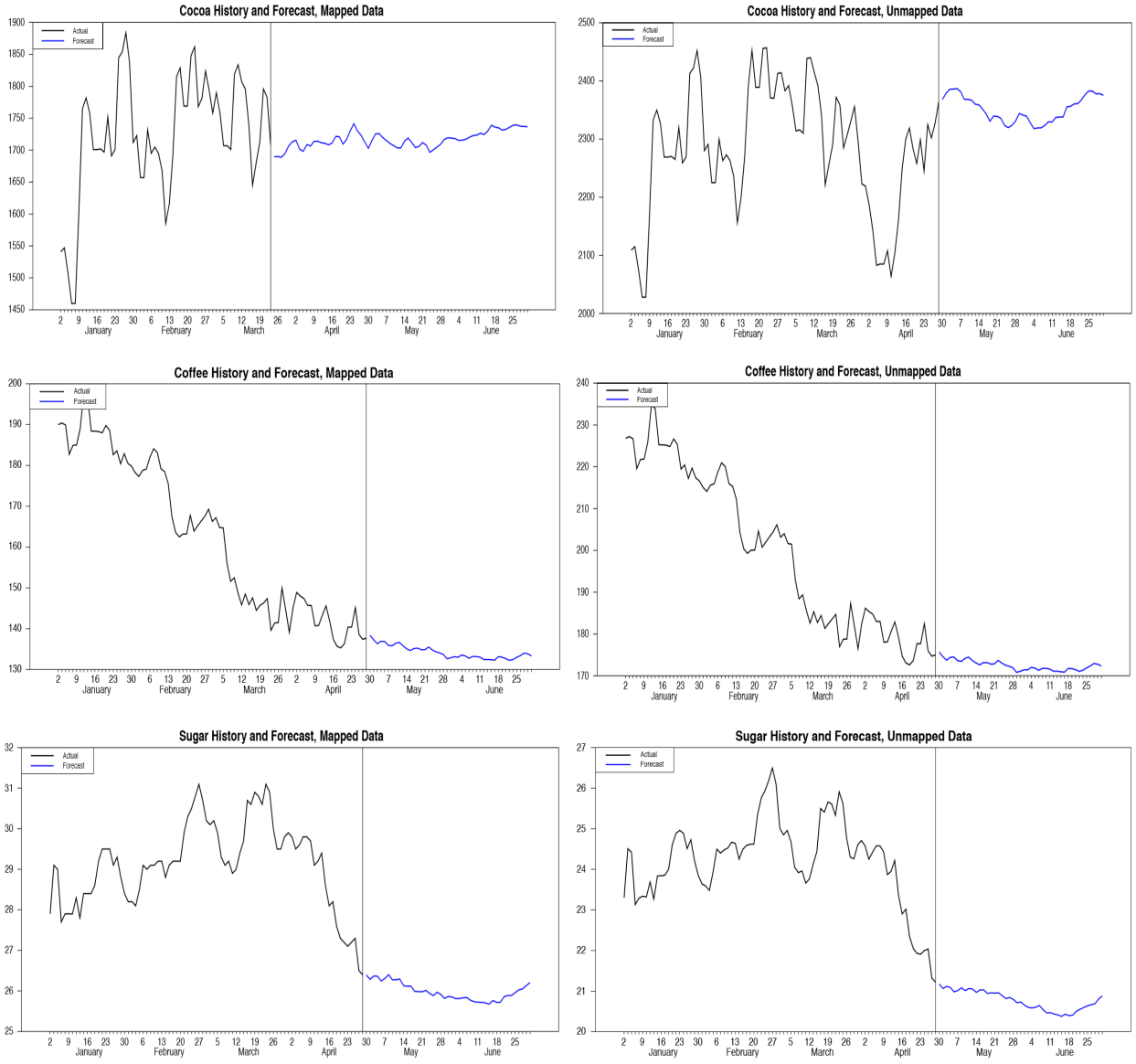

Natural Gas History and Forecast, Unmapped Data
Actual
Forecast
4.5
4.0
3.5
3.0
2.5
2.0
1.5
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2012

Figure 8.6. History and Forecast for Softs (Mapped and Unmapped Data)



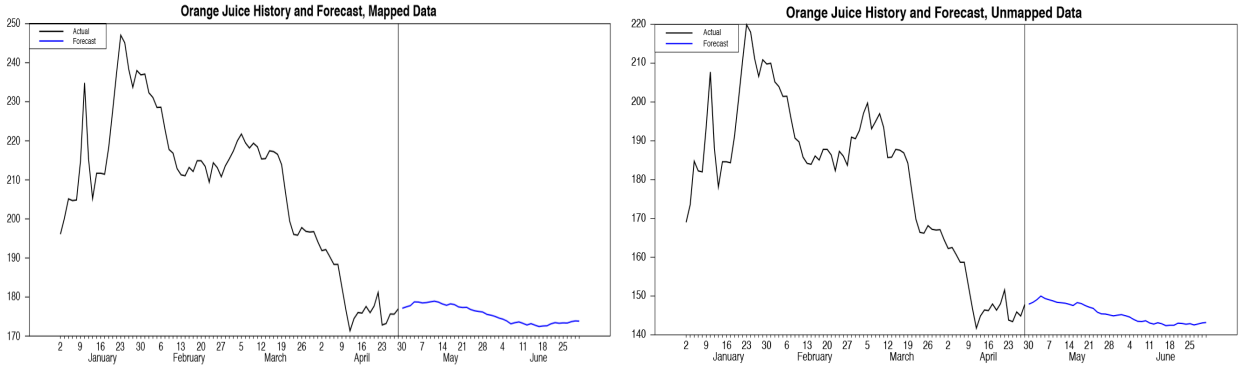
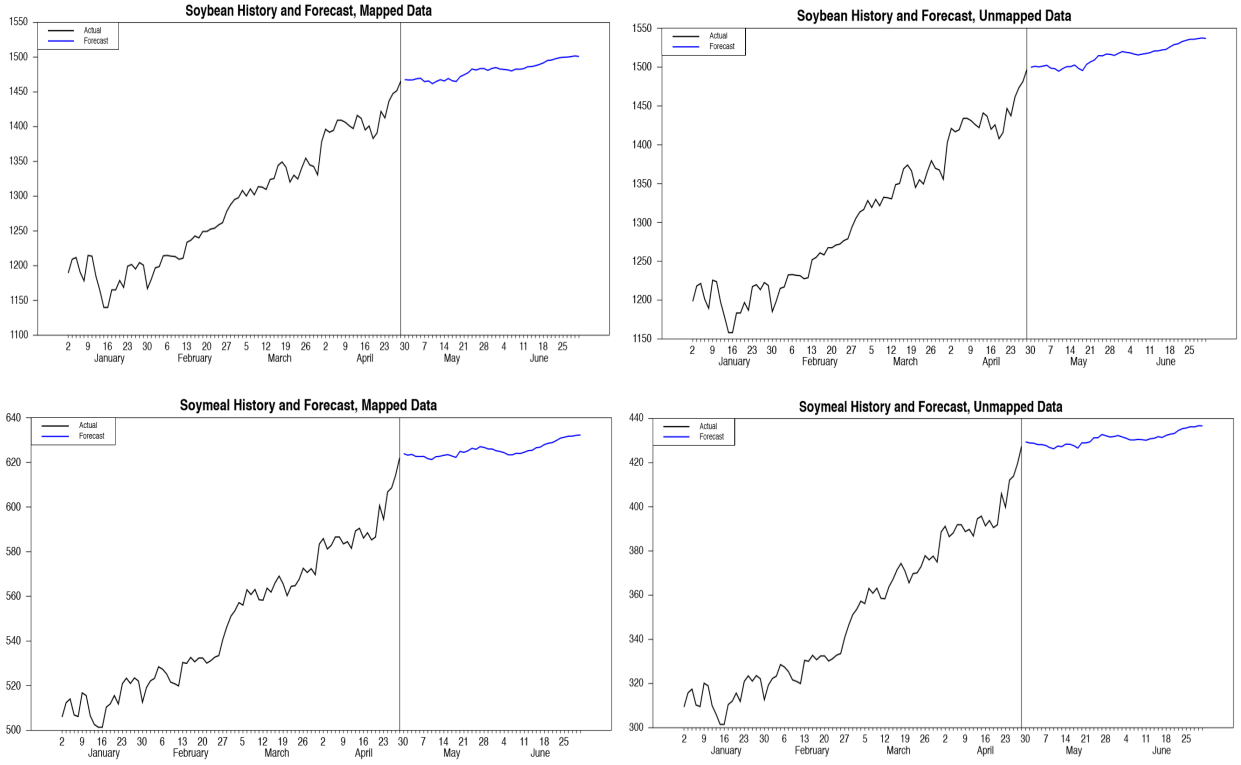


Figure 8.7. History and Forecast for Soya Complex (Mapped and Unmapped Data)



8.6. Conclusions

This study has provided evidence about the volatility of various daily commodity futures prices during the financial and EU sovereign debt crisis. Using data and a mapping procedure based on an algorithm provided by Margaronis et al. (2014, 2015) we first detected five breaks (employing the Bai-Perron estimation technique) for each of the commodity series which we associate with the recent global financial crisis of 2007-2008, and the European sovereign-debt crisis of 2009-present. Having obtained the breaks we then applied PARCH models to the commodity returns allowing the conditional means and variances to switch across the breakpoints identified by the Bai and Perron procedure.

Regarding the dynamics in the mean and the volatility, our results indicate that in general they have been both affected by the financial and EU sovereign debt crises. As far as the leverage effects are concerned, these were detected only on few occasions. Finally, the power parameter δ is fixed and different from either one or two in the majority of the cases.

Concluding we employ a spectral forecasting method which to the best of our knowledge has been employed for the first time in commodity time series. Our predictions show (regardless of whether the data are mapped or unmapped) that in the case of corn the prices remain almost stable while for wti and orange juice the prices decrease slightly. For natural gas and coffee overall significant deflationary behaviour was observed in the predicted price, whereas that of sugar followed an inhomogeneous pattern. Finally, the prices of oats, rbob, cocoa, soybean, soymeal and soyoil displayed an upward trend.

However, the impact of the recent financial and EU sovereign-debt crises could also be tested by employing a smooth transition GARCH model, allowing for breaks in both the conditional mean and the volatility), the role of the exchange rate on the futures returns and further examination of their long-memory properties (futures returns) are issues we feel future research should try to address.

Chapter 9

The Effect of Health and Military Expenditures on Economic Growth: A Panel Analysis

9.1. Introduction

After the end of the Cold War the world map changed completely and hence the priorities both in sociopolitical and strategic level. The majority of the countries previously belonging to the Warsaw Pact now are an integral part of the European Union and the North Atlantic Treaty Organization (NATO). In this Chapter we will attempt to jointly address the effect of health and military expenditures as well as that of trade openness and political instability on growth within a panel context.

Our preliminary results show that there is a negative effect of health and military expenditures, and political instability on output growth. With respect to the trade openness there is a positive impact on economic expansion.

This Chapter contributes to this literature by further investigating this link between military and health expenditures, trade openness, political instability and economic growth since little research has been conducted related to these four factors jointly. We may also add, that to the best of our knowledge this is the first study that conducts the aforementioned analysis focusing on the NATO countries.

This Chapter is organized as follows. Section 9.2 presents a brief literature review. Section 9.3 provides details for our data and justification for our econometric methodology and Section 9.4 presents our results. Section 9.5 concludes and suggests directions for further research.

9.2. Literature Review

Quite a few studies have addressed the impact of military and health expenditures, trade openness and political instability on economic growth.

As far as the military expenditures literature is concerned, Rothschild (1977) considering 14 OECD countries argued that military expenditures have a negative effect on output growth. Similarly Lim (1983) by employing the Harrod-Domar econometric framework, found evidence of a detrimental effect of defence spending on growth from a sample of 54 Less Developed Countries (LDC). In addition Leontief and Duchin (1983) cited that pragmatically all the countries that gradually lower their military expenditures can increase output. More recent studies such as Knight et al. (1996), Galvin (2003) and Dune and Tian (2015) all argue in favor of the negative effect of military burden on economic growth.

The issue of health and its impact on economic growth attracted much of the interest of previous research. Despite the fact that health has a beneficial impact on output growth there seems to be a dissatisfaction among the empirical health-growth literature when health expenditures as a share of GDP were utilized a health proxy. In particular, Diamond (1989) found a negative though insignificant impact of social expenditures (including health) on growth. In addition Lindert (1996) argued in favor of a negative but also insignificant link between health expenditures and income levels. Similarly, Kelly (2001) cited that health expenditures are negatively associated with economic growth. Finally, according to Wang (2011) in the case of countries with low and high levels of income, an increase in health care expenditure will be harmful to output growth.

With respect to trade openness, Krueger (1978) and Wacziarg and Welch (2008) argued that trade openness favors economic growth. Moreover, International Monetary Fund (IMF, 1997) stated that policies promoting international trade are among others essential in promoting economic expansion and

convergence in developing countries. In addition, OECD (1998) argued that more open and outward oriented economies tend to surpass countries with restrictive and more isolated trade policies. Finally, Fischer (2000) during a lecture (see also Rodriguez and Rodrick, 2001) noted that the most appropriate way for a nation to grow is the harmonization of its national policies with those of the international economy.

Finally, a series of previous research such as Barro (1989), De Gregorio (1992), Alesina et al. (1996), Ades and Chua (1997) and Aisen and Veiga (2013) report a negative relationship between political instability and economic growth.

9.3. Data and Econometric Framework

Annual data on economic, health, military, political and trade variables, over a period from 1993 to 2010 were gathered for 19 NATO countries[50]. The main sources were Cross National Time Series Data Archive — CNTS (see Banks et al., 2015) for the GDP growth, the various political instability measures (pi) and trade openness series (to), OECD (2015) for health expenditures as a share of GDP (he), and SIPRI (2015) for the military expenditures as a share of GDP (me).

As far as trade openness is concerned we use the standard ratio of exports plus imports as a share of GDP. For the various political instability measures we use the number of general strikes (str), guerilla warfare (gw), governmental crises (gc), riots (ri) and anti-government demonstrations (agd). For stationarity purposes we use the first difference of the (he) and (me) and (to) respectively.

In order to estimate our models we apply a pooled generalized least squares (GLS) method. The vector of explanatory variables, for the models of Table 1 below contains the drift, the (he) and (me) measures, to and the various political instability indicators (pi). That is, $\mathbf{x}_{it} = (1, fe_{it}, me_{it}, to_{it}, pi_{it})$. The model for the economic growth series $\mathbf{y}_{it}$ is given by:

$$y_{it} = \phi_1 + \phi_2 fe_{it} + \phi_3 me_{it} + \phi_4 to_{it} + \phi_5 pi_{it} + u_{it}, \tag{1}$$

where $u_{it} = \mu_i + \nu_{it}$ is the innovation. Due to the fact that we run the models taking under consideration cross-section random effects without time effects, it follows that $\mu_i \sim i.i.d.N(0, \sigma^2_{\mu t})$ and $\nu_{it} \sim i.i.d.N(0, \sigma^2_{\nu t})$, meaning that the two errors are independent from each other.

9.4. Empirical Results

Table 9.1 reports the principal results. First notice that there is a negative impact of health and military expenditures on economic growth. Second a positive link between trade openness and output growth while a negative one for political instability indicators (negative though insignificant in the case of gw and agd). The latter means that the higher the political unrest the lower the economic expansion.

[50] namely Belgium, Bulgaria, Canada, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Latvia, Netherlands, Norway, Poland, Portugal, Spain, Turkey, United Kingdom, United States.

Table 9.1. Results from the estimated models

Variables	GDP growth					
he	−0.0128**	−0.0131**	−0.0131**	−0.0131**	−0.0125**	−0.0127**
	(0.00566)	(0.00571)	(0.00578)	(0.00564)	(0.00567)	(0.00567)
me	−3.862***	−4.261***	−3.813***	−4.107***	−3.946***	−3.867***
	(1.233)	(0.905)	(1.230)	(1.363)	(1.232)	(1.222)
to	0.0849***	0.0805***	0.0846***	0.0814***	0.0857***	0.0867***
	(0.0270)	(0.0253)	(0.0264)	(0.0280)	(0.0270)	(0.0272)
str		−0.0103*				
		(0.00538)				
gw			−0.00502			
			(0.0122)			
gc				−0.0085***		
				(0.00233)		
ri					−0.00268**	
					(0.00114)	
agd						−0.00151
						(0.00219)
constant	0.0248***	0.0259***	0.0251***	0.0261***	0.0251***	0.0254***
	(0.00235)	(0.00245)	(0.00263)	(0.00242)	(0.00234)	(0.00267)
obs	323	323	323	323	323	323
countries	19	19	19	19	19	19

Notes: Table reports the parameter estimates of the following model:

$x_{it} = \phi_1 + \phi_2 fe_{it} + \phi_3 me_{it} + \phi_4 to_{it} + \phi_5 pi_{it} + u_{it}$

Robust standard errors in parentheses.

***, **, * indicate signicance at 1%, 5% and 10% level respectively.

9.5 Conclusions

This Chapter has provided evidence about the link between health and military expenditures, trade openness, political instability and economic growth in nineteen NATO countries over a period 1993 to 2010. By applying a pooled GLS method our results indicated a negative impact of health and military expenditures, and political instability on growth, whereas that of trade openness is positive.

However, a breakpoint analysis (this could be conducted by employing structural change models), and the implementation of a panel smooth transition framework that takes into account the estimated breaks are issues that this research is going to focus in the near future.

Chapter 10

Concluding Remarks

In this thesis we considered issues in the field of futures-commodities, macroeconomic volatility and financial development.

Chapter 2 attempts to explain why Argentina is the only country in the World that was developed in 1900 and developing in 2000. The main goal of this Chapter was to conduct a thorough evaluation of the dating of the debacle that has not been tried previously. For the purpose of this study, we employed an extensive set of Argentinean per capita GDP and an econometric evaluation of the number and timing of structural changes that could potentially exist in each of them, we conclude that there are two key dates in Argentina's economic history (1918 and 1948) that need to be inspected closely in order to further our understanding of the Argentine debacle. The importance of the aforementioned dates lies on the fact that the Argentina debacle might be explained in terms of both financial and institutional development, candidate explanations that have not received so much attention so far. Our baseline findings support the positive effect of financial development on economic growth in the long-run. In addition, different types of political instability and institutional development impact growth through different channels over different time periods, establishing a powerful and durable effect that proves to be rather powerful with regards to the benefits brought by financial development. Future research should try first to shed light on whether the effect of these two reasons in different countries varies over the long-run and second to examine the interrelationship between finance and institutions.

Chapter 3 and 4 by employing the smooth transition approach and annual time series data in Brazil over a period covering from 1890 to 2003 tried to answer two research questions. What is the relationship between financial development, trade openness, political instability and economic growth in Brazil? Does the intensity and the sign of these effects vary over the time?. The results of our Chapter can be summarised as follows. As far as the impact of trade openness on growth is concerned, that is positive throughout the sample period. Nevertheless, among others we detect low positive size effects during the Great Depression (1929 to 1933). A possible explanation for the observed low size effects of trade openness on growth during 1929-1933 could be the reduction in exports and imports in that period, which in turn reduced the level of trade openness. With respect to the various measures of political instability, there is a mainly negative impact of both informal and formal political instability on growth. However, in the case of rev we detect a number of occasions where a positive relationship exists between the latter and growth. More specifically one of them covers the period from 1975-1978. The successes in the field of economy of that period, despite the enforcement of the military junta that took place shortly before, promoted economic growth that was growing on average by 11%. Regarding our baseline findings for financial development in contrast to the existing literature, which reports a negative short-run relation between financial development and growth, we argue in favor of a mixed time-varying effect (in the short-run) for CBD and dbb while a mainly negative one for M1. As far as the time-varying results are concerned we detect three periods where financial development has a clearly positive effect on economic growth, namely 1968-1974, 1991-1993 and 1997-1999. Finally, the γ parameter measuring whether or not the change between the two regimes is smooth, shows that in the majority of the models the aforementioned transition was not smooth. Summarizing, the finance-growth nexus in Brazil intrinsically depends on political institutions and on the regime-switching factor, which is trade openness. However, a breakpoint analysis (this could be conducted by employing structural change models), and the implementation of a LST econometric framework that takes into account the estimated breaks are issues we feel future research should try to address.

Chapter 5 has provided evidence about the behaviour of European inflation rates covering a period from 1980 to 2013. By applying panel unit root tests we show that the stationarity hypothesis seems to hold, before and after the birth of the common currency in 1997, even when CSD is accounted for. This means that some differentials are stationary and therefore there might be clubs of countries which have been in the process of converging absolutely or relatively. For the pre-euro period, regarding absolute convergence, the univariate stationarity tests provide weak overall evidence and the unit root tests provide moderate evidence for the pairwise contrasts that include one early and one late accession country. However, in all other cases they show that inflation rates displayed strong convergence with each other. Next, having obtained mixed evidence in favor of convergence using the univariate unit root testing procedures, we examined the possibility that stability had occurred only for some subset of the countries by employing multivariate stationarity tests and the clustering algorithm for the identification of stability clubs. We found no evidence of overall stability-around either a zero mean or a broken mean- of inflation differentials. However, inflation rates appeared to move homogeneously among sub-groups of early accession countries. For the pre-euro period three absolute convergence clubs were identified, all of which included early accession countries: a sub-group with Germany and France, one with The Netherlands and Finland, and a bigger sub-group with Austria, Belgium and Luxembourg. For the post-1997 period Germany turned out to belong to a big sub-group together with Austria, Belgium and Luxembourg while France clustered with Finland. For the rest of the countries/cases we find evidence of divergent behaviour.

However, the analysis in Conrad and Karanasos (2015a) and Canepa and Karanasos (2015) about the size distortion and low power of the unit root/stationarity tests in the presence of strong PARCH in-mean effects and of structural breaks, together with our evidence on such effects (for at least a few inflation differentials), call for some caution on the interpretation of the results from the unit root/stationarity testing procedures.

For the high inflation countries deviations from the ERM policies led to higher inflation rates that were above the average. This can be easily seen from graphical representations in Figures 5.1-5.3. In particular, Figure 5.3 displays quarter on quarter contour plots of inflation rates of European countries and their average. The vertical axis reports the average European inflation rates and the horizontal one the period that this research examines. The colours in each graph represent each European member's level of inflation rate. From these graphs we can notice that the more we move to the right of the horizontal axis the blue colour becomes darker. This means that the differential between the average European and each country's inflation rate is diminishing.

Finally, Figures 5.4 to 5.10 above show the average inflation rates of each of the twelve eurozone countries distinguished into seven different periods and in particular the two periods before the launch of the EMU (1980-1983, 1984-1989), the three EMU stages, the post enlargement period (2004-2007) and the years covering the financial and EU sovereign-debt crisis (2008-2013). The first four figures clearly verify the downward trend of average inflation rates for all the countries, the beneficial impact of ERM and the faster pace of the early accession countries relatively to the late accession ones. In contrast, with the launch of the third stage of EMU (Figure 5.8), average inflation rates started rising (with the exception of Germany, Greece and Italy) whereas the same pattern continued to occur [with the exception of Italy (though the drop is very slight), Portugal, Spain and The Netherlands] during the post enlargement period (Figures 5.9). Finally, Figure 5.10 reports the deflationary dynamics that the financial crisis and the EU-sovereign debt crisis imposed on the eurozone economies.

However, the impact of the recent financial and EU sovereign-debt crises on inflation differentials (this could be tested by employing sensitivity analysis), the role of the persistence of inflation pairwise contrasts on the European economy and forecasting (of inflation differentials), are issues we feel future research should try to address.

In Chapter 6 we summarize the opinion of three renowned economists (alphabetically), namely Paul De Grauwe, Paul Krugman and Joseph Stiglitz, on the eurozone crisis as well as the Greek case. In

support of their claims we provide evidence of the negative impacts of the austerity plans on the Greek economy for a period covering 2010-2014. Since the Greek economy's integration in the EAP in 2010, much has been written and said about the necessity and efficiency of these programs. Among them are the three economists Paul De Grauwe, Paul Krugman and Joseph Stiglitz.

In particular, De Grauwe argued, first that the euro area crisis contributed towards unsustainable government debts, second, the ill-designed fiscal policies remain at the centre of the continuously weakened economic expansion of the zone and third despite the Institutions' efforts for reforms, these were not sufficient to address and solve the design failures of the eurozone. All the parties are responsible for the imbalances that existed between the euro area countries, 'for every foolish debtor there must be a foolish creditor' (De Grauwe, 2015).

Krugman, with a series of articles, illustrates the incomplete tackling of the Greek crisis by the Institutions and that the creation of the euro was a 'terrible mistake' (see Krugman 2015a). He pointed out that with negative GDP growth rates in the period 2008-2013 and participation in a hard currency (euro) that allowed limited space and freedom for progressive and bold monetary policies, the future of the Greek economy is at stake. Krugman (2010) argued that with German support (which unfortunately did not materialize) the European countries should have guaranteed Greek debt in exchange for an obligation to undertake harsh fiscal measures. According to Krugman (2015a), the fact that the leftist coalition under Syriza in Greece has acceded to the troika's (the institutions representing creditor interests) ultimatum represents the 'final abandonment of any pretence of Greek independence'. He says that 'the troika officials, these supposed technocrats, are in fact fantasists who have disregarded everything we know about macroeconomics'. Krugman (2015b) wonders whether a Grexit might work, as in the case of Argentina, which abandoned its one-peso-one-dollar policy in the period 2001-2002.

Stiglitz (2010) argues that although Greece is among the poorest of the European family, if Europe had developed a more efficient solidarity and stabilisation framework, then budget deficits in the periphery of Europe might have been smaller and hence easier to manage. In addition, Europe did not adopt the principle of do no 'harm'. For example, announcements made by the EU leaders exacerbated Greece's problem. Stiglitz (2015c) brings up the point that Greece's bailout was not a bailout of the country but of the Western banks, who did not do adequate due diligence. In full agreement with De Grauwe's (2015) arguments, Stiglitz noted that the lenders 'bear even more responsibility for the current mess than the borrowers'. Moreover, despite the fact that the IMF has warned of the dangers that the high taxation might impose, yet in Greece the troika insisted on imposing high taxes even at low income levels. Stiglitz (2015f) points out that Although the requirement is intended to reduce tax evasion, in the case of Greece it will destroy small business. Finally, Stiglitz (2015e) points out that an alternative way to exit the crisis might be moving towards a dual currency circulation. Argentina and others have shown how this can be done. Despite the fact that every country is different there are, however, some astonishing resemblances between the two countries. Both countries were being choked by austerity as well as (under the IMF programs) experiencing rising unemployment, poverty, and immense suffering (Stiglitz, 2015d).

In support of their claims, we provide nineteen socioeconomic indicators that show the deterioration of the Greek economy and the difficulties faced by society during the five years of austerity measures. At the same time, since much has been written about the problem of competitiveness of the Greek Economy, the latest ranking lists reveal that little has been achieved in this field (see Figure 6.22 above). In particular, after five years of restrictive policies the position of the Greek economy in the global rankings does not seem to have improved dramatically. In addition, the credit default swap (CDS) spread (at basis points) is still at high levels (see Figure 6.23 above), just above the dam of two thousand basis points, suggesting that the risk of a credit event is too high (the cost of insuring against a Greek default). Verifying the lack of competitiveness and the high risk of bankruptcy of the Greek economy the Big Three rating agencies [namely, Standard & Poor's (S&P), Moody's and Fitch and the Rating and Investment Information Inc. (R&I)] negatively assessed the creditworthiness of the bonds issued by the Greek government (see Figure 6.24 above) in the period covering 2009-2015.

Chapter 7 has provided evidence about the properties of inflation rates and their volatilities for five EU countries over a long period of time 1960-2013. Using quarterly data we first detected five breaks (employing the Bai-Perron estimation technique) for each of the inflation rates series, which we associate mainly to the Merger Treaty of the 1965, the oil crises of 1970s, the global economic crisis of the early 1980s, the launch of the ERM in 1979 and the adoption of the Spinelli draft in the first quarter of 1984. Having obtained the breaks we then apply various PARCH models with or without in-mean effects on the inflation rates allowing the conditional means and variances to switch across the breakpoints identified by the Bai and Perron procedure.

With respect to the conditional mean and volatility, our results detect time-varying dynamics, which could be attributed mainly to the oil crises of 1970s and the launch of the ERM. As far as the power parameter is concerned, this is fixed and different from either one or two. In addition we detect (the period preceding all the breaks) a positive impact of the inflation uncertainty on inflation rates for the case of France, Austria and Denmark and to a less extent in Italy, whereas there are negative asymmetric effects for some of the countries.

However, although the breakpoint analysis did not capture the impact of the recent financial and EU sovereign-debt crises, in addition of abrupt breaks it could also be tested the time-varying behaviour of inflation rates by employing a smooth transition GARCH (where the transition variable could be either the financial or the EU crisis) model allowing for breaks in both the conditional mean and the volatility. Finally a forecasting analysis of inflation rates are among the issues we feel future research should try to address.

Chapter 8 has provided evidence about the volatility of various daily commodity futures prices during the financial and EU sovereign debt crisis. Using data and a mapping procedure based on an algorithm provided by Margaronis et al. (2014, 2015) we first detected five breaks (employing the Bai-Perron estimation technique) for each of the commodity series which we associate to the recent global financial crisis of 2007-2008, and the European sovereign-debt crisis of 2009-present. Having obtained the breaks we then apply PARCH models on the commodity returns allowing the conditional means and variances to switch across the breakpoints identified by the Bai and Perron procedure.

Regarding the dynamics in the mean and the volatility, our results indicate that in general they have been both affected by the financial and EU sovereign debt crises. As far as the leverage effects are concerned, these were detected only in few occasions. Finally, the power parameter δ is fixed and different from either one or two in the majority of the cases.

Concluding we employ a spectral forecasting method which to the best of our knowledge is employed for the first time in commodity time series. Our predictions show (regardless of whether the data are mapped or unmapped) that in the case of corn the prices remain almost stable while for wti and orange juice the prices decrease slightly. For natural gas and coffee overall significant deflationary behaviour was observed in the predicted price, whereas that of sugar followed an inhomogeneous pattern. Finally, the prices of oats, rbob, cocoa, soybean, soymeal and soyoil displayed an upward trend.

However, the impact of the recent financial and EU sovereign-debt crises (could also be tested by employing a smooth transition GARCH model allowing for breaks in both the conditional mean and the volatility), the role of the exchange rate on the futures returns and further examination of their long-memory properties (futures returns), are issues we feel future research should try to address.

Chapter 9 has provided evidence about the relationship between health and military expenditures, trade openness, political instability and economic growth in nineteen NATO countries over a period 1993 to 2010. By applying a pooled GLS method our results indicated a negative impact of health and military expenditures, and political instability on growth, whereas that of trade openness is positive. However, a breakpoint analysis (this could be conducted by employing structural change models), and the implementation of a panel smooth transition framework that takes into account the estimated breaks are issues that this research is going to focus in the near future.

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