Growth, Cycles and Macroeconomic Policy in the European Union

by

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Declaration

This thesis is presented in accordance with the regulations for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree. Moreover, all the work in this thesis has been undertaken by myself only. All quoted text remains the copyright of the original attributed author.

The major body of this thesis is based on papers that I presented in different workshops and conferences: earlier versions of Chapter 2 were presented at the Seminar to upgrade from the MPhil/PhD to a PhD in Economics, University of Warwick, 5 December 2006, and at the INFER Workshop on 'Integration and Globalization', University of Coimbra, Portugal, 29-30 June 2007; an earlier version of Chapter 4 was presented at the Macroeconomics Workshops, University of Warwick, 20 May 2008; and an earlier version of Chapter 5 was presented at the Macroeconomics Workshops, University of Warwick, 30 September 2008, and at the 10^{th} *INFER* Annual Conference, University of Évora, Portugal, 19-21 September 2008.

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Abstract

The implementation of the Maastricht criteria, establishment of the Stability and Growth Pact (SGP), creation of the European Central Bank (ECB) and the Economic and Monetary Union (EMU) raised several challenges for the European Union (EU) countries. The main aim of this dissertation is to analyse the economic implications of those institutional changes. Chapter 2 provides an empirical answer to the question of whether Maastricht and SGP fiscal rules have affected growth in the EU countries. Results from the estimation of a growth equation show that growth of real GDP per capita in the EU was not negatively affected in the period after Maastricht. The main conclusion of this analysis is that the institutional changes that occurred in some European countries after 1992 were not harmful to growth.

Chapter 3 tries to identify the main causes of excessive deficits in the EU. A conditional logit model is estimated over a panel of EU countries, where an excessive deficit is defined as a deficit higher than 3% of GDP. Results indicate that a weak fiscal stance, low economic growth, elections and majority left-wing governments are the main causes of excessive deficits. They also show that the institutional constraints imposed after Maastricht over the EU countries have succeeded in reducing the probability of excessive deficits, especially in small countries and in countries traditionally affected by large fiscal imbalances.

A widespread idea in the business cycles literature is that the older is an expansion or contraction, the more likely it is to end. Chapter 4 provides further empirical support for this idea of positive duration dependence controlling simultaneously for the effects of other factors on the duration of expansions and contractions. This study employs for the first time a discrete-time duration model to analyse the impact of some variables on the likelihood of an expansion and contraction ending for a group of EU and non-EU countries. The evidence suggests that the duration of expansions and contractions is not only dependent on their actual age: the duration of expansions is also positively dependent on the behaviour of the OECD composite leading indicator and on private investment, and negatively affected by the price of oil and by the occurrence of a peak in the US business cycle; the duration of a contraction is negatively affected by its actual age and by the duration of the previous expansion.

Finally, Chapter 5 raises the question of whether central banks' monetary policy can be described by a linear Taylor rule or, instead, by a more complex nonlinear rule. This chapter also analyses whether those rules can be augmented with a financial conditions index containing information from some asset prices and financial variables. A forward-looking specification is employed in the estimation of the linear and nonlinear rules. A smooth transition model is used to estimate the nonlinear rule. The results indicate that the behaviour of the Federal Reserve of the United States can be described by a linear Taylor rule, whilst the behaviour of the ECB and Bank of England is best described by a nonlinear Taylor rule. In particular, these two central banks tend to react to inflation only when inflation is above or outside their targets. Moreover, the evidence also suggests that the recently created ECB is targeting financial conditions, contrary to the other two central banks.

Abbreviations

AIC – Akaike Information Criterion

AMECO –Annual Macroeconomic Database of the European Commission

AS-AD – Aggregate Supply-Aggregate Demand

BOE – Bank of England

CPI – Consumer Price Index

DF – Dickey-Fuller (unit root test)

DFE – Dynamic Fixed effects

DW – Durbin-Watson (statistic)

ECB – European Central Bank

ECOFIN – Economic and Financial Affairs Council for the European Union

ECRI – Economic Cycle Research Institute

EFCI – Extended Financial Conditions Index

EMU – Economic and Monetary Union

ERM – Exchange Rate Mechanism

EU – European Union

FCI – Financial Conditions Index

Fed – Federal Reserve of the United States

GBS – Government Budget Surplus

GDP – Gross Domestic Product

GM – Great Moderation

GMM – Generalized Method of Moments

GNP – Gross National Product

HICP – Harmonized Index of Consumer Prices

IV – Instrumental Variables

KPSS – Kwiatkowski-Phillips-Schmidt-Shin (stationarity test)

LSTR1 – Logistic Smooth Transition Regression

LSTR2 – Quadratic Logistic Smooth Transition Regression

MRS – Multinomial Regime Switching

NBER – National Bureau of Economic Research

NP – Ng-Perron (unit root test)

PBC – Political Business Cycles

PMG – Pooled Mean Group

PPP – Purchasing Power Parity

OECD – Organization for Economic Cooperation and Development

RBC – Real Business Cycles

RPI – Retail Price Index

RPIX – Retail Price Index excluding mortgage interest payments

SBIC – Schwartz Bayesian Information Criterion

SGP – Stability and Growth Pact

STR – Smooth Transition Regression

SVAR – Structural Vector Autoregression

UK – United Kingdom

US – United States

USD – United States Dollar

VAR – Vector Autoregression

WWII – World War II

1. Introduction

In 1992 the twelve countries that formed the European Economic Community signed a Treaty – the Maastricht Treaty – that formally established the European Union (EU) and led to the creation of a new currency, the Euro. With this Treaty they agreed to comply with some fiscal and monetary criteria in order to actively control their public accounts and to converge in nominal terms before taking part in the Economic and Monetary Union (EMU) by 1999.

By taking part in EMU, these countries had to cede control over exchange rate and monetary policies to a new monetary institution, the European Central Bank (ECB). This organization was created to conduct the monetary policy in the group of countries that adopted the Euro as new currency. The only policy remaining in the hands of EMU members is fiscal policy, but even this is limited by the requirements of the Stability and Growth Pact (SGP). The SGP was created to regulate fiscal policy after the introduction of the Euro, i.e. to prevent countries from relaxing their convergence efforts or their fiscal policy after they have taken part in EMU.

The intention of the countries that are taking part in this challenge is to create an economic area in which – besides factors mobility – trade and general economic relations between them can be simplified, intensified and improved so that they can benefit from a common higher level of development and economic growth and, in the end, economic and political stability.

Given the asymmetries between some of the member countries and the complexity of the integration process, some authors have raised doubts about its success. Thirlwall (2000), Arestis *et al*. (2001), Warin (2005) and Wyplosz (2006) argue that the fiscal criteria imposed by the Maastricht Treaty and reinforced by the

SGP may have undermined economic growth in the EU countries. The fiscal criteria impose that over the economic cycle countries should avoid deficits higher than 3% of GDP and keep public debt lower than 60% of GDP.

Arguments for fiscal rules have their foundations in the theory of Optimal Currency Areas, which states that when countries form an EMU they lose their independence over both monetary policy and the exchange rate. Therefore, a significant centralization of the national budgets to accommodate asymmetric shocks in the different countries would be desirable or expected. However, in the EU context this did not occur because of the fears that the resulting temporary fiscal transfers might become permanent, which could create political problems among the EU countries and endanger the unity of the EU. Therefore, the alternative was to leave fiscal policy in the hands of national governments – to face asymmetric shocks when necessary – and to put in place rules to avoid excessive deficits. Those rules are important because governments' temptation to create budget deficits to absorb negative shocks in an EMU can lead to problems of sustainability of those deficits and to growing government debts. There could also be negative spillovers for other EMU states, and the price stability policy of the ECB could be threatened. These issues led to the definition in the Maastricht Treaty of the fiscal rules for the deficit and debt – that countries have to satisfy in order to take part in EMU – and to the creation of the SGP, for countries in EMU, to avoid the problems mentioned above.

However, with those fiscal constraints and without the monetary instruments, the margin of manoeuvre of the countries in EMU to face asymmetric shocks is substantially reduced. Hence, countries have to rely on supply side measures for adjusting to adverse situations. Since the labour market is not as flexible and dynamic as required, and factor productivity varies substantially between some member countries, it may take some time until countries can fully adjust to the new economic reality. Meanwhile, economic growth in the EU might be compromised by the restrictions imposed over important instruments of macroeconomic policy.

As the phenomenon of economic integration in the EU is still relatively recent, few empirical studies have yet focused on studying the implications of EU institutional changes on economic growth. The most relevant studies that have attempted to analyse empirically the effects of this process on economic growth were provided by Savona and Viviani (2003), Hein and Trugger (2005) and Soukiazis and Castro (2005). However, they tend to either use an *ad-hoc* specification without taking into account the economic growth literature (Hein and Trugger, 2005) or ignore important assumptions of this literature (Savona and Viviani, 2003 and Soukiazis and Castro, 2005), like the role of physical and human capital.

The economic growth literature has a long tradition in economics that goes back to the works of Adam Smith and David Ricardo. However, the first attempt to model growth analytically was made by Robert Solow and Trevor Swan only in the 1950s. Their models comprise some equations showing the relationship between labour, capital, investment and output. Here the role of technological change became important, while labour and capital are assumed to have diminishing returns. One important implication of these models is that economic growth is generated by an increase of capital relative to labour. However, given the diminishing returns the economy will converge to a point at which no additional increase in capital will produce more growth. This point is called a “steady-state”. Only technology improvements are able to increase this steady state, so more investment will generate more growth. As all this growth process is exogenous and data do not confirm the predictions of these models, a new group of growth theorists decided to revise them "endogenizing" the technology.

Thus, in the late 1980s, Paul Romer, Robert E. Lucas and Robert J. Barro developed the "endogenous growth theory" to explain the technological advance. This framework incorporates human capital as well as physical capital. Returns to capital are now considered constant and growth does not slow as capital accumulates, but it depends on the type of capital a country invests in (i.e. human or physical).

The most recent advances in the economic growth literature rest on these important theoretical developments. The first study developed in this dissertation is greatly based on this literature, extending it to the analysis of the impact of Maastricht criteria and SGP fiscal rules on economic growth. Hence, contrary to the other empirical works for the EU, this study builds the analysis around a formal growth model. The growth equation estimated in the first part of this dissertation is augmented with fiscal variables and variables to control for the period in which fiscal rules were implemented over the EU countries. Dynamic fixed effects, pooled mean group and generalized method of moments estimators are employed in the estimation of the growth equation for the period 1970-2005 over a panel of 15 EU countries. Some other OECD countries (non-EU countries) are used as a control group. These advances in the method of analysis allow us to confirm some of the results of other studies on economic growth and to conclude that the institutional changes that occurred in some European countries after 1992 were not harmful to growth.

Taking into account the problems that may arise from unbalanced public accounts for countries in an EMU pointed out in the first essay, this dissertation also tries to find the reasons why EU countries sometimes run excessive deficits. The literature provides a plethora of interrelated economic and political causes for public deficits, but the particular study of the determinants of excessive deficits remains practically unexplored. Therefore, this study intends to contribute to the literature with a broad analysis of the economic, political and institutional determinants of an excessive public deficit and, in that way, help to explain why EU countries are sometimes affected by excessive deficits and try to clarify what conditions may help them to avoid such a situation in the future. As this analysis focuses its attention on a group of EU countries, it defines an excessive deficit as a deficit higher than 3% of GDP, in line with the legal concept established by the Maastricht Treaty and later reinforced by the SGP.

According to the Keynesian theory, (large) budget deficits may arise when an economy is in recession. Hence, these are the result of the redistributive policy that a government follows to stabilize the impact of a recession. On one hand, more subsidies are transferred for people who lost their jobs and more public investments should be undertaken; on the other side, less revenue is collected due to the economic slowdown. However, during expansions public deficits should disappear to satisfy the intertemporal budget constraint of the government. According to this theory this should be the case, but some economists noticed that – especially in the 1980s – several industrial countries were still presenting excessive deficits even when they were in expansion. Given that evidence, they started to look for other reasons for those deficits. Political variables were then added to the equation to tackle that issue.

In an important seminal paper on the political and economic determinants of public deficits Roubini and Sachs (1989) demonstrate that deficits are more common when many parties are present in a ruling coalition. Their paper opened the road to several other studies on the analysis of political factors that can lie behind a public deficit. Many equations for the public deficit were filled with political variables like timing of elections, ideological orientation of the government, fragmentation and type of government, among others. These led to a better understanding of public deficits in industrial democracies. However, with the establishment of a criterion for excessive deficits that EU countries have to accomplish, more research is required to better understand the reasons why those countries sometimes violate that criterion.

Contrary to the traditional literature on public deficits, this study estimates an equation for a binary dependent variable (excessive deficit) instead of an equation for a continuous variable (public deficit). This kind of analysis permits us to infer more directly the factors that may lead an EU country to break the reference value for the public deficit. Another novelty is the inclusion of political variables in this kind of analysis. As noticed above, political variables are often used in the study of public deficits but, to our knowledge, no other study has provided so far a detailed analysis of the political conditionings of excessive deficits. This part of the dissertation provides that analysis controlling especially for opportunistic and partisan effects and political fragmentation. Finally, this study also focuses its attention on the effects of the constraints imposed after Maastricht over fiscal behaviour of governments.

This analysis provides evidence that a weak fiscal stance, low economic growth, parliamentary elections and majority left-wing governments are important causes of excessive deficits in the EU. The results also indicate that the institutional constraints imposed after Maastricht over EU countries' fiscal policy have been important in reducing the probability of excessive deficits in the EU, especially in small countries and in countries traditionally affected by large fiscal imbalances.

Hence the first two essays provide interesting evidence that the institutional changes in which the EU countries were involved did not undermine their economic performance and that fiscal discipline was important to consolidate their accounts.

The next topic studied in this thesis arose from an idea raised by Buti *et al.* (1997) and Metz (2005). These authors notice that the EU fiscal rules may generate longer recessions in the EU countries because they are not allowed to run sufficiently large deficits to stimulate the economy. Considering this issue as a starting point, the analysis provided in this dissertation was then extended to the broader study of the duration of the business cycle phases: expansions and contractions. Besides considering some EU countries, we also enlarge the analysis to other non-EU countries to study this issue in more detail. In the case of the EU countries, we test for the validity of the argument raised by Buti *et al.* (1997) and Metz (2005).

The tendency for an economy to behave in a cyclical fashion has been a puzzle for economists for a long time. Expansions, contractions and their turning points were the central focus of seminal studies in this area by Fisher (1925) and Burns and Mitchell (1949). They were the first to analyse consistently the mechanisms by which output alternates between states of expansion and recession, and to study the effect of duration on transition probabilities between those states. The issue of whether business cycles are duration dependent – i.e. whether the likelihood of an expansion or recession ending is dependent on its age – has gained special interest in the last two decades, due to an increase in the average duration of expansions and a decrease in the duration of recessions after World War II.

The literature in this field rests on the idea that the older is an expansion or recession, the more likely it is to end (see Sichel, 1991). This is known as positive duration dependence. Several papers using different methods have tried to provide empirical support for this idea and most of them have been successful in finding some evidence of positive duration dependence for expansions and contractions (see references in Chapter 4). However, little attention has been given to the potential effects of other factors. With this study we intend to shed more light on the analysis of the duration of business cycle phases by looking at other factors that can affect the likelihood of an expansion or recession ending, beyond its own length. Hence, several other variables are taken into account in this analysis.

Some recent studies have found that leading or coincident indices can be very useful in predicting the end of an expansion or contraction (Filardo, 1994, Filardo and Gordon, 1998, Kim and Nelson, 1998, Di Venuto and Layton, 2005 and Layton and Smith, 2007). However, like most studies in this field, they have focused almost exclusively on the US business cycle. This study enlarges the analysis to other industrial countries and considers the effect of other variables. It starts by considering the impact of a composite leading indicator – constructed by the OECD – on the likelihood of an expansion or contraction ending. This indicator is considered to contain relevant information (or expectations) about the future behaviour of the economy. The effect of the length of the previous phase on the duration of the current phase, private and government investment, the price of oil, spillover effects from the US business cycle on other economies and political conditionings are also taken into account in this analysis. The last issue analysed here is whether the great moderation in output volatility registered in the last two to three decades has affected the duration of expansions and contractions.

Duration models will be used in this analysis. To our knowledge, this is the first time that these models have been employed to test simultaneously for duration dependence and for the effect of the factors mentioned above on the likelihood of an expansion or contraction ending. Our results provide evidence of positive duration dependence for both expansions and contractions in a group of industrial countries (EU and non-EU countries) for the period after World War II. The duration of expansions in those countries has proved to be linked to the behaviour of the variables in the OECD composite leading indicator and affected by private investment, the price of oil and a peak in the US economy. The duration of contractions is essentially explained by the duration of the previous phase. Regarding the recent behaviour of the EU business cycle, our evidence does not support the idea that fiscal rules may have lengthened recessions in the EU, a conclusion that is in line with the findings provided in the first essay. The political factors did not prove to be important in explaining the duration of the business cycle phases. Finally, the evidence and magnitude of duration dependence are not significantly affected during the period of great moderation in output volatility, except for the US.

The last issue analysed in this dissertation is concerned with the monetary policy followed by some influential central banks such as the ECB, the Fed and the BOE. In this part, special attention is given to the monetary policy behaviour of the recently created ECB. As the ECB and the creation of the single currency – the Euro – are other outcomes of the institutional changes that occurred in some European countries over the 1990's, we think that the best way of completing this study is by analysing the behaviour of this new institution, the ECB, in comparison with the behaviour of other well established monetary institutions like the Fed and the BOE. In our view, this complements the analysis of the economic implications of the institutional changes that occurred in the EU countries over the last two decades.

Above all, it is worth mentioning that monetary policy has acquired an important role in Economics during the last fifty years as more and more influential papers have contributed to clarify the way it works and/or should work. Kydland and Prescott (1977) and Barro and Gordon (1983) were the first to demonstrate the advantages of rules over discretion in the conduct of monetary policy and to emphasize the important role of reputation in controlling inflation. The independence of central banks from the political power is another idea that gained relevance and support with those studies. Consequently, those papers influenced the way policymakers started to look at monetary policy, as well as its understanding and the focus of research in the last two decades.

In the 1990s, influenced by those advances, some central banks began to adopt inflation targets to make monetary policy more transparent. An important contribution to the understanding of inflation targeting and the use of monetary rules was offered to the literature by Taylor (1993), who set the agenda for most of the following empirical analyses on monetary rules. In his paper he defines a simple algebraic interest rate rule that demonstrates quite well how the Fed adjusts its interest rate to inflation and the output gap. This rule is known as the "Taylor rule". Over the last years several papers have extended this rule in different directions by including in its basic structure expectations, interest rate smoothing and variables such asset prices, exchange rates, money supply among others; other central banks, besides the Fed, have also been under the scope of most of those studies.

More recently some authors have started to question the assumption of symmetric preferences on which the Taylor rule is grounded. In fact, contrary to what is stated by the linear Taylor rule, central banks can react differently to inflation or output above or below their targets. This recent development in the literature has influenced greatly the work presented in the last chapter of this dissertation. Adding to this the fact that the ECB has been recently created – and that little is known about its actual behaviour – more needs to be done to improve our knowledge of its policy.

To analyse the behaviour of the ECB – and to compare it with the behaviour of two other influential central banks (the Fed and the BOE) – we make two extensions to the forward-looking Taylor rule developed by Clarida *et al.* (1998, 2000). First, we extend it by considering the reaction of the central bank to an indicator that collects information from some asset prices and financial variables; second, we test whether the monetary policy followed by the ECB, Fed and BOE can be described by a linear Taylor rule or, instead, by a more complex nonlinear rule.

We start by considering whether the basic Taylor rule could be augmented with a variable that collects and synthesises the information from asset and financial markets, i.e. whether central banks are targeting the relevant economic information contained in a group of financial variables and not simply targeting each financial variable *per se*. Therefore, we estimate a Taylor rule augmented with a financial conditions index that captures the information contained in some financial variables. This index synthesises the relevant information provided by those variables in a single variable, where the weight of each asset and financial variable is allowed to vary over time. Synthesizing that information in a weighted index permits us to extract the particular relevance of each variable at each point in time and, therefore, put together an amount of information that is more likely to be targeted by the central bank at any time. The results from the estimation of a linear Taylor rule indicate that the ECB targets the information contained in the financial conditions index developed in this study, but the Fed and BOE are not doing so; they only take into account one or two financial variables and clearly do not target asset prices.

The traditional Taylor rule can be viewed as an optimal policy rule that is derived from the minimization of a symmetric quadratic central bank's loss function assuming that the aggregate supply function is linear. However, in reality, this may not be the case and the central bank can have asymmetric preferences, therefore, following not a linear but a nonlinear Taylor rule. As stated before, only very recently some studies started to consider these asymmetries or nonlinearities in the analysis of monetary policy (Martin and Milas, 2004, Taylor and Davradakis, 2006, Assenmacher-Wesche, 2006, Surico, 2007a, 2007b and Petersen, 2007). This dissertation extends the analysis into two areas not yet explored by those studies. First, it applies, for the first time, a nonlinear model to the study of ECB monetary policy, where the presence of asymmetries is taken into account directly in the structure of the model. This procedure will provide answers to the following questions: Can the ECB's monetary policy be characterized by a nonlinear Taylor rule, or more precisely, is the ECB reacting differently to levels of inflation above and below the target? Does the ECB attempt to hit the inflation target precisely or keep inflation within a certain range? Second, this study also extends the nonlinear specification of the Taylor rule with the financial index used in the linear estimations to check whether, after controlling for nonlinearities, the ECB and the other two central banks are still (or not) reacting to the information contained in this index.

The results from the estimation of the nonlinear smooth transition regression model provide evidence that the ECB's monetary policy can indeed be described by a nonlinear Taylor rule and show that the ECB only reacts actively to inflation when it is above a certain level; moreover, it only reacts to the business cycle when inflation is stabilised well below that threshold. The results also show that the ECB – contrary to the other central banks – continues to consider the information contained in the financial index even after nonlinearities are controlled for. Moreover, we find weak evidence to reject the linear model for the US; but, we find enough evidence to reject it for the UK, where the BOE seems to be pursuing a target range for inflation.

To summarize, this thesis is organized as follows. Chapter 2 – analyses the impact of the European Union fiscal rules on economic growth. This chapter starts by presenting some motivation for this analysis and an overview of the literature. The econometric model is specified next, followed by a description of the data used, estimation of the model and discussion of the empirical results. The main findings of this approach are emphasized in the last section of this chapter.

Chapter 3 provides an analysis of the causes of excessive deficits in the EU. It starts with a review of the literature on the causes of public deficits. A simple theoretical framework and the empirical model to be estimated are described next. The data and the empirical results are analysed in the following section. This chapter ends providing a summary of the main findings and some ideas for future research.

Chapter 4 discusses the factors that affect the duration of expansions and contractions. After reviewing the literature on business cycle duration dependence, this chapter presents the data, main hypotheses to test and the econometric model. The empirical results are presented and discussed next. The last section emphasizes the main findings and offers some suggestions for future research.

Chapter 5 analyses whether central banks' monetary policy can be described by a linear or nonlinear Taylor rule and analyses the role of a financial conditions index in a monetary rule. This chapter starts by presenting a brief review of the literature on the Taylor rule. The specification used to estimate the linear Taylor rule is then described, as well as the data. It proceeds with the analysis of the empirical results of the estimation of the linear Taylor rule augmented with a financial conditions index. The model used to estimate the nonlinear Taylor rule is presented and estimated in the following section. The last section concludes this chapter.

Finally, Chapter 6 synthesises the main conclusions of this thesis.

2. The impact of the European Union fiscal rules on economic growth

2.1. Introduction

The impact of Maastricht criteria and Stability and Growth Pact (SGP) fiscal rules on economic growth is an important issue that has generated a lively discussion among economists. This discussion has progressed much further in the theoretical field than in the empirical one.

Arguments for fiscal rules have their foundations in the theory of Optimal Currency Areas, which states that when countries form an Economic and Monetary Union (EMU) they lose their independence over both monetary policy and the exchange rate. Therefore, a significant centralization of the national budgets to accommodate asymmetric shocks in the different countries would be desirable or expected. However, in the European Union (EU) context this did not occur because of the fears that the resulting temporary fiscal transfers might become permanent, which could create political problems among the EU countries and endanger the unity of the EU.

Therefore, the alternative was to leave fiscal policy in the hands of national governments – to face asymmetric shocks when necessary – and to put in place rules to avoid excessive deficits. Those rules are important because governments' temptation to create budget deficits to absorb negative shocks in an EMU can lead to problems of sustainability of those deficits and to growing government debts. There could also be negative spillovers for other EMU states, and the price stability policy of the European Central Bank (ECB) could be undermined. For example, a country that allows its debt-GDP ratio to increase continuously can force the EU interest rate upwards, which will increase the burden of government debts in the other countries and force them to follow more restrictive fiscal polices to stabilize their debt-GDP ratios. This might also compel countries to pressure the ECB to relax its monetary stance, which could endanger the stability of prices in the EMU.

These considerations led to the definition in the Maastricht Treaty of budgetary rules that countries have to satisfy in order to take part in EMU: the 3% of GDP deficit rule and the 60% of GDP debt rule. These same rules were later reinforced in the SGP for countries in EMU, in order to avoid the problems mentioned above.

Some politicians and economists have recently argued that, despite the justification for fiscal rules in an EMU without a centralised budget, EU fiscal rules may have undermined economic growth.[1] However, very few empirical contributions exist to sustain or refute such a suggestion. This study tries to contribute to the literature by evaluating empirically the impact of the EU fiscal rules on economic growth in the framework of a simple growth model. The results presented here do not support the contention that fiscal rules have damaged growth in the EU countries.

The remainder of this chapter is organized as follows. Section 2.2 presents some motivation for the analysis of the impact of the EU fiscal rules on growth: Maastricht and SGP rules are described and EU economic performance is evaluated; an overview of the literature is presented and some ideas are advanced to fill its gaps. Section 2.3 specifies the econometric model and the estimation techniques. Section

[1] See, for example, Thirlwall (2000), Arestis *et al.* (2001), Warin (2005) and Wyplosz (2006), among others.

2.4 presents the data followed by the estimation of the model and discussion of the empirical results. Finally, section 2.5 concludes emphasizing the main findings.

2.2. Motivation and literature on EU fiscal rules

The aim of this section is to present an overview of the EU fiscal rules complemented with some data analysis and references from the literature that try to assess the implications of those rules on the recent economic performance in the EU.

2.2.1. From the Maastricht Treaty to the Stability and Growth Pact

The first great step toward the creation of an EMU in Europe was the signing of the Maastricht Treaty by some European countries in 1991. With this step, twelve EU countries promised to abide by some criteria in order to be accepted as members of the future EMU.[2] Those criteria were numerically very simple and clear. To take part in the EMU by 1999: (i) a country should have a government budget deficit and debt not higher than 3% of GDP and 60% of GDP, respectively; (ii) its inflation rate should be no more than 1.5 percentage points above that of the three best performing states; (iii) its nominal long-term interest rate should be no more than 2 percentage points above the average rate of the three best performing member states concerning inflation; (iv) and finally, its currency should remain stable in the normal bands of the Exchange Rate Mechanism (ERM) for at least 2 years without devaluations. Having committed to these criteria, the EU countries lost some degree of control over monetary policy and some degree of flexibility at the economic policy level.

[2] The countries that formed the EU in 1992 were the following: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and the United Kingdom. Austria, Finland and Sweden joined the EU in 1995.

By 1999, almost all countries had accomplished most of the criteria, with the exception of Greece which fulfilled none, and Sweden and the United Kingdom which did not have their currencies in the ERM, meaning that 12 of the (at the time) 15 EU countries could take part in EMU. Furthermore, Denmark and the United Kingdom decided not to take part, arguing that they were not prepared yet to lose their independence over monetary policy. Thus, Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain were the first countries to take part in the EMU created in 1999. Greece joined in 2001.

By taking part in EMU, these countries ceded control over exchange rate and monetary policies to the ECB. The only policy remaining in the hands of EMU member states is fiscal policy, but even this is limited by the requirements of the SGP. The main objective of the SGP is to regulate fiscal policy after the introduction of the Euro in 1999, i.e. to prevent countries from relaxing their convergence efforts or their fiscal policy after they have taken part in EMU. Therefore, the SGP was supposed to guide national fiscal policies in the EMU and persuade countries to achieve balanced deficits in the medium-term, with the aim of producing greater budgetary flexibility when members suffer asymmetric shocks and fall into recession, without disturbing price stability.

Basically, the SGP consists of two parts: a surveillance part and a dissuasive part.[3] The surveillance part or the warning mechanism of the SGP intends to prevent countries from falling into excessive deficits. The Council of the Ministry of Finances (ECOFIN) examines national stability programmes and recommends adjustments if a country's budget deviates from the medium-term objective.

[3] For more details on the working of these mechanisms see, for example, De Grauwe (2005).

The dissuasive part is activated when surveillance is not efficient in avoiding excessive deficits. In the original version of the SGP an excessive deficit was defined as a deficit higher than 3% of GDP, unless it was considered exceptional, i.e. unless it resulted from an unexpected event (like a natural disaster) or from a severe economic slowdown. The latter was defined as an annual decline of GDP of at least 2%. In such a situation no excessive deficit procedure was activated. If the fall in real GDP was between 0.75% and 2% and the deficit was higher than 3%, the member state could present arguments to justify the excessive deficit and then the Council would decide whether the arguments were valid or not. However, when the decline in real GDP was less than 0.75% no exceptionality could be invoked. So, if a deficit was detected, the Council should issue a recommendation for the member state to correct it. If it was not corrected, sanctions could be imposed: the country in default would have to make a non-interest bearing deposit of 0.2% of GDP plus 0.1% for each point of the deficit above 3% of GDP. The maximum amount of the deposit was set at 0.5% of GDP. If the excessive deficit was not corrected in two years it was turned into a fine; otherwise, it was returned to the country in question.

However, in practice, this process presents some flaws. Because the fines can only be decided upon by a qualified majority of the Council of Ministers of Finance, the original SGP creates a situation in which the judges who have to decide about the sanctions are the same persons (countries) who could be adopting the defence position next time (De Grauwe, 2005). That was probably one of the main reasons why no sanctions were applied to France, Germany, Greece, Italy, and Portugal when they broke the 3% rule several times in this decade. The Commission insisted that those countries should correct their excessive deficits even in the middle of a declining business cycle (2002-2003), but France and Germany, in order to avoid a deeper economic slowdown, preferred not to follow this recommendation. This undermined the SGP power, which boosted the discussion of its reform.[4]

A consensus on the reform of the SGP was achieved in March 2005 and some changes were introduced:[5] (a) the medium-term objective now refers to the cyclically adjusted budgetary position of a country; (b) countries with low debt ratio (and a high growth potential) are allowed to maintain a deficit of 1% over the business cycle; the others have to maintain a balanced budget over the business cycle; (c) the 3% budget deficit ceiling is maintained for all countries and more importance is given to the reduction of the debt ratio to less than 60% of GDP; (d) it is now enough to have a negative growth rate or a "protracted period of very low growth relative to potential growth" for a country to be allowed to (temporarily) exceed the 3% limit; (e) countries are now able to invoke more special circumstances for exceeding the 3% ceiling; for example, investment programmes or pension reforms that increase the debt today while improving the future sustainability of government finances will be accepted as special circumstances allowing for a temporary breach of the 3% rule; (f) the adjustment path to the medium-term objective is now defined in conformity with the business cycle: countries have to commit to reinforce consolidation when the economy is growing, but that effort can be reduced in phases of weak economic growth; (g) countries which exceed the 3% ceiling, but have low debt levels, will be allowed to stretch the adjustment over a longer period of time.

With a large number of specificities contemplated in the reformed Pact, it is clear that more flexibility was obtained at the cost of less simplicity and

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[4] The critics and suggestions of reform to the SGP are not new. Arestis *et al.* (2001) and Arestis and Saywer (2003) have already proposed its abolition and the creation of an alternative 'Full Employment, Growth and Stability Pact'; Buiter and Grafe (2004) also called for the rethinking or revision of the existing SGP, given its flaws.

[5] On the reformed SGP, see Artis and Onorante (2006), Buti (2006) and Diebalek *et al.* (2006).

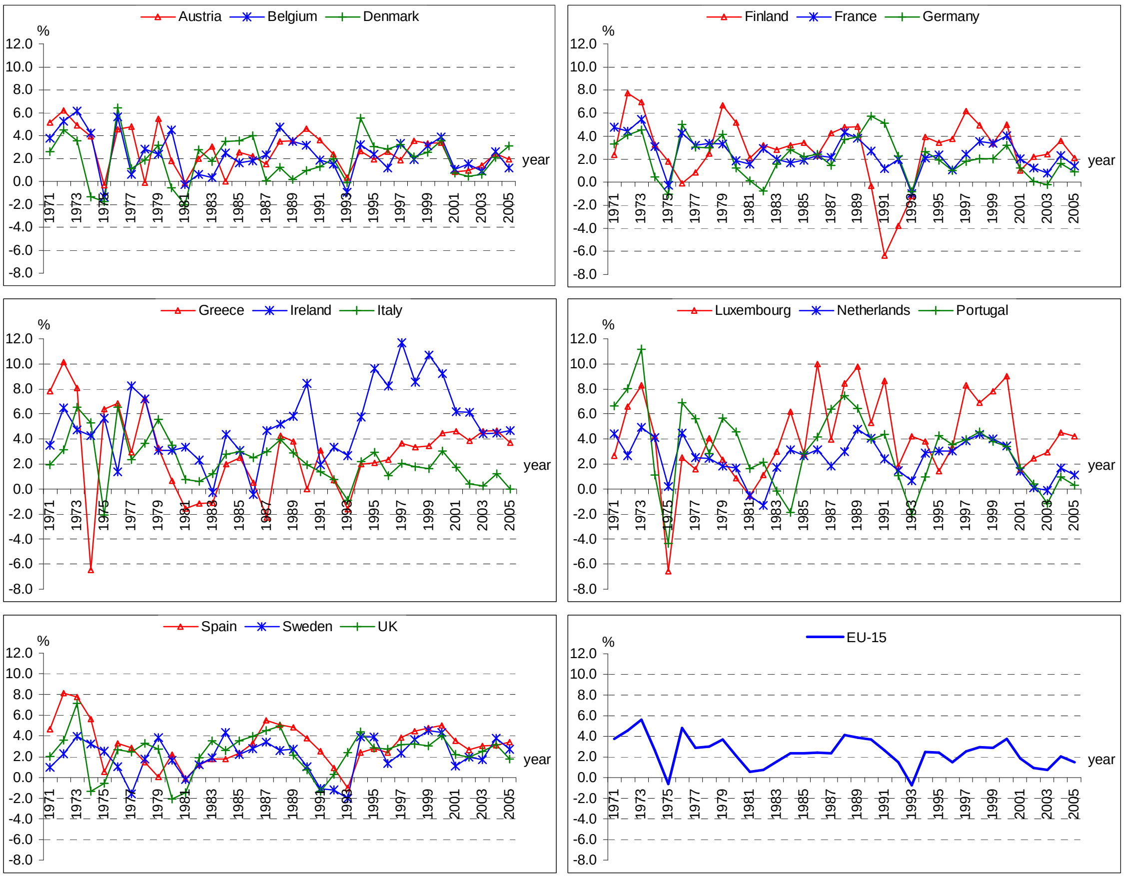
transparency. However, despite that trade-off, it is important to emphasize that both the former and reformed SGP – and even the Maastricht Treaty – stick to the idea that fiscal policies in a Monetary Union (without a centralised budget) should be subjected to rules. Whether those rules have affected the economic performance of the EU countries is an issue that this essay will start to analyse in the next section.

2.2.2. Economic growth in the EU and in other OECD countries

In this section, the evolution of growth of real GDP in the EU countries is compared with growth in a group of industrial (non-EU) countries. Those countries are the following OECD countries: Australia, Canada, Iceland, Japan, New Zealand, Norway, Switzerland, and the United States. Figure 2.1 shows the evolution of growth of real GDP in each EU country and in the EU as a whole; Figure 2.2 reports the evolution of this variable in the other countries. In the analysis of these figures, particular attention should be given to the EU countries in the post-Maastricht period.

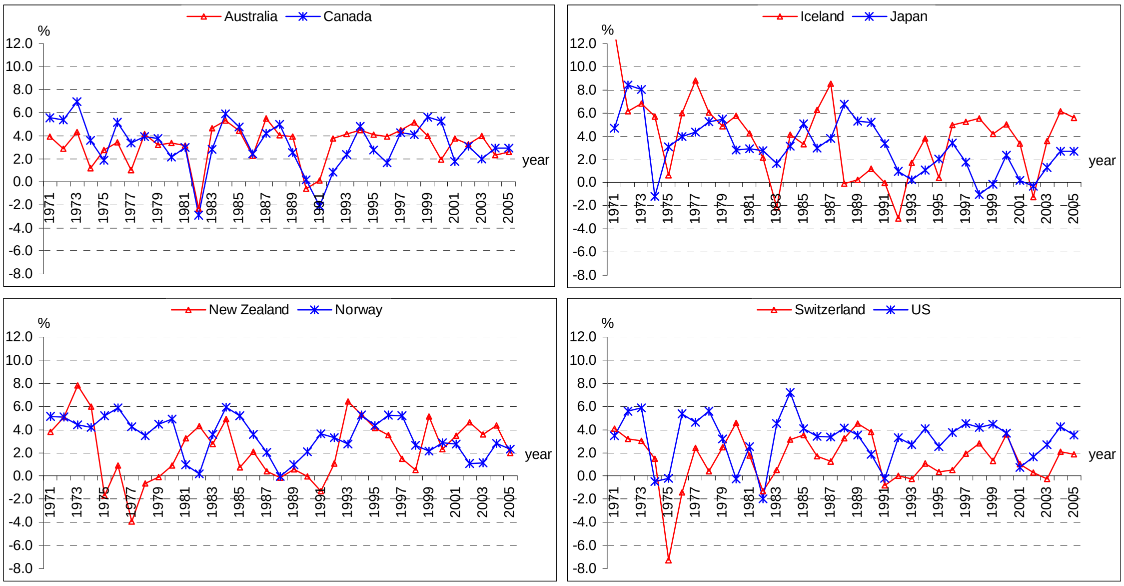
Figure 2.1 shows a higher synchronisation of economic growth in the group of EU countries in the period after Maastricht. This evidence can be interpreted as the natural result of the efforts of integration towards the creation of an EMU in Europe. Besides countries presenting similar growth trends, it is even possible to identify a long lasting episode of sustainable economic growth in the post-Maastricht period: after the recession of 1993, countries grew at rates of around 2% to 4% until 2001 (Ireland and Luxembourg reached even higher rates).

Figure 2.1. Growth of real GDP in the EU countries 1971-2005



Source: OECD (2006). *Statistical Compendium*.

Figure 2.2. Growth of real GDP in the other OECD countries 1971-2005



Source: OECD (2006). *Statistical Compendium*.

That episode of sustainable growth is followed by a slowdown in economic activity in almost all EU countries. As the economic slowdown of 2001-2003 is the first episode of low growth after important institutional changes that have occurred in some European countries, economists wonder whether that prolonged period of low growth can be due to those changes. More specifically, as this period is characterized by the implementation of fiscal rules (the SGP rules for the deficit and debt), economists ask whether those rules are influencing overall economic performance in in the EU countries. The aim of this study is to answer this question, or more precisely, to identify what has been the real impact of the fiscal rules imposed by the Maastricht Treaty, and later reinforced by the SGP, on EU economic growth.

Looking just at Figure 2.1 and comparing EU economic performance before and after the imposition of fiscal rules in Europe, no significant differences in economic growth are found between both periods.[6] Furthermore, there is no substantial difference in growth rates even when average growth in the EU is compared with average growth in the other OECD countries (or simply with the US) for the period after Maastricht.[7] However, as there are many countries involved in the

[6] On average, the growth rate of real GDP is not substantially different in both periods. In fact, the results of the simple computation of the annual average growth across the 15 EU countries shows an average rate of about 2.9% for the period before Maastricht (1971-1991) and 2.7% for the period after Maastricht (1992-2005). However, the annual average growth in the period in which the fiscal rules started to be officially assessed (1997-2005) is slightly higher than in the period before: 3.0% in the period 1997-2005 versus 2.5% in the period 1970-1996.

[7] The annual growth rate across the 8 OECD countries for the period 1992-2005 is, on average, approximately 2.8% (and it is 3.1% for the period 1971-1991). These averages are the same when we compare the pre- and post-97 periods. These values are not very different from the ones obtained for the EU countries in the same periods. In fact, a simple (unconditional) differences-in-differences estimation (controlling for fixed and time effects) has shown no significant differences in growth rates between the EU and OECD countries as a result of the imposition of the fiscal rules. The following equation was used in this analysis: $y_{it}=\beta d_{it}+\eta_i+\tau_t+\varepsilon_{it}$, where y_{it} is the growth rate of real GDP, d_{it} is a variable that takes the value of 1 in the period in which EU countries are affected by the fiscal rules

analysis and non-EU countries present a mixed behaviour (see Figure 2.2), we cannot simply rely in the analysis of these figures. It is necessary to proceed with a more sophisticated and accurate statistical analysis. That work will be done in the empirical part of this chapter.

2.2.3. Literature and its gaps

In the literature there are several studies that try to evaluate the effectiveness of the EU fiscal rules. Some simply raise doubts about the rules and the way they were defined in the SGP. Others analyse, either theoretically or empirically, the impact of those rules on the conduct of fiscal policy by national governments (deficit and debt behaviour) and their impact on public investment and economic growth.

2.2.3.1. EU fiscal rules and the behaviour of fiscal policy

One group of studies analyses the response of fiscal policy to the business cycle. Their results seem to indicate that the improvement of budgetary balances in Europe was mainly the result of good economic growth rather than active policy adjustments. However, the effect of those adjustments on growth is not examined.

Gali and Peroti (2003) and Annett (2006) evaluate to what extent the constraints associated with the Maastricht Treaty and the SGP have affected the way national governments have conducted fiscal policy. Their results show that fiscal policy has become more counter-cyclical (or less pro-cyclical) over time: before Maastricht it was pro-cyclical, but after Maastricht it is essentially a-cyclical.

(either after 1992 or after 1997) and 0 both in the other periods and for the unaffected countries (OECD countries), η_i and τ_t are the fixed and time effects, respectively, and ε_{it} is the error term. The estimated coefficient for d is 0.002 (t-value = 0.55) when the threshold is 1992 and 0.004 (t-value = 1.28) when the threshold is 1997.

Marinheiro (2004) confirms that EU fiscal rules have reinforced the counter-cyclicality of fiscal policy and that this result is even more evident during downswings. However, the results provided by Annett (2006) seem to indicate that fiscal policy in the EU countries has become pro-cyclical during the SGP period.

More recently, Artis and Onorante (2006) estimate a set of structural vector autoregression (SVAR) models for each Eurozone country with the purpose of assessing the importance of a set of fiscal rules, in particular the SGP rules in its old and reformed versions. Their results suggest that fiscal policy had a limited smoothing effect on the cycle in the 1990s. They also state that the changes in the rules of the Pact are likely to have very little impact on fiscal policies and conclude that the extra margin to conduct fiscal policies is extremely limited resulting in a negligible effect on growth.

2.2.3.2. EU fiscal rules and public investment

The relation between EU fiscal policy rules and public investment is analysed in another group of papers. Unfortunately, these studies do not proceed to test the subsequent effect of public investment on EU economic growth.

Blanchard and Giavazzi (2004) blame the SGP for putting no pressure on the reduction of current government spending and consider it important to exclude (net) public investment from the definition of the budget deficit. However, this rule for excluding public investment from the computation of the deficit may present some problems like the possibility of "creative accounting", risk of a growing debt and unequal treatment of expenditure on human and physical capital. According to Balassone and Franco (2000) the idea of creating such a 'golden rule' in the EU may not be the best option because it can conflict with the objective of a sound fiscal stance. Verde (2004) suggests a more consensual approach of (temporarily) excluding high quality – or growth promoting – public spending from the computation of the fiscal deficit during periods of economic slowdown.

By applying an empirical analysis, Gali and Peroti (2003) seek to confirm whether Maastricht and SGP rules have a negative effect on investment. Their results show a mildly pro-cyclical behaviour of public investment both before and after Maastricht. However, they conclude that the observed decline in public investment as a percentage of GDP in the last decade among the EU countries is not due to the constraints of either the Maastricht criteria or the SGP. Indeed the decline in public investment started well before Maastricht and other industrial countries have registered an even greater decline. Perée and Välilä (2005) and Välilä and Mehrotra (2005) came to a similar conclusion. They also show that the SGP deficit rule is not responsible for the observed decline in public investment in Europe. For that reason, they are sceptical about the exclusion of public investment from fiscal deficit targets.

2.2.3.3. EU fiscal rules and economic growth

Another group of authors emphasizes the need to boost economic performance as a condition for improving a country's budgetary position in the long run. According to this view, economic growth should receive precedence over a strict application of the fiscal rules. Von Hagen (2003) argues that countries should be encouraged to adopt more growth-friendly policies by restructuring their government tax and expenditure systems. He supports the idea that authorities should pay more attention to the role of economic growth in achieving sustainable public finances. Using simple graphical analysis he observes that an increase in public investment, primary spending cuts, and reductions in direct taxes have a positive impact on GDP growth, which provides a strong foundation for the subsequent sustainable reduction of the deficit and debt. Therefore, he blames the SGP for focusing excessively on annual deficits which prevents governments from adopting important fiscal reforms that might result in larger deficits initially but which would bring the desired positive growth effects in the future.

A detailed examination of the extent to which the quality of the consolidation efforts during the 1990s affected macroeconomic performance in the EU is provided by Fatás *et al.* (2003). Their evidence indicates that fiscal adjustments based on the reduction of primary expenditures (wages and transfers in particular) are more persistent and successful in terms of debt reduction and are less damaging to growth than revenue-driven consolidations. They show that the growth rates remained persistently above the EU average after expenditure-driven consolidations, while the difference vanishes quickly after revenue-driven consolidations. Thus, they conclude that tax-driven consolidations have been less favourable to growth than expenditure-led consolidations.

Few empirical studies have intended to demonstrate how economic behaviour in the EU countries has been affected by Maastricht and SGP rules. Furthermore, there are some methodological flaws in these works and the results are unsatisfactory or do not provide a clear answer. For example, Hein and Truger (2005) examine the effects of EMU monetary and fiscal policies on growth and on convergence across the Euro-area. They observe that, despite a significant convergence in nominal variables (interest rate, inflation rate, deficit/GDP, debt/GDP), there was no convergence in terms of GDP growth, labour productivity and unemployment rates. Using simple pooled least squares regressions for 11 EU countries (1981-2001) they show that EMU macroeconomic policy institutions (ECB policy stance and SGP rules) have had restrictive effects on growth. More specifically, they show that an increase in interest rates and a reduction in the structural primary government deficit have a negative effect on growth. Therefore, they conclude that the years before and after the introduction of the Euro were characterized by a restrictive policy mix that has not been conducive to aggregate growth or to real convergence.

However, Hein and Trugger's (2005) study presents some flaws that may undermine their results. First, the conclusion that EMU macroeconomic policy institutions have restrictive effects on growth seems too strong, in the sense that in their model they are analysing the whole period 1981-2001 without distinguishing the periods before and after the institutional cooperation has become stronger. They could, for example, use a dummy for the period after 1992 or proceed to a separate analysis for the periods before and after Maastricht. Second, they use an *ad hoc* model specification without taking into account the economic growth literature. Hence, their specification can be criticised for a lack of important variables.

A more consistent analysis can be found in Savona and Viviani (2003) and Soukiazis and Castro (2005). Despite some flaws, their approaches are more in conformity with growth theory. However, a more adequate specification could be used, including, for example, physical and human capital and short-term dynamics in the model, since both studies use annual data.

Savona and Viviani (2003) perform econometric tests in a fixed effects panel data model for a group of 12 EU countries for the period 1987-2002 and find evidence of a negative effect of current public spending on output growth and a positive impact of public capital spending on growth. According to their results, they argue for the modification of the rules of the Pact: it should exempt public investment from its constraints, but the automatic checks on current public spending should be maintained.

Like Hein and Truger (2005), Savona and Viviani (2003) do not analyse the pre- and post-Maastricht (or SGP) periods separately nor the direct impact of Maastricht criteria and SGP rules on growth. Soukiazis and Castro (2003, 2005) perform such direct analysis by using panel data estimations for the 15 EU countries for the period 1980-2001. They observe that the fiscal discipline after Maastricht was harmful to both growth of real output and convergence in per capita income in the EU. But the evidence behind this conclusion is not strong enough: although they find a lower rate of convergence in per capita output after Maastricht, their dummy for the period after Maastricht is not statistically significant. Moreover, they do not proceed in separately estimating the effects of the components of the deficit (current spending, public investment, tax revenues) on growth and they do not include human capital in their regressions. The inclusion of those variables would make the analysis more interesting and more in line with recent economic growth theory.

2.2.4. Aims and contributions of this study

Using the existing literature as starting point, this study intends to provide a clear empirical answer to the question of whether the Maastricht and SGP fiscal rules have affected growth in the countries that formed the EU at the time those rules were created and implemented (i.e. without considering the 12 new countries that entered the EU after 2004; in fact, this study considers just the period before the SGP has been reformed). The analysis of this issue will be based on the estimation of a growth equation augmented with fiscal and economic variables.

This study also tries to contribute to the literature through some improvements relative to the previous empirical works on the impact of EU institutional changes on growth. First, in this study the econometric analysis of the economic phenomenon is built around a formal growth model, contrary to the existing approaches that rely on *ad-hoc* growth specifications.

Second, short-run dynamics of output are controlled for by using both short-run regressors in the growth equations for annual data and a five-year time spans analysis. These procedures are not used in the previous empirical studies in this area.

Third, a recently developed estimator is implemented in this analysis: a pooled mean group estimator. As this estimator allows for heterogeneity not only on the intercepts but also on other coefficients, it has some advantages over a simple fixed effects estimator in the estimation of a growth equation using annual data.

Fourth, a new time dummy for the period in which fiscal rules started to be officially assessed is now used, instead of just a dummy for the period after Maastricht. This dummy seems to be more appropriate because it covers the period of effective enforcement of the fiscal rules. Additionally, an indicator to control more directly for the constraints that result from the implementation of the fiscal rules is developed and included in the analysis: a margin of manoeuvre indicator.

Finally, this study goes even further by providing a comparative analysis between the economic performance of the EU countries and a group of industrial non-EU countries for the period after Maastricht, regarding the effects of the EU fiscal rules.

2.3. Specification of the model and estimation techniques

A growth equation augmented with fiscal and economic variables will be used in the analysis of the impact of EU fiscal policy rules on economic growth. The aims of this section are the following: (i) to derive the growth equation to be estimated; and (ii) define the adequate econometric estimation techniques.

2.3.1. Specification of the growth equation

Following the works of Mankiw *et al.* (1992), Islam (1995) and Bassanini and Scarpetta (2001), a policy-augmented growth equation can be derived from a traditional constant-returns-to-scale growth model. The standard neo-classical growth model is derived from a constant-returns-to-scale Cobb-Douglas production function of the type:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} \left[A(t)L(t)\right]^{1-\alpha-\beta}, \qquad \textbf{(2.1)}$$

where the level of output at time t ($Y(t)$) is a function of physical capital ($K(t)$), human capital ($H(t)$), labour ($L(t)$) and the level of technological and economic efficiency ($A(t)$). The partial elasticities of output with respect to physical and human capital are represented by α and β, respectively. Labour is assumed to grow at a rate $n(t)$: $\dot{L}(t) = n(t)L(t)$.

Next, according to Bassanini and Scarpetta (2001), it is assumed that $A(t)$ can be divided in its two components: economic efficiency ($E(t)$), which will depend on economic policy and institutions; and level of technological progress ($T(t)$), which is assumed to grow at a constant rate g: $\dot{T}(t) = gT(t)$ Therefore, we have:

$$\ln A(t) = \ln T(t) + \ln E(t) = \ln T(t) + q_0 + \sum_j q_j \ln X_j(t), \qquad \textbf{(2.2)}$$

where $X_j(t)$ is a vector of variables affecting economic efficiency.

The remaining two time paths on the right hand-side variables of equation **(2.1)** are described as follows:

$$\dot{k}(t) = s_k(t)A(t)^{1-\alpha-\beta}k(t)^{\alpha}h(t)^{\beta} - [n(t)+d]k(t) \qquad \textbf{(2.3.1)}$$

$$\dot{h}(t) = s_h(t)A(t)^{1-\alpha-\beta}k(t)^{\alpha}h(t)^{\beta} - [n(t)+d]h(t) \qquad \textbf{(2.3.2)}$$

where, $k=K/L$, $h=H/L$, s_k and s_h are the investment rates in physical and human capital, respectively, and d denotes the constant depreciation rate of both types of capital.

Under the assumption that $\alpha+\beta<1$ (i.e. decreasing returns of physical and human capital), the system of time path equations can be solved to obtain the steady-state values of k and h.[8] Thus, after taking logs, we get:

$$\ln k^*(t) = \ln A(t) + \frac{1-\beta}{1-\alpha-\beta}\ln s_k(t) + \frac{\beta}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha-\beta}\ln[n(t)+g+d] \qquad \textbf{(2.4.1)}$$

$$\ln h^*(t) = \ln A(t) + \frac{\alpha}{1-\alpha-\beta}\ln s_k(t) + \frac{1-\alpha}{1-\alpha-\beta}\ln s_h(t) - \frac{1}{1-\alpha-\beta}\ln[n(t)+g+d] \qquad \textbf{(2.4.2)}$$

where ”*” denotes steady-state values. Taking logs in the production function and substituting these two equations there, we obtain the expression for the steady-state path of output in intensive form:

$$\ln y^*(t) = \ln A(t) + \frac{\alpha}{1-\alpha}\ln s_k(t) + \frac{\beta}{1-\alpha}\ln h^*(t) - \frac{\alpha}{1-\alpha}\ln[n(t)+g+d]. \qquad \textbf{(2.5)}$$

[8] This system of equations includes equations **(2.2)**, **(2.3.1)**, **(2.3.2)** and the time paths for labour and technological progress. For further details on its derivation, see Mankiw *et al.* (1992) and Bassanini and Scarpetta (2001).

The steady-state value of output per capita, y^*, is represented as a function of the steady-state stock of human capital (h^*) instead of a function of investment in human capital (s_h) because: (i) the data available to represent human capital (h) is the 'stock' of years of schooling of the (working-age) population from 25 to 64 years of age; and (ii) it can be shown that the unobserved h^* is a function of the actual human capital (h):

$$\ln h^*(t) = \ln h(t) + \varphi \Delta \ln\left[\frac{h(t)}{A(t)}\right]. \quad \textbf{(2.6)}$$

Assuming that observed growth rates include out-of-steady-state dynamics, then a linear approximation of the transitional dynamics can be expressed as follows (Mankiw *et al.*, 1992):[9]

$$\begin{aligned}\Delta \ln y(t) = &-\phi(\lambda)\ln y(t-1) + \phi(\lambda)\frac{\alpha}{1-\alpha}\ln s_k(t) + \phi(\lambda)\frac{\beta}{1-\alpha}\ln h(t) \\ &-\phi(\lambda)\frac{\alpha}{1-\alpha}\ln[n(t)+g+d] + \sum_j q_j \phi(\lambda)\ln X_j(t) \\ &+\frac{\varphi\beta}{1-\alpha}\Delta\ln h(t) + [1-\phi(\lambda)(1+\varphi)]g + \phi(\lambda)[q_0 + \ln T(0)] + [\phi(\lambda)g]t,\end{aligned} \quad \textbf{(2.7)}$$

where $\phi(\lambda)$ represents the convergence factor as a function of the speed of convergence to the steady-state ($\lambda=(1-\alpha-\beta)[n(\mathrm{t})+g+d]$, $-1<\lambda<0$). Adding short-term dynamics to equation **(2.7)** in order to capture the short-run components of the dependent variable,[10] we obtain the basic functional form that is empirically estimated in this study:

[9] This equation is obtained substituting equations **(2.2)** and **(2.6)** into **(2.5)** and proceeding to the subsequent linear approximation around the steady-state.

[10] See Bassanini and Scarpetta (2001).

$$\Delta \ln y(t) = a_0 - \phi \ln y(t-1) + a_1 \ln s_k(t) + a_2 \ln h(t) - a_3 \ln[n(t) + g + d] + a_4 t + \sum_j a_{j+4} \ln X_j + b_1 \Delta \ln s_k(t) + b_2 \Delta \ln h(t) + b_3 \Delta \ln[n(t) + g + d] + \sum_j b_{j+3} \Delta \ln X_j + \varepsilon(t). \quad \textbf{(2.8)}$$

Using the estimated coefficients from this equation and comparing them with those in equation **(2.7)**, we can obtain estimates of the steady-state coefficients and the parameters of the production function. The estimated speed of convergence to the steady-state ($\hat{\lambda}$) can be derived from the estimated convergence parameter ($\hat{\phi}$) as follows: $\hat{\lambda} = -\ln(1-\hat{\phi})$; the time to cover half way to convergence (*hwtc*) can be computed as: $hwtc = \ln(0.5)/\ln(1-\hat{\phi})$; the estimated long-run effects or coefficients on the investment rate, human capital and population growth on output (or the estimate of the respective elasticities) are given by $\hat{a}_1/\hat{\phi}$, $\hat{a}_2/\hat{\phi}$ and $\hat{a}_3/\hat{\phi}$, respectively; a similar deduction can be done to get the long-run coefficients on the other variables: $\hat{a}_{j+4}/\hat{\phi}$; finally, an estimate of the share of physical and human capital in output (α and β) can be obtained, respectively, as follows: $\hat{\alpha} = \hat{a}_1/(\hat{\phi} + \hat{a}_1)$ and $\hat{\beta} = \hat{a}_2(1-\hat{\alpha})/\hat{\phi} = \hat{a}_2/(\hat{\phi} + \hat{a}_1)$.

2.3.2. Econometric estimation techniques

In this model the observed growth of GDP per capita is the result of technological progress, the convergence process to each individual-specific steady-state and the shifts in the steady-state that may arise from changes in policy, institutions, investment rates and changes in population growth rate (Bassanini and Scarpetta, 2001).

Annual data are used to estimate the growth equation – in line with the works by Cellini (1997) and Bassanini and Scarpetta (2001) – instead of averages over time (twenty or five-year time spans) as in the works by Mankiw *et al.* (1992) and Islam (1995). Data with annual frequency is preferred because large time spans can involve the loss of important information. Moreover, according to Cellini (1997), the use of annual data produces more plausible values for the elasticity of output to the exogenous variables than the estimates reported by lower frequency regressions.

However, annual variations in output contain cyclical components. Thus, it is necessary to consider a specification that takes into account those short-run dynamics. A way of controlling for those business cycle fluctuations is by including first-differences of the determinants of growth as short-run regressors in the equations.[11] As a result, the general form of the growth equation can be written as an error correction model:

$$\begin{aligned}\Delta \ln y_{i,t} = -\phi\Bigg[& \ln y_{i,t-1} - \theta_1 \ln sk_{i,t} - \theta_2 \ln h_{i,t} + \theta_3 \ln(n_{i,t} + g + d) - \theta_4 t - \theta_{0,i} \\ & - \sum_{j=5}^{m} \theta_j \ln X_{i,t}^{j} \Bigg] + b_1 \Delta \ln sk_{i,t} + b_2 \Delta \ln h_{i,t} + b_3 \Delta \ln(n_{i,t} + g + d) \\ & + \sum_{j=4}^{m} b_j \Delta \ln X_{i,t}^{j} + \varepsilon_{i,t}\ ,\end{aligned} \qquad \textbf{(2.9)}$$

where ε symbolizes the error term and θ_s represents the long-run coefficients. As usually assumed in the growth literature, a value of 0.05 is assigned to the constant $g{+}d$.[12]

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[11] Another way of controlling for those annual fluctuations on output is by using longer time spans. Despite the already mentioned loss of important information, a specification for a longer time span (five-year time spans) will be considered latter in this chapter with the aim of comparing results.

[12] For details see, for example, Mankiw *et al.* (1992) and Cellini (1997).

The model will be estimated by using pooled cross-country time-series data for 15 EU countries, controlling for country-specific effects. In some particular regressions 8 additional industrial countries (OECD countries) will be included for comparative purposes. Equation **(2.8)** will be the basis for these estimations and the long-run coefficients (θ_s) will be obtained as indicated in Section 2.3.1.

Fixed effects are preferred to random effects because the population of the 15 EU countries is entirely represented in the sample for the period under analysis. Thus, according to Marinheiro (2004), in a case like this it makes no sense to use a random effects estimator. A similar argument can be used for the estimations with the 23 OECD countries. The use of fixed effects will also allow controlling for and capturing the actual specific characteristics of each country in the sample.[13]

However, this may not be the most adequate method for this analysis. The fixed effects estimator allows intercepts to differ across countries while the other coefficients are constrained to be the same. Indeed, there is no reason to assume that the speed of convergence to the steady-state should be the same across countries (Bassanini and Scarpeta, 2001). Although there are reasons to believe in common long-run coefficients across EU countries – given they have access to common technologies and have intense trade relations – short-run dynamics and the speed of convergence may not be the same across them. In order to control for that case a pooled mean group (PMG) estimator is employed in a second phase of this study. This estimator, developed by Pesaran, Shin and Smith (1999), allows the intercepts, speed of convergence, short run coefficients, and error variances to differ freely across groups, but imposes homogeneity on long-run coefficients. Thus, with the

[13] Hausman tests also support the fixed effects estimator in most of the regressions (see Table 2.2)

PMG procedure, we are able to estimate directly the following error correction version of the growth equation:[14]

$$\begin{aligned}\Delta \ln y_{i,t} = -\phi_i \Bigg[& \ln y_{i,t-1} - \theta_1 \ln sk_{i,t} - \theta_2 \ln h_{i,t} + \theta_3 \ln(n_{i,t} + g + d) - \theta_4 t - \theta_{0,i} \\ & - \sum_{j=5}^{m} \theta_j \ln X_{i,t}^{j} \Bigg] + b_{1,i} \Delta \ln sk_{i,t} + b_{2,i} \Delta \ln h_{i,t} + b_{3,i} \Delta \ln(n_{i,t} + g + d) \\ & + \sum_{j=4}^{m} b_{j,i} \Delta \ln X_{i,t}^{j} + \varepsilon_{i,t} ,\end{aligned} \qquad \textbf{(2.10)}$$

and the long-run homogeneity hypothesis permits the direct identification of the parameters that affect the steady-state path of output per capita ($\theta_s = a_{s,i} / \phi_i$).

This method requires a T large enough such that we can estimate the model for each group separately. Therefore, when the data allow, this method will be used and its results compared with the results obtained with the dynamic fixed effects estimator.

2.4. Empirical work

This section starts by describing the data and variables used in the estimation of the growth equation. Then, the empirical results obtained from both the dynamic fixed effects estimator and the pooled mean group estimator will be presented and analysed. In the final part of this section those results will be compared with the results from the estimation of a growth equation using data for five-year time intervals instead of annual intervals.[15]

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[14] Note that both this equation and equation **(2.9)** rely on the assumption that regressors are cointegrated.

[15] All growth equations were estimated by using the statistical software STATA 9.0.

2.4.1. Data and description of the variables

The annual data used to estimate the growth equation derived in the previous section were mainly collected from the OECD *Statistical Compendium* (2006) for 23 OECD countries over the period 1970-2005. Besides the 15 EU countries, Australia, Canada, Iceland, Japan, New Zealand, Norway, Switzerland, and the USA are also included in the sample, which will permit a comparison of their economic performance with the performance of the EU countries in the period after Maastricht. This procedure allows us to determine whether economic growth was significantly higher or lower in the EU than in other developed countries during the period in which fiscal rules were imposed over the EU countries.

A detailed description of the main variables used in this study, respective sources and descriptive statistics can be found in Annex (see Table A.2.1.1 and Table A.2.1.2). The dependent variable is defined as the growth rate of real GDP per capita ($\Delta \ln GDPpc$). Traditional economic growth literature considers that the rate of accumulation of physical capital, the accumulation of human capital and population growth are the most important factors in determining the level of real output per capita.[16] Indeed, significant differences in the investment rate over time and across countries are seen as a source of cross-country differences in output per capita. Studies on growth also assume that labour force skills and experience can represent a form of capital: human capital (Mankiw *et al.*, 1992). The variables used to collect the effects of the physical and human capital are the ratio of real private fixed capital formation to real GDP ($\ln PInv$) and the average number of years of schooling of the working-age population ($\ln HK$), respectively. Population growth ($\ln Pop$) is another important variable to be considered in the growth equation.

[16] See Barro (1991), Barro and Sala-i-Martin (1992), Mankiw *et al.* (1992) and Islam (1995).

Like several other works on economic growth, Bassanini and Scarpetta (2001) verify that some macroeconomic issues must also be considered in a growth analysis, namely the impact of fiscal policy, the benefits of having low and stable inflation and the benefits of exploiting comparative advantages from trade. According to their analysis – and a previous contribution by Kneller *et al.* (1999) – fiscal policy can affect output and growth in the medium-term and over the business cycle. Those effects may come from the financing and composition of public expenditure. More than the overall deficit, it is the composition of public spending that is relevant for economic growth. These studies show that negative effects on growth arise when the government relies more on distortionary taxation (direct taxes) and when its expenditure focuses on unproductive activities (current consumption). Hence, the impact of fiscal policy will be evaluated in this study by looking at the effect of government revenues (direct to indirect taxes ratio: ln*GovTx*) and expenditures – government consumption (ln*GovC*) and investment (ln*GovI*) – on GDP per capita.

Finally, a low and stable inflation can have a positive effect on the level of capital accumulation and consequently on growth because investment decisions are usually made with a long-run perspective. On the other hand, higher volatility in inflation brings uncertainty which discourages firms from investing in some interesting projects. Additionally, gains from trade and exposure to external competition must be also taken into account because of their potential positive effect on growth. The effects of inflation volatility are captured by the standard deviation of the rate of growth in the consumer price index (*SdInfl*) and the log of the ratio of exports to imports (ln*X/M*) is used as a proxy for gains from trade.

Besides the traditional determinants of economic growth described above, some dummies or qualitative variables to control for the period in which fiscal rules were imposed in over the EU are included in the growth equation. Particular attention is given to the results from those variables because they will allow us to answer the question of whether EU fiscal rules have affected real economic growth in the EU countries and, if so, whether that impact has been positive or negative.

A dummy variable, similar to the one used by Soukiazis and Castro (2005), was built to control for the period after Maastricht. This dummy is named *D92EU* and is equal to 1 when we are observing an EU country for the period 1992-2005, and 0 over the period 1970-1991. It will take value 0 over the entire period 1970-2005 for the other OECD countries. As an alternative, a second dummy is built and used for the period in which the fulfilment of the 3% criteria for the deficit is to be officially assessed. This period started in 1997 with the assessment of the countries that would take part in EMU.[17] This second dummy is called *D97EU* and takes value 1 for EU countries in the period 1997-2005 and 0 otherwise. In practice, *D97EU* can be seen as a dummy that will account for the impact of the SGP rules since they really come into effect, i.e. since the 3% fiscal rule has to be really accomplished, otherwise sanctions can be imposed.

To circumvent the problem that these dummies might be capturing the effects of other factors and not exclusively the effect of the EU fiscal and institutional changes, the other 8 non-EU countries will also be included in the sample to control for common macroeconomic effects. Both the EU and the non-EU countries are industrialised countries with similar characteristics, intense economic relations, access to common technologies and linked economic cycles, which means that they

[17] Before 1997 countries just had to make efforts to converge; there was no particular sanction if the convergence criteria were not accomplished in a particular year between 1992 and 1996.

are more or less similarly affected by economic shocks (like the recession after September 11th 2001, the effect of an increase in oil prices, the slowdown of the US economy, etc.). The dummies will, in this case, capture and reflect with more accuracy the particular effect of the EU fiscal constraints and not the effects of other specific factors that affected growth in both groups of countries. Assuming that those other effects will affect both groups in a similar way, the main differences will come from the specificities of the institutional changes in the EU economy, where the fiscal rules assume an important role.

This analysis can be done either for the period after Maastricht (1992-2005) or just for the period in which rules were officially assessed (1997-2005). In this case, as dummies *D92EU* and *D97EU* take the value of 1 for EU countries and 0 for non-EU countries, they can be used as the indicator to compare the performance of both groups of countries in those periods. Therefore, these dummies are now controlling for specific effects on the EU economy in the period post-Maastricht. Considering that the fiscal rules established by the Maastricht Treaty and SGP are a very important specific characteristic of the EU economy during the period 1992-2005, this will mean that the coefficients on both dummies will allow us to conclude whether those rules have had a particular impact on the EU economic growth. This approach constitutes an original contribution to the analysis of the impact of the EU fiscal rules on growth.

According to the alternatives mentioned above, we may have either a time comparison (panel of EU countries over the period 1970-2005) or a cross-country comparison (panel of EU and non-EU countries over the post-Maastricht period) of the impact of the EU institutional changes on economic growth – or even both.

Finally, to control more directly for the effects of the main (and well known) constraint imposed over the budget deficit after 1992, this study builds an indicator for the margin of manoeuvre of fiscal policy (*MgM*). This indicator measures the (normalised) distance of the actual level of the government budget surplus to the 3% fiscal rule for the deficit imposed after Maastricht. The (normalised) *MgM* variable takes values from 0 to 1, where 0 means no margin of manoeuvre and 1 means total margin of manoeuvre over fiscal policy.[18] The expectation is that the greater the margin of manoeuvre is this period, the stronger will be economic growth in the next period, because countries with a good fiscal margin of manoeuvre can always boost the economy in "bad times". As Maastricht and SGP rules reduce the margin of manoeuvre of fiscal policy in most EU countries then, if the coefficient on this variable is significantly positive, we can infer that the impact of those rules on EU economic growth was negative.

Regression results for growth equations taking into account those alternatives are provided in the next section. In practice, the growth equations to be estimated are equal to equations **(2.9)** or **(2.10)** – depending on which estimator is used – plus the term $\gamma d_{i,t}$, where $d_{i,t}$ represents one of the qualitative variables that controls for the period in which EU fiscal rules were imposed in the EU (*D92EU*, *D97EU* or *MgM*).

[18] There are three special cases to consider here: (i) the EU countries are considered to have total margin of manoeuvre over fiscal policy before Maastricht; (ii) the same is assumed for the period after Maastricht if a country is running a surplus or is in a severe recession; (iii) on the contrary, if a country breaks the rule, it is assumed that it has no margin of manoeuvre over fiscal policy. In the other cases the *MgM* is computed as indicated above. See Table A.2.1.1 in Annex for further details on how this indicator is built.

2.4.2. Regressions and interpretation of the main results

Based on the theoretical approach and data presented above, this study will proceed with the empirical analysis to determine whether fiscal rules imposed in Europe in the period after Maastricht have had a significant effect on growth in the EU countries. First, it presents and analyses the results from the dynamic fixed effects (DFE) estimator and then the results from a PMG estimator. Additionally, some robustness checks and sensitivity analyses will be provided.

However, before proceeding to the estimation of the error correction models, using either the DFE estimator or the PMG estimator, it is convenient to analyse whether the regressors are $I(0)$ or $I(1)$, i.e. whether they are stationary or not. Pesaran, Shin and Smith (1999) show that the same algorithm can be used to compute the PMG estimators whether regressors are $I(0)$ or $I(1)$, but their asymptotic distributions are slightly different. If the regressors are not stationary but are $I(1)$, then it is convenient that they are cointegrated. This would make the error term a stationary process for all countries. Therefore, the order of integration of the regressors is established in first place and then – if they are non-stationary or $I(1)$ – cointegration tests are performed.

Panel unit root tests for each variable are presented in Table 2.1. Statistics were obtained by applying Im, Pesaran and Shin (2003) unit root test. This test assumes that all series are non-stationary under the null hypothesis. Results provide evidence that most of the regressors can be considered non-stationary at a significance level of 5%: only *SdInfl* and ln*Pop* seem to be clearly stationary; the other regressors are either non-stationary or borderline, so this study proceeds with treating them as non-stationary.

Table 2.1. Panel unit root and cointegration tests

Panel unit root tests	Level	1st diff.	*Pedroni panel cointegration tests*	
ln*GDPpc*	-1.43	-3.57	Panel υ –statistic	4.54
ln*PInv*	-1.93	-4.39	Panel rho-statistic	2.28
ln*HK*	-0.38	-3.58	Panel pp-statistic	-2.69
ln*Pop*	-2.34	-4.88	Panel ADF-statistic	-1.85
ln*GovI*	-1.39	-4.15	Group rho-statistic	3.67
ln*GovC*	-1.80	-4.05	Group pp-statistic	-1.99
ln*GovTx*	-1.71	-4.29	Group ADF-statistic	-0.71
SdInfl	-3.32	-5.56		
ln*X/M*	-1.92	-4.22		

Notes: In the panel unit root tests the critical values for 1%, 5% and 10% are -2.04, -1.90, and -1.81, respectively; for example, a k<-1.90 implies rejection of the null hypothesis of unit root or non-stationarity at 5%. Results and critical values for these tests were obtained by using the 'ipshin' command in STATA.
Pedroni tests were performed by using a procedure written by Peter Pedroni for RATS; all reported values for Pedroni statistics are distributed N(0,1) under the null hypothesis of no cointegration and those statistics are one-sided tests with a critical value of -1.64 for a level of significance of 5% (k<-1.64 implies rejection of the null), except the υ-statistic that has a critical value 1.64 (k>1.64 means rejection of the null hypothesis).

Having concluded that the series are essentially integrated of order 1, some cointegration tests were performed by using Pedroni (1999) tests. Pedroni's panel tests for cointegration are also reported in Table 2.1. Results show that 4 of the 7 tests reject the null hypothesis of no-cointegration (panel υ, pp, ADF and group pp tests). Although not all tests reject the null hypothesis, the majority do. This fact provides some evidence of cointegration among the variables, which permits us to proceed with the estimation of the growth model presented above using either a DFE estimator or a PMG estimator in the context of an error correction mechanism.

2.4.2.1. Dynamic fixed effects panel data estimation

The results from a dynamic panel data estimation controlling for fixed effects are presented in Table 2.2. The presence of any pattern of heteroscedasticity and autocorrelation is controlled for by using robust standard errors. Economic policy variables are lagged one period in all estimations in order to better identify their long-run impact on output, to avoid simultaneity problems and to account for the usual delays in the reporting of economic data. As the time trend has never proved statistically significant, it is not included in the analysis presented here.[19] Columns 1, 2 and 3 of Table 2.2 present results just for EU countries over the period 1972-2004. In the remaining estimations the non-EU countries are included with the aim of doing a comparative analysis.

Results for the traditional determinants of economic growth are as expected. The convergence coefficient is statistically significant in all the regressions presented in Table 2.2. Estimations show that convergence in output per capita in the EU countries runs at an annual rate of about 3.5%, which indicates that each year an economy's GDP covers about 3.5% of its distance from the steady state.[20] This means that it takes about 19 years to reduce by half the differences in output per capita among EU countries.[21]

The coefficients on physical and human capital and population growth have the expected signs and are highly significant in almost all specifications. Thus, an increase in private investment and years of schooling and a decrease in population growth have a positive impact on output per capita. It is important to notice that in this analysis more attention is given to the long-run coefficients because short-run dynamics are just used to control for cyclical fluctuations.

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[19] Note that, in practice, the time trend is replaced by the fiscal dummies for the periods after Maastricht.

[20] Although rather low, this value is in accordance with some seminal empirical contributions to the growth literature. Barro (1991), Barro and Sala-i-Martin (1992), Mankiw *et al.* (1992), among others, show that countries converge to their steady-state level of output per capita at a slow rate of approximately 2% to 3% per year.

[21] This seems quite a long time, but we will verify below, in Table 2.3, that for the period 1997-2004 that time was reduced to about 7 years (see column 6 in Table 2.3). This means that the EU countries have been converging in real terms at a good pace over the last few years.

Table 2.2. Results from dynamic fixed effects panel data estimations

	1	2	3	4	5	6	7
$\ln GDPpc_{it-1}$	-0.0346 (-2.99)***	-0.0375 (-3.33)***	-0.0350 (-3.12)***	-0.0352 (-4.53)***	-0.0590 (-3.71)***	-0.0275 (-2.06)**	-0.0697 (-4.39)***
Implied λ	[0.035]	[0.038]	[0.036]	[0.036]	[0.061]	[0.028]	[0.072]
hwtc (a)	19.7 years	18.1 years	19.4 years	19.3 years	11.4 years	24.9 years	9.6 years
$\ln PInv_{it}$	0.8103 (2.57)**	0.6537 (2.40)**	0.7960 (2.60)***	0.5073 (2.31)**	0.8021 (2.19)**	0.1897 (0.41)	0.4055 (1.42)
$\ln HK_{it}$	1.662 (3.85)***	1.1573 (3.65)***	1.6359 (5.22)***	1.1010 (3.99)***	1.1815 (3.08)***	0.4656 (0.88)	0.8096 (2.54)**
$\ln Pop_{it}$	-1.589 (-2.35)**	-1.4384 (-2.56)**	-1.5892 (-2.46)**	-1.7553 (-3.86)***	-1.4018 (-3.09)***	-0.2449 (-0.41)	-1.1757 (-3.45)***
$\ln GovI_{it-1}$	0.3694 (2.19)**	0.3616 (2.40)**	0.3550 (2.21)**	0.3203 (2.66)***	0.1027 (1.18)	0.1935 (0.91)	0.1508 (1.94)*
$\ln GovC_{it-1}$	-2.411 (-2.80)***	-2.164 (-3.06)***	-2.366 (-2.97)***	-2.0996 (-4.11)***	-0.9888 (-2.65)***	-0.6251 (-1.20)	-0.9780 (-3.17)***
$\ln GovTx_{it-1}$	0.1270 (0.68)	0.1137 (0.67)	0.1286 (0.70)	-0.0352 (-0.26)	-0.0193 (-0.16)	0.2387 (1.08)	0.0263 (0.27)
$SdInfl_{it-1}$	-0.0577 (-1.97)**	-0.0581 (-2.18)**	-0.0577 (-2.01)**	-0.0514 (-2.33)**	-0.0681 (-1.99)**	-0.0581 (-0.36)	-0.0658 (-2.41)**
$\ln X/M_{it-1}$	0.8044 (2.42)**	0.7181 (2.45)**	0.7800 (2.48)**	0.5004 (2.26)**	0.4101 (1.29)	0.6157 (1.45)	0.1462 (0.57)
$D92EU_{it}$	-0.0007 (-0.25)				0.0039 (0.61)		
$D97EU_{it}$		0.0054 (2.22)**		0.0060 (2.98)***		0.0112 (1.97)**	0.0093 (3.72)***
MgM_{it-1}			0.0012 (0.52)				
$\Delta\ln PInv_{it}$	0.1045 (5.52)***	0.1047 (5.59)***	0.1050 (5.54)***	0.1025 (7.12)***	0.1106 (4.42)***	0.1171 (3.77)***	0.1143 (4.77)***
$\Delta\ln HK_{it}$	-0.0509 (-0.81)	-0.0250 (-0.40)	-0.0541 (-0.87)	0.0264 (0.49)	-0.0784 (-1.42)	0.0005 (0.01)	-0.0668 (-1.23)
$\Delta\ln Pop_{it}$	0.0116 (0.94)	0.0104 (0.83)	0.0120 (0.96)	0.0099 (1.00)	0.0155 (1.36)	-0.0200 (-1.85)*	0.0154 (1.37)
$\Delta\ln GovI_{it}$	0.0364 (3.72)***	0.0372 (3.81)***	0.0361 (3.67)***	0.0354 (4.28)***	0.0341 (3.40)***	0.0357 (2.68)***	0.0354 (3.56)***
$\Delta\ln GovC_{it}$	-0.2585 (-8.08)***	-0.2593 (-8.12)***	-0.2586 (-8.09)***	-0.2618 (-10.32)***	-0.1841 (-5.27)***	-0.1904 (-4.69)***	-0.1850 (-5.54)***
$\Delta\ln GovTx_{it}$	0.0258 (2.20)**	0.0252 (2.14)**	0.0260 (2.22)**	0.0141 (1.49)	0.0145 (1.37)	0.0288 (1.97)**	0.0177 (1.72)
$\Delta SdInfl_{it}$	0.0001 (0.11)	-0.0001 (-0.03)	0.0001 (0.10)	-0.0003 (-0.35)	-0.0022 (-1.12)	0.0014 (0.36)	-0.0021 (-1.09)
$\Delta\ln X/M_{it}$	-0.0118 (-0.52)	-0.0139 (-0.62)	-0.0117 (-0.52)	-0.0154 (-1.06)	0.0342 (1.29)	0.0500 (1.40)	0.0286 (1.13)
Constant	0.0489 (0.40)	0.1134 (1.00)	0.0511 (0.47)	0.0652 (0.89)	0.2382 (1.40)	0.2504 (1.74)*	0.3505 (2.09)**
R^2	0.5873	0.5913	0.5875	0.5634	0.5946	0.5030	0.6133
Hausman test	27.1 (0.076)	32.3 (0.020)	29.5 (0.043)	93.4 (0.000)	27.7 (0.067)	21.9 (0.235)	28.5 (0.055)
Time period	1972-2004	1972-2004	1972-2004	1972-2004	1992-2004	1997-2004	1992-2004
No. countries	14	14	14	21	21	21	21
No. Observ.	448	448	448	641	273	168	273

Sources: See Table A.2.1.1 in Annex.

Notes: *t*-statistics are in parentheses; significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%; the estimated speed of convergence to the steady-state (λ) is in square brackets. Models estimated controlling for fixed effects as suggested by the Hausman test: the Chi2 statistic (for 18 degrees of freedom) are reported and the respective p-values are in parenthesis; the null hypothesis is the hypothesis that the differences in the coefficients are not systematic (random effects); the alternative is the fixed effects hypothesis; (see also text for reasons why fixed effects make more sense in this context; the equation in column 6 was estimated by random effects because Hausman test suggests that and because the dummy *D97EU* was dropped in the fixed effects estimation due to lack of variability). In all estimations the presence of any pattern of heteroscedasticity and autocorrelation was controlled for by using robust standard errors. The long-run coefficients, their respective standard errors and *t*-statistics were estimated according to the relation $\theta_s = a_{si}/\phi_i$.

Luxembourg and Iceland were excluded from the sample due to lack of observations for human capital.

(a) *hwtc* means half way to convergence and measures the time it takes to go half way to the new steady-state output per capita or the time it takes to reduce half of the differences in output per capita among countries.

As expected, government investment (ln*GovI*) has a positive and significant impact on real output per capita while government final consumption expenditure (ln*GovC*) affects it negatively. These results support the view of the EU authorities that cuts in current expenditures to control for the deficit may have positive effects on output in the long-run, but they also enhance the relevance given by some authors to public investment (Savona and Viviani, 2003, Blanchard and Giavazzi, 2004 and Verde, 2004). In fact, EU authorities should take into account not only the importance of controlling for excessive deficits but also the benefits of 'productive' public investment in the definition and application of the fiscal rules to the EU countries. It was also expected that a shift from taxing factor incomes to taxing consumption would have positive growth effects. Nevertheless, this study does not identify those positive effects in the EU context. The long-run coefficient on the variable ln*GovTx* is not statistically significant in any of the regressions.

The variability of inflation (*SdInfl*) has a negative impact on output per capita, which is consistent with the findings of Bassanini and Scarpetta (2001). As inflation shows a high correlation with the convergence variable and human capital, the variability of inflation is used instead.[22] The results also suggest significant gains from trade and exposure to external competition in the EU context. The sign of the coefficient on ln*X/M* means that the higher the proportion of exports over imports the higher output per capita.

However, the results of most interest in this analysis come from the dummy variables for the post-Maastricht period. In the first regression presented in Table 2.2,

[22] Theoretically, it makes more sense to use the variability of inflation than its level, because the variability of inflation affects much more the decisions of consumption and investment (and economic growth) in the medium and long-term than its level.

the dummy *D92EU* was used to control for the growth effects in the EU-15 for the period after Maastricht. The coefficient on this variable is not significant. A similar result was obtained by Soukiazis and Castro (2005) in their analysis of output per capita convergence. This result seems to indicate that the institutional changes that took place in Europe after Maastricht were not harmful to output growth. Indeed, when a dummy for the period in which the fiscal rules started to be assessed (*D97EU*) is considered, it is even possible to conclude that growth of real GDP per capita is significantly higher than before: results show that after 1997 growth of real GDP per capita is, on average, about 0.5 percentage points higher than before. Therefore, these results allow us to conclude that economic growth in the EU was not negatively affected by those rules, contrarily to what some authors argue.[23]

The third regression includes the indicator for the margin of manoeuvre lagged one period, but results show an insignificant coefficient. One interesting conclusion can be retrieved from this result: the reduction of the margin of manoeuvre over fiscal policy in the period after Maastricht did not have the expected negative impact on growth, meaning that fiscal rules were not harmful to growth of real GDP per capita.[24]

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[23] If the coefficients associated with those dummies were significantly negative, it would not be clear that the low economic growth was essentially caused by the fiscal constraints or by other factors. But as the coefficient on *D97EU* is significantly positive and *D92EU* is not significant, we have evidence to say that growth was not lower in the period in which fiscal rules were imposed in Europe than before. In reality, evidence shows (on average) a higher growth after 1997 than before.

[24] This variable was also included in other regressions instead of the dummies, but it remained insignificant. It was even included as regressor in a simple government investment equation, similar to the one used by Perée and Välilä (2005), to test if it might affect growth indirectly via a potential effect on public investment. Nevertheless, even in that case, the coefficient on this variable was not significant. Given this lack of significance and to keep the analysis parsimonious, those results are not presented here.

Next, other industrial OECD countries were included in the sample for the period 1972-2004. Column 4 in Table 2.2 presents the results for the whole period. The coefficient on the dummy *D97EU* remains significant. In this case, that means that growth of GDP per capita in EU was not only higher than before 1997 but, at the same time, higher than in the other non-EU countries.[25] To separate the temporal effect from the cross-country effects, estimations were performed just for the period after Maastricht. The results for the period after 1992 are reported in column 5. In this case, the dummy *D92EU* is directly comparing the difference in growth between EU countries and non-EU countries. Results for the dummy do not show a significant difference in growth of GDP per capita: the estimated coefficient on the dummy is positive but insignificant. However, when we consider only the period after 1997, and *D97EU* is included instead, it is possible to observe a significantly higher growth in the group of EU countries than in the other group. In this case, a random effects estimator was used because the dummy *D97EU* was dropped in the fixed effects estimation due to lack of variability. In order to overcome that problem, an estimation for the period 1992-2004 was performed (column 7) using the dummy *D97EU*. The significance of the coefficients improves and the dummy remains highly significant. In fact, it is strengthening the idea that growth in the EU countries was not negatively affected by the fiscal constraints and institutional changes that occurred in Europe after 1992. Indeed, if we gather the results from columns 6 and 7, there is evidence that growth was not lower in the EU than in the other non-EU countries.

[25] In the unconditional differences-in-differences estimations no significant differences were found between EU and non-EU countries' growth rates (although the estimated coefficient on the dummy was positive – see footnote 7), but when control variables are included in the equation, results indicate a significantly higher growth in the EU countries than in the OECD countries in the period after 1997 (see columns 4, 6 and 7 in Table 2.2).

2.4.2.2. Pooled mean group panel data estimation

Results of the PMG estimations and some robustness analyses are presented in Table 2.3. Only long-run and dummy coefficients are reported, but all equations were estimated including short-run dynamics and a constant. In the first 3 columns of Table 2.3 we report the results of the PMG estimations for the EU countries over the period 1972-2004. The results of some robustness checks are shown in the remaining part of the table.

In the fixed effects estimations it was considered that intercepts could differ across groups but the other coefficients were constrained to be the same. Although the fact that the EU countries have access to common technologies and intense economic relations may justify the presence of common long-run coefficients, the speed of convergence to the steady-state and the short-run dynamics may not be the same across countries. Indeed, each country can follow a different path to the steady-state. Therefore, the PMG estimator developed by Pesaran, Shin and Smith (1999) seems to be a suitable instrument to control for these specificities.

This method improves the significance of most estimates and generates a higher convergence coefficient. These results are a consequence of the improvements made on the assumptions of the model and are in line with the examples presented by Pesaran, Shin and Smith (1999). Now results suggest that it takes about 10 years to reduce by half the differences in output per capita among EU countries. Indeed, this result seems to be more adequate for industrial countries that have been increasing their efforts of integration over the last decades.

Table 2.3. Pooled mean group panel data estimations and robustness analysis

	1	**2**	**3**	**4**	**5**	**6**	**7**
ln$GDPpc_{it-1}$	-0.0700	-0.0643	-0.0594	-0.1726	-0.0377	-0.0871	-0.0886
	(-6.72)***	(-7.59)***	(-7.87)***	(-5.51)***	(-2.14)**	(-3.28)***	(-1.35)
Implied λ	[0.073]	[0.066]	[0.061]	[0.1894]	[0.0384]	[0.0911]	[0.0928]
hwtc [(a)]	9.6 years	10.4 years	11.3 years	3.7 years	18.0 years	7.6 years	7.5 years
ln$PInv_{it}$	0.5451	0.3551	0.4937	0.4745	0.5679	1.1965	0.2398
	(4.21)***	(3.09)***	(3.87)***	(4.48)***	(1.67)*	(2.40)**	(0.30)
lnHK_{it}	1.2879	0.8142	1.4183	-0.0131	0.8971	-0.7826	2.3633
	(7.78)***	(3.89)***	(10.27)***	(-0.07)	(1.78)*	(-0.96)	(1.59)
lnPop_{it}	-0.9556	-1.0070	-0.9183	-0.4429	-1.8416	-0.5974	-1.4288
	(-5.28)***	(-4.52)***	(-3.99)***	(-4.78)***	(-1.89)*	(-2.31)**	(-1.10)
ln$GovI_{it-1}$	0.1770	0.2672	0.2120	0.1089	0.2812	0.1041	0.0407
	(3.14)***	(3.01)***	(3.21)***	(3.21)***	(1.29)	(0.83)	(0.18)
ln$GovC_{it-1}$	-1.5428	-1.5558	-1.8797	-0.3853	-1.9274	-0.1352	-1.6997
	(-5.42)***	(-4.36)***	(-5.23)***	(-2.42)**	(-1.75)*	(-0.35)	(-1.15)
ln$GovTx_{it-1}$	0.0077	-0.0428	0.0925	0.0187	-0.2074	-0.0357	-0.3744
	(0.10)	(-0.43)	(1.12)	(0.42)	(-0.86)	(-0.22)	(-1.03)
$SdInfl_{it-1}$	-0.0421	-0.0547	-0.0480	-0.0131	-0.0507	-0.0358	-0.0531
	(-3.48)***	(-4.34)***	(-3.48)***	(-0.74)	(-1.63)	(-0.78)	(-0.68)
lnX/M_{it-1}	0.1948	0.4043	0.3992	0.1634	0.7463	0.3146	0.3369
	(1.41)	(3.17)***	(3.09)***	(1.51)	(1.73)*	(0.78)	(0.70)
$D92EU_{it}$	-0.0010						
	(0.29)						
$D97EU_{it}$		0.0087		0.0101			
		(4.06)***		(5.38)***			
MgM_{it-1}			0.0012				
			(0.42)				
R^2					0.5953	0.7355	0.6172
Log-likelihood	1472.3	1469.9	1464.2				
Time period	1972-2004	1972-2004	1972-2004	1997-2004	1972-1996	1997-2004	1997-2004
No. countries	14	14	14	21	14	14	7
No. Observ.	448	448	448	168	336	112	56
ln$GDPpc_{it-1}$ [(b)]				-0.1946	-0.0593	-0.0611	-0.0592
				(-2.40)**	(-2.32)**	(-2.70)***	(-1.71)*
$D92EU_{it}$ [(b)]				0.0068			
				(0.87)			
Time period				1992-2004	1972-1991	1992-2004	1992-2004
No. observations				252	266	182	91

Sources: See Table A.2.1.1 in Annex.

Notes: All equations were estimated including short-run dynamics and a constant, but to keep the analysis parsimonious only long-run and dummy coefficients are reported. PMG estimations are presented in columns 1, 2 and 3; Arellano-Bond techniques are used to estimate model 4; and a fixed effects estimator is used to estimate models in columns 5, 6 and 7. Robust standard errors are used to control for the presence of heteroscedasticity. *t*-statistics are in parentheses (*z*-statistics for the PMG and Arellano-Bond estimations); significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%.; again, the speed of convergence (λ) is in square brackets.

Luxembourg and Iceland were excluded from the sample due to lack of observations for human capital.

(a) See Table 2.2.

(b) In these lines the convergence coefficient and the coefficient on the dummy *D92EU* (when included in the model, instead of *D97EU*) are presented and result from a similar specification to the one above but using another time period or threshold; the coefficients on the other exogenous variables are not reported here to save space, but results remain quite similar to the ones presented above.

Estimated coefficients on physical and human capital and population growth have the expected signs and remain highly significant. Evidence on fiscal variables is also consistent with the previous findings: there is evidence favouring both the positive impact of public investment and the negative effect of public consumption on GDP per capita; and, once again, the positive effect of shifting taxes from factor incomes to consumption is not evident in the data. Finally, results confirm the negative impact of inflation on output and the expected gains from trade.

The most important findings are provided by the time dummies and by the margin of manoeuvre indicator. The coefficient on the dummy for the period after Maastricht remains insignificant. Considering the dummy for the period in which the fiscal rules started to be officially assessed (*D97EU*), we get evidence that supports the previous finding that real growth of GDP per capita was slightly higher during that period than before. In this case, results show that after 1997 growth in real GDP per capita is, on average, about 0.9 percentage points higher than before. Finally, when the indicator for the margin of manoeuvre is included instead of the dummies, results confirm the insignificance of its coefficient.

Thus, evidence from the fixed effects estimator is now corroborated by the PMG estimator: the results from the PMG estimations reinforce the conclusion that in the period in which fiscal rules were implemented in Europe economic growth was not negatively affected by them, in contrast to what some authors claim.

Robustness checks are presented in columns 4 to 7 of Table 2.3.[26] Those checks are performed with the purpose of confirming if the results obtained so far are

[26] The intention was to proceed with a comparison of the economic performance of the EU and non-EU countries using the PMG estimator, but PMG estimations become impossible in these cases because of the lack of variability of the dummy variables when the model is being estimated for each country separately before retrieving the PMG estimates. Moreover, the PMG estimator requires a *T* large enough such that the model can be estimated for each country individually. This means that it is not viable to proceed with a comparative analysis of the model for the periods before and after Maastricht either. Due to the very low number of degrees of freedom it is not possible to get estimates

statistically solid. Column 4 presents the results of an identical specification to columns 6 of Table 2.2, but using a different estimation method, which is more adequate to cases like this where the number of time periods is substantially smaller than the number of individuals (*T* small, *N* large). This specification is based on the application of Arellano and Bond (1991) GMM estimator. In this case, the regression equation is written in the form of a dynamic model using ln*GDPpc* as a dependent variable and subsequently transformed for reasons of comparability with the other equations. Time-invariant country specific effects are removed by taking first-differences in the estimation. Then the right-hand-side variables in the first-differenced equation are instrumented.[27] This method improves the statistical significance of the results and allows us to conclude that after 1997 growth of GDP per capita in the EU countries is, on average, higher than growth in other industrial OECD countries; when the threshold is 1992 no significant differences are found (in this case only the results for the convergence coefficient and the dummy are reported).

In columns 5 and 6, the economic performance of the EU countries before and after 1997 is compared (the same is done for the periods before and after 1992, but only the convergence coefficient is reported). Instead of using dummies, a separate regression for each period is estimated. The focus of this analysis is in comparing the convergence coefficient of each regression. The convergence coefficient for the period before 1997 is considerably lower (in absolute value) than the one for the period after 1997, meaning that the speed of convergence to the

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for the convergence coefficient for some countries in the sample. Therefore, in this case, a fixed effects estimator is used.

[27] In the regression of column 4, the log of real GDP per capita is instrumented with its second and subsequent lags and the other variables are instrumented with their own values.

steady-state is higher in the period in which fiscal rules are officially enforced than before. This evidence confirms the result given by *D97EU* above. When the pre- and post-Maastricht periods are compared separately no substantial differences are found either, confirming once again the results obtained before when *D92EU* was used.

The last column of Table 2.3 reports estimates to compare the performance of the non-EU countries (column 7) with the performance of the EU countries (column 6) in the period after 1997 (and 1992). Despite the problems of significance – due to the small number of observations in the regression for non-EU countries – results show that the speed of convergence in the EU countries is not substantially different from the other OECD countries, whichever period is considered. This represents more evidence to sustain the idea that EU fiscal constraints were not harmful to growth in the EU countries.

From this simple analysis it is possible to conclude that output growth was not negatively affected in the period after Maastricht in the EU and that Maastricht and SGP fiscal rules for the deficit and debt should not be blamed for being harmful to growth of real GDP per capita in the EU countries. Moreover, our evidence shows that growth is, on average, higher in the period in which the fulfilment of the 3% criteria for the deficit started to be officially assessed. This is true either comparing it with the past performance of the EU countries or even with the performance of other developed countries.

2.4.2.3. Sensitivity analysis

In addition to the robustness checks presented above, other estimations were performed to verify whether the main results are sensitive to the exclusion or inclusion of some variables. Some of the results of that sensitivity analysis are reported in Table 2.4 and Table 2.5. Those results were obtained by using a PMG estimator and the regressions were performed including either a dummy for the period after Maastricht (*D92EU*) or for the period in which fiscal rules are officially assessed (*D97EU*).

As the variable used to control for the revenue side of the government budget (ln*GovTx*) was never statistically significant, a new variable was included in the model: the log of the total government tax and non-tax receipts divided by GDP (ln*GovRv*). Nevertheless, its coefficient is not significant either and the main results are not affected (see column 1 in Table 2.4).

Despite the justifications advanced before to use the volatility of inflation instead of its level, the results of a regression including the level of inflation (*Infl*) are reported in column 2 of Table 2.4. They show a significant negative effect of a higher level of inflation, but its inclusion in the model does not change the main conclusions of this study. Those conclusions remain valid even when both ln*GovTx* and *SdInfl* are excluded from the model (column 3), or when a simple growth specification *à la* Mankiw *et al.* (1992) is considered (column 4).

Some other variables were included in the model to control for the omission of other potential factors that might affect output, like the OECD crude oil import price (ln*OilPr*) and the average real GDP growth in the OECD countries (*OECDgdp*). Empirical evidence shows that the price of oil has a negative impact on output per capita, whilst a better economic environment in the group of OECD countries has a positive spillover affect on convergence in output per capita in the EU. Nevertheless, the most important point to emphasize here is the fact that the other results are not substantially affected by the inclusion of those control variables.

Table 2.4. Sensitivity analysis I

	1	2	3	4	5	6	7	8
ln$GDPpc_{it-1}$	-0.0623	-0.0657	-0.0678	-0.1062	-0.0538	-0.0593	-0.0722	-0.0629
	(-6.99)***	(-9.24)***	(-9.40)***	(-6.88)***	(-7.48)***	(-7.02)***	(-7.37)***	(-6.35)***
ln$PInv_{it}$	0.4559	0.5297	0.4361	0.4521	0.4669	0.6222	0.4250	0.4578
	(3.32)***	(3.74)***	(3.22)***	(6.91)***	(3.10)***	(4.03)***	(3.33)***	(3.31)***
lnHK_{it}	1.2519	1.0804	1.5567	0.8579	1.7914	1.4134	0.9969	1.2262
	(7.10)***	(5.22)***	(8.70)***	(14.58)***	(6.44)***	(7.61)***	(5.85)***	(6.94)***
lnPop_{it}	-0.9477	-0.4132	-1.1205	-0.6763	-0.8816	-1.0763	-0.8216	-1.0391
	(-5.11)***	(-2.84)***	(-5.27)***	(-5.26)***	(-3.52)***	(-4.70)***	(-4.19)***	(-5.06)***
ln$GovI_{it-1}$	0.2112	0.2971	0.1815		0.2110	0.1668	0.2802	0.2432
	(3.26)***	(3.43)***	(3.20)***		(2.36)**	(2.64)***	(3.35)***	(3.91)***
ln$GovC_{it-1}$	-1.9465	-1.6298	-1.5047		-1.2972	-1.5463	-1.0231	-0.8947
	(-3.12)***	(-4.33)***	(-4.94)***		(-3.60)***	(-4.71)***	(-4.58)***	(-3.95)***
ln$GovTx_{it-1}$		0.2615			0.1679	0.0763	-0.0131	-0.1172
		(3.07)***			(1.57)	(0.91)	(-0.17)	(-1.35)
ln$GovRv_{it-1}$	0.0915							
	(0.37)							
$SdInfl_{it-1}$	-0.0509				-0.0505	-0.0378	-0.0399	-0.0296
	(-3.68)***				(-3.04)***	(-2.78)***	(-3.57)***	(-2.36)**
$Infl_{it-1}$		-0.0314						
		(-4.12)***						
lnX/M_{it-1}	0.0482	0.4305	0.1882		0.6289	0.1389	0.2443	0.1852
	(0.29)	(2.84)***	(1.36)		(2.84)***	(0.97)	(2.03)**	(1.42)
ln$OilPr_{it-1}$					-0.2046			
					(-2.86)***			
$OECDgdp_{it}$						0.3411		
						(7.15)***		
$Debt_{it-1}$							0.0001	
							(0.03)	
$\Delta Debt_{it-1}$								-0.0208
								(-4.09)***
$D92EU_{it}$	-0.0002	-0.0035	0.0001	0.0054	-0.0070	-0.0004	0.0011	-0.0005
	(-0.04)	(-1.24)	(0.02)	(1.18)	(-2.36)**	(-0.11)	(0.32)	(-0.13)
ln$GDPpc_{it-1}$ (a)	-0.0460	-0.0427	-0.0450	-0.0841	-0.0595	-0.0582	-0.0732	-0.0526
	(-8.11)***	(-8.23)***	(-11.13)***	(-5.93)***	(-6.57)***	(-7.80)***	(-6.20)***	(-6.17)***
ln$Oilpr_{it-1}$ (a)					-0.1716			
					(-3.66)***			
$OECDgdp_{it}$ (a)						0.3481		
						(6.15)***		
$Debt_{it-1}$ (a)							0.0001	
							(0.05)	
$\Delta Debt_{it-1}$ (a)								-0.0266
								(-3.82)***
$D97EU_{it}$ (a)	0.0080	0.0078	0.0062	0.0110	0.0090	0.0065	0.0076	0.0053
	(2.90)***	(3.98)***	(2.54)**	(3.36)***	(3.41)***	(3.45)***	(2.77)***	(2.11)**
Time period	1972-2004	1971-2004	1971-2004	1971-2004	1972-2004	1972-2004	1972-2004	1972-2004
No. countries	14	14	14	14	14	14	14	14
No. Observ.	448	462	462	462	448	448	439	436

Sources: See Table A.2.1.1 in Annex.

Notes: All equations were estimated including short-run dynamics and a constant, but only long-run and dummy coefficients are reported; a PMG estimator is used to estimate the models; *z*-statistics are in parentheses; significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%.
Luxembourg is excluded from the sample due to lack of observations for human capital.

(a) In these lines only the convergence coefficient, the coefficients on the control variables and debt and the coefficient on the dummy *D97EU* (when included in the model, instead of *D92EU*) are presented and come from a similar specification to the one above; the coefficients on the other exogenous variables are not reported here to save space, but the results remain quite similar.

Table 2.5. Sensitivity analysis II

	1	2	3	4	5	6	7
ln$GDPpc_{it-1}$	-0.0959 (-5.77)***	-0.0810 (-7.51)***	-0.0625 (-7.38)***	-0.0665 (-7.36)***	-0.1004 (-4.40)***	-0.0599 (-2.57)***	-0.0997 (-2.10)**
ln$PInv_{it}$	0.2218 (1.73)*	0.3771 (3.12)***	0.4537 (3.70)***	0.4380 (3.86)***	0.3967 (3.46)***	1.0348 (4.65)***	0.5205 (5.52)***
lnHK_{it}	0.9069 (10.42)***	1.3549 (8.22)***	1.4433 (10.72)***	1.4600 (11.49)***	1.3724 (5.08)***	0.7508 (4.68)***	0.5444 (3.73)***
lnPop_{it}	-0.9707 (-6.25)***	-0.9518 (-5.38)***	-0.9324 (-4.26)***	-0.8825 (-4.40)***	-0.8830 (-3.93)***	-1.0884 (-3.96)***	-0.2041 (-1.86)*
ln$GovI_{it-1}$		0.2152 (3.77)***	0.2188 (3.31)***	0.2215 (3.53)***	0.1978 (1.85)*	0.1756 (2.60)***	
ln$GovC_{it-1}$		-1.2463 (-5.35)***	-1.8386 (-5.59)***	-1.7376 (-5.91)***	-1.5269 (-3.54)***	-0.0477 (-0.29)	
ln$GovTx_{it-1}$		-0.0688 (-0.88)	0.1085 (1.33)	0.0770 (0.98)			
$SdInfl_{it-1}$	-0.0162 (-2.23)**	-0.0395 (-3.72)***	-0.0499 (-3.86)***	-0.0480 (-4.03)***	-0.0433 (-3.67)***	0.0201 (1.43)	
lnX/M_{it-1}	0.0332 (0.46)	0.2802 (2.12)**	0.4169 (3.31)***	0.3948 (3.40)***	0.5277 (2.75)***	0.2429 (1.89)*	
GBS_{it-1}	0.0239 (5.11)***						
$DefRule_{it-1}$		0.0039 (2.65)***					
$D92EU_{it}$	-0.0014 (-0.25)	-0.0008 (-0.21)			-0.0075 (-1.20))	0.0023 (0.37)	0.0110 (1.89)*
MgM_{it-1} (b)			0.0031 (1.02)	0.0027 (0.90)			
ln$GDPpc_{it-1}$ (a)	-0.0985 (-5.56)***	-0.0765 (-10.07)***			-0.0775 (-4.69)***	-0.0555 (-3.81)***	-0.0871 (-5.27)***
GBS_{it-1} (a)	0.0192 (4.90)***						
$DefRule_{it-1}$ (a)		0.0065 (2.41)**					
$D97EU_{it}$ (a)	0.0044 (0.84)	0.0097 (2.97)***			0.0096 (2.06)**	0.0098 (3.52)***	0.0045 (0.66)
Time period	1972-2004	1972-2004	1972-2004	1972-2004	1972-2004	1972-2004	1971-2004
No. countries	14	14	14	14	6	8	7
No. Observ.	448	448	448	448	192	256	231

Sources: See Table A.2.1.1 in Annex.

Notes: See Table 2.4. Regression 5 considers only the sample of the 6 EU countries that have had problems in accomplishing the 3% rule for the deficit (France, Germany, Greece, Italy, Portugal and UK), whilst regression 6 encompasses the other 8 countries; column 7 presents the results of a regression including just the non-EU countries.

(a) In these lines only the results for the convergence coefficient and the coefficients on the deficit and *D97EU* variables (when included in the model, instead of *D92EU*) are reported and come from a similar specification to the one above; by the reasons already mentioned, the estimated coefficients on the other exogenous variables are not reported here.

(b) In column 3, the margin of manoeuvre was computed in the same way as before, but the values for the GBS were estimated by rolling regressing GBS as a function of time; In column 4, the margin of manoeuvre was computed considering the following non-linear relation: $MgM=\exp\{GBS\}$ if $GBS<0$ and year>1991; and $MgM=1$, otherwise.

Theoretically, we would expect that a higher level of public debt had a negative impact on output (Saint-Paul, 1992). Estimations presented in columns 7 and 8 of Table 2.4 show that, in the case of the EU countries, it is not the level of debt (*Debt*) but the accumulation of (*ΔDebt*) that has a negative impact on output per capita. This evidence supports the concern of the EU authorities in avoiding growing debts and, somehow, justifies the rule for the public debt.

Results also support the rule for the deficit. When the government budget surplus (*GBS*) is included instead of the other fiscal variables (see column 1 in Table 2.5), we observe that output decreases as the deficit increases. However, the results of this estimation can be criticised due to a bias coming from the reciprocal causality between the government budget surplus and the dependent variable. A way of attenuating that problem and, at the same time, taking into account the rule for the deficit in the model more directly is to include a dummy that takes the value of 1 when the deficit is lower than 3% of GDP (*DefRule*). The lag of this variable is included in the regression presented in column 2 of Table 2.5. Results show that deficits lower than 3% of GDP in the present are positively related to a higher level of GDP per capita in the future. This result can be interpreted as some evidence in favour of the EU rule for the deficit. Thus, as the significance of the other variables, especially the dummies, is not affected by the inclusion of those fiscal variables, we again conclude that fiscal rules were not harmful to growth in the EU.

The margin of manoeuvre was also included in all the specifications reported before instead of the dummies, but it remained insignificant (results are not reported here). Some attempts were made to improve this indicator. In a first attempt, the values for the deficit (or *GBS*) were estimated from a rolling regression of the *GBS* on a time trend to control for the time effects on the deficit and to make the deficit endogenously determined. Then the margin of manoeuvre was computed as the linear relation indicated in Table A.2.1.1 in Annex. However, when included in the growth specification, the coefficient associated with this variable is not significant (see column 3 in Table 2.5). This variable remains insignificant even when estimated directly from a rolling regression of the (original) marginal of manoeuvre variable on a time trend. In another attempt, the following non-linear relation was considered in the computation of the margin of manoeuvre: *MgM* is equal to the exponential of *GBS* if *GBS*<0 and year>1991; and equal to 1, otherwise. This indicator allows some (little) margin of manoeuvre even when the deficit is higher than 3% of GDP. The idea is to capture the implicit margin of manoeuvre that the countries that broke the rule in this decade seem to have enjoyed without being sanctioned. But, once again, no effect on output comes from this variable (see column 4).[28] Thus, this evidence seems to give more support to the argument that the reduction of the margin of manoeuvre over fiscal policy in some countries in the period after Maastricht did not have a negative impact on growth of real GDP per capita.

Another interesting aspect to clarify is whether growth in the group of countries that have had problems in accomplishing the 3% rule for the deficit (France, Germany, Greece, Italy, Portugal and UK) was indeed affected in the periods after Maastricht and after 1997. Results presented in column 5 confirm the findings obtained with the panel of all EU countries: growth of GDP per capita is not

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[28] Similar results were obtained when the square of the (original) *MgM* was used as another alternative and when a different relation was considered to compute the margin of manoeuvre for large and small countries. In this second case, the original *MgM* variable was used for large countries (France, Germany, Italy, Spain, UK), while the square of that variable was used for the other countries, meaning that a larger margin of manoeuvre is allowed for large countries than for small countries. Given this lack of further new and relevant evidence, those results are not reported here to keep the analysis parsimonious.

significantly different in the periods before and after Maastricht but it is higher, on average, in the period after 1997. The same happens when we consider a regression with the other 8 EU countries that have accomplished the rule (see column 6).[29] One interesting finding comes from the fiscal variables: cuts in government spending have a positive and significant effect on output per capita in the group of countries that have had problems in accomplishing the 3% rule for the deficit. These cuts are important because they promote not only a higher growth but also the necessary reduction of their deficits (directly, via the cuts, and indirectly, via a higher growth). Hence, this group of countries should promote measures to reduce their public spending. On the contrary, in the group of countries that has achieved a stable budgetary position, it is not spending cuts but the government investment that has a significant impact on output per capita.

A final analysis assesses whether growth was higher in the non-EU countries after 1997, like it was in the EU countries. If so, the higher growth in the EU in the period in which fiscal rules started to be officially assessed can be due to international spillovers that may help to cover eventual negative effects of the rules. Nevertheless, results show that, on average, growth was not significantly higher in the other OECD countries after 1997 (or even after 1992 – see column 7).[30] Therefore, this gives more support to the idea advanced in this study that EU

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[29] This can mean that the first group of countries did not take advantage of the 'good years' after 1997 to stabilize their public accounts in order to have enough budgetary margin of manoeuvre to avoid breaking the rule in the 'bad years'. This does not seem to be the case in the other 8 EU countries that have been accomplishing the rule. They also present a higher growth after 1997, but they seem to have taken advantage of it to stabilize their accounts.

[30] In this case, we consider just a basic specification of the model to avoid the loss of more degrees of freedom, once we consider just a small sample of countries in this PMG estimation. In reality, the PMG estimator does not converge and cannot retrieve the estimates when the other variables are included. The same problem affected regressions 5 and 6, but it was solved by simply excluding ln*GovTx*.

economic growth was not negatively affected by the fiscal constraints and institutional changes.

Other additional experimental regressions – not reported here – were performed including some political and institutional variables, like the timing of elections, ideological orientation of the government, constraints on the executive, and even including variables controlling for the iteration of the exogenous variables with the dummies. However, the coefficients associated with those variables were not significant in any of the experiments, providing no additional explanation for the understanding of the behaviour of economic growth in the EU. Moreover, the results of this study were not significantly affected by the inclusion of those variables. The results and conclusions of this work have also proved to be robust to the exclusion of one EU country at a time from the sample and to the exclusion of the 3 EU countries that did not take part in the EMU (Denmark, Sweden and UK).

In sum, the main conclusions of this study remain valid even when some variables are excluded from or included in the model: growth was not negatively affected in the period after Maastricht; and in the period in which fiscal rules are officially assessed we have (on average) a higher growth of GDP per capita in the EU. Additionally, the results of the sensitivity analysis for the fiscal variables give support to the rules for the deficit and debt and call attention to the importance of government spending cuts in the group of countries that have failed to accomplish the fiscal rule for the deficit.

2.4.3. Estimations using five-year time intervals

In the empirical work done so far, annual data have been used to estimate the growth equation. Yearly time spans are used to avoid the loss of important information that might result from the use of larger time spans. The justification for the choice of annual data becomes more evident when the economic performance of the EU and non-EU countries is compared and when a separate comparative analysis for the periods before and after Maastricht (or SGP) is made. Nevertheless, this choice implied the inclusion of short-run dynamics in the equation to control for cyclical fluctuations of output.

Another way of avoiding the problem of the short-run business cycle fluctuations of output is by using data from larger time intervals. Therefore, despite the mentioned loss of information that may result from the use of these larger time spans, this study will proceed with the estimation of some growth equations using data from five-year time intervals in line with the works by Islam (1995), Caselli *et al.* (1996), Bond *et al.* (2001) and Ederveen *et al.* (2006). The objective of this final analysis is basically to evaluate the robustness of the results to a change in the time spans and assess whether the main conclusions are affected or not by that change.

As a result of the use of five-year time intervals, the generic form of the growth equation can simply be written as:

$$\begin{aligned}\Delta \ln y_{i,t} = \alpha_{0,i} + \phi \ln y_{i,t-1} + \beta_1 \ln sk_{i,t} + \beta_2 \ln h_{i,t} + \beta_3 \ln(n_{i,t} + 0.05) \\ + x'_{i,t}\delta + \gamma d_{i,t} + \varepsilon_{i,t} \ ,\end{aligned} \qquad \textbf{(2.11)}$$

for $i = 1,...,N$ and $t = 2,...,T$, where $\Delta \ln y_{i,t}$ is the log difference in output per capita over a five-year period, $\ln y_{i,t-1}$ is the logarithm of output per capita at the start of that period and $x_{i,t}$ is a vector of additional variables to be included in the basic growth equation. These variables and the other explanatory variables (ln*sk*, ln*h*, ln(*n+0.05*)) are measured as the average over five-year periods. A dummy or qualitative variable ($d_{i,t}$) is added to the equation to control for the period in which

EU fiscal rules were imposed in the EU, similarly to the case where annual data was used instead.

Considering the same data and time period used in the annual analysis (1970-2005), 7 five-year time spans are constructed for the 15 EU countries. These data are then used in the estimation of equation **(2.11)**. Different estimators have been used in the literature to estimate this kind of dynamic panel data model. In this analysis, fixed effects (FE) and generalized method of moments (GMM) estimators are employed.

Fixed effects are widely employed in several growth studies. However, Caselli *et al.* (1996) argue that this estimator may lead to inconsistent estimates in the context of a dynamic panel data model because it does not take into account the fact that some of the explanatory variables can be endogenous and measured with error. Additionally, the incorrect treatment of country-specific effects may lead to omitted variable bias. A way of addressing this problem is using a first-differenced GMM estimator (DIF-GMM). This estimator was developed by Arellano and Bond (1991) and introduced in the growth literature by Caselli *et al.* (1996). The idea is to take first-differences of the regression equation, written in the form of a dynamic model, to remove unobservable time-invariant country-specific effects. Then the right-hand-side variables in the first-differenced equation can be instrumented. This procedure will solve the problem of omitted variable bias that is constant over time; parameters are estimated consistently despite the endogeneity of right-hand-side variables; and the use of instruments allows for consistent estimation even in the presence of measurement errors.

However, Bond *et al.* (2001) show that this method may present a serious problem when the empirical growth models are based on five-year averages to avoid the high persistence of the output series. This procedure reduces the number of time periods considered in the analysis to a small number and the first-differenced GMM estimator has been found to have poor finite sample properties in terms of bias and imprecision. In fact, under these conditions, lagged levels of the variables are only weak instruments for the first-differences (see Blundell and Bond, 1998). Therefore, the results of this estimator must be analysed with caution.

A refinement to this estimator that tries to solve the problem of the small sample bias was developed by Blundell and Bond (1998) and then introduced in the growth literature by Bond *et al.* (2001). These authors demonstrate that more reliable results can be obtained by using a system GMM estimator (SYS-GMM). The idea is to estimate a system of equations for both first-differences and levels, where the additional instruments used in the levels equations are lagged first-differences of the series. Since Bond *et al.* (2001) consider that this estimator may have superior finite sample properties, they recommend using the system GMM estimator for empirical growth research.

The results of the estimation of the growth equation using these estimators for five-year time spans are reported in Table 2.6. Growth regressions were essentially estimated including the same variables used in the annual analysis and incorporating a dummy either for the period after Maastricht or for the period in which fiscal rules started to be assessed.[31] The indicator for the margin of manoeuvre (*MgM*) was also included in some regressions.

[31] As we are considering five-year time intervals, it is not possible to use dummies covering exactly those periods. The best we can do is to use a dummy that takes value 1 from the time interval 1991-1995 onwards (*D91EU*) and a dummy that takes value 1 in the intervals starting in 1996 and 2001 (*D96EU*).

Table 2.6. Results from five-year time spans estimations

	(1) FE	(2) FE	(3) DIF-GMM	(4) SYS-GMM	(5) SYS-GMM	(6) 2SLS
ln*GDPpc*$_{it-5}$	-0.3427	-0.3272	-0.5334	-0.3802	-0.3123	-0.2825
	(-5.44)***	(-5.15)***	(-4.57)***	(-3.10)***	(-2.96)***	(-3.67)***
Implied λ	[0.084]	[0.079]	[0.152]	[0.096]	[0.075]	[0.066]
hwtc (a)	8.3 years	8.7 years	4.5 years	7.2 years	9.3 years	10.4 years
ln*PInv*$_{it}$	0.1935	0.1972	0.1204	0.1217	0.1028	0.0859
	(2.91)***	(3.08)***	(1.10)	(2.14)**	(3.10)***	(1.94)*
ln*HK*$_{it}$	0.3989	0.4586	0.6555	0.3094	0.2658	0.2400
	(3.61)***	(6.94)***	(3.13)***	(2.88)**	(2.31)**	(3.01)***
ln*Pop*$_{it}$	-0.2443	-0.2822	-0.2363	-0.2436	-0.2296	-0.2212
	(-4.19)***	(-5.32)***	(-4.76)***	(-5.71)***	(-4.07)***	(-2.73)***
ln*GovI*$_{it}$	0.0126	0.0062	-0.0290	0.0240		0.0462
	(0.63)	(0.31)	(-2.19)**	(1.21)		(2.10)**
ln*GovC*$_{it}$	-0.3309	-0.3429	-0.3239	-0.0880		0.1083
	(-3.81)***	(-4.08)***	(-3.45)***	(-0.82)		(-1.52)
ln*GovTx*$_{it}$	0.0750	0.0769	0.0874	-0.0282		0.0365
	(2.25)**	(2.33)**	(1.57)	(-0.81)		(1.42)
SdInfl$_{it}$	-0.0110	-0.0112	-0.0111	-0.0100		-0.0108
	(-1.17)	(-1.26)	(-1.36)	(-1.02)		(-0.98)
ln*X/M*$_{it}$	0.1587	0.1362	0.0648	0.1689		0.1511
	(2.19)**	(1.84*)	(0.64)	(2.06)*		(1.83)*
D96EU$_{it}$	0.0151		0.0149	0.0432	0.0444	0.0369
	(0.84)		(1.07)	(3.47)***	(2.59)**	(2.05)**
MgM$_{it}$		0.0294				
		(1.21)				
R^2	0.6115	0.6162				0.4418
Hansen *J*-test			0.74	0.90	0.63	
ln*GDPpc*$_{it-5}$ (b)	-0.3251		-0.4606	-0.2866	-0.2322	-0.2303
	(-4.96)***		(-4.52)***	(-1.76)*	(-1.81)*	(-3.13)***
Implied λ	[0.079]		[0.123]	[0.068]	[0.053]	[0.052]
hwtc (a)	8.8 years		5.6 years	10.3 years	13.1 years	13.2 years
D91EU$_{it}$ (b)	-0.0141		-0.0217	0.0059	0.0070	-0.0010
	(-0.91)		(-1.79)*	(0.33)	(0.49)	(-0.05)
R^2	0.6114					0.3986
Hansen *J*-test			0.70	0.92	0.65	
No. countries	14	14	14	14	14	14
No. time periods	7	7	6	7	7	6
No. Observ.	98	98	84	98	98	84

Sources: See Table A.2.1.1 in Annex.

Notes: *t*-statistics are in parentheses; significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%; the estimated speed of convergence to the steady-state ($\lambda=[-ln(1-\phi)]/5$) is in square brackets. In columns 1 and 2 the model is estimated controlling for fixed effects. The instruments used for DIF-GMM are the second and third lags of the log of output per capita; all other right-hand-side variables are assumed exogenous and are instrumented with their own values; the additional instrument used in the SYS-GMM is the difference of the log of output per capita lagged one period. A two-stage least squares estimator is used to obtain the results presented in column 6 (here the log of initial output per capita is instrumented with its second lag). The presence of any pattern of heteroscedasticity and autocorrelation is controlled for by using robust standard errors. The values reported for the Hansen's *J*-test are the *p*-values for the null hypothesis of valid instruments. Luxembourg was excluded from the sample due to lack of observations for human capital.

(a) See Table 2.2.

(b) These results come from a similar specification to the one reported above in the same column but including the variable *D91EU* instead of *D96EU*; the estimated coefficients on the other exogenous variables are not reported here since they have proved to be quite similar to the ones reported above in the same column.

The estimates presented in column 1 and 2 were obtained by using a FE estimator. The convergence coefficient has the correct sign and is statistically significant in any of the estimations presented in those two columns (i.e. either including *D91EU*, *D96EU* or *MgM*). Results show that convergence in output per capita runs at an annual rate of about 8%.[32]

The coefficients on physical and human capital and population growth also have the expected signs, according to the growth literature, and are significant. The additional variables do not present robust results: only the government consumption (ln*GovC*) and the log of the ratio of exports over imports (ln*X/M*) have the expected signs and are significant; a shift from taxing factor incomes to taxing consumption has a negative effect on output, contrarily to the expected; and the other variables are not significant.

Moreover, neither of the dummies nor the margin of manoeuvre are significant, which can be interpreted as additional evidence that the institutional changes that took place in Europe after Maastricht were not harmful to growth.

However, as the fixed effects estimator may lead to inconsistent estimates in the context of empirical growth models for the reasons indicated above, results from GMM estimators are reported in columns 3 to 5. The instruments used for DIF-GMM are the second and third lags of the log of output per capita. All other right-hand-side variables are assumed exogenous and are instrumented with their own values only in order to avoid the problem of too many instruments. The additional instrument used in the SYS-GMM is the difference of the log of output per capita

[32] This value is not very different from the one obtained by Islam (1995) using a fixed effects estimator in a basic growth equation over a panel of 22 OECD countries.

lagged one period.[33] Moreover, the Hansen's (1982) test of over-identifying restrictions does not reject the overall validity of those instruments.

Results for the DIF-GMM estimator show a higher rate of convergence in output per capita to its steady-state, but the physical capital variable is no longer significant and government investment has a coefficient opposite to the expectations. As the sample contains just a small number of time periods, this might be the result of the finite sample bias and imprecision of this estimator. In order to avoid that problem, we also report the results from a system-GMM estimator (SYS-GMM) that seems to produce more reliable results in this kind of studies.

The SYS-GMM estimator reports a lower estimate for the speed of convergence than the DIF-GMM, but not very different from the one obtained by

[33] Here it is important to clarify two technical issues:

First, despite being reasonable to consider that some other right-hand side variables like, for example, physical and human capital and population growth, can be considered endogenous because they can be determined simultaneously with the rate of growth (Caselli *et al.*, 1996), practical and technical reasons inherent to the finite sample used in this work impede us from proceeding in that way. When those variables are treated as potentially endogenous in the estimation, we end up with a problem of too many instruments in comparison with the number of observations. Although this fact does not bias the coefficient estimates – indeed, treating those variables as endogenous did not affect greatly the coefficient estimates or their statistical significance in this work (results are not reported here) – it increases the distance of the feasible efficient GMM estimator from the asymptotic ideal and weakens the Hansen's (1982) test to a point it generates unreliable *p*-values of 1.000 (Roodman, 2006). Therefore, the solution to reduce the number of instruments and solve this problem was to consider those right-hand side variables as exogenous. In fact, Ederveen *et al.* (2006) also consider them as exogenous in a growth specification to study the impact of structural funds in a group of 13 EU countries.

Second, Blundell and Bond (1998) and Bond *et al.* (2001) argue that in finite samples the asymptotic standard errors from a two-step GMM estimator can be biased and unreliable for inference. Therefore, the choice was to present the results from the one-step GMM estimators, with robust standard errors to heteroscedasticity, which seem to be more reliable for finite sample inference.

using a FE estimator.[34] In fact, the majority of the coefficients are not very different from the ones obtained with fixed effects. The main difference comes from the dummy for the period in which fiscal rules are officially assessed. In this case, we find evidence of a higher growth rate in that period than before. Results show that in the period after 1996 the annual growth of real GDP per capita is, on average, about 0.86 percentage points higher than in the period before.[35] In addition, no significant differences in growth are found in the pre- and post-Maastricht periods.[36] Hence, these results strengthen the conclusion that EU economic growth was not negatively affected by the imposition of fiscal rules in this period.

As the coefficients associated with the additional explanatory variables are not significant, a simple basic growth model was considered in the regression presented in column 5. Despite the evidence of a slightly lower speed of convergence, the main conclusions of this study remain.

As a final robustness check to the results obtained so far, column 6 reports the results obtained by a simple two-stage least squares estimator (2SLS), where the log

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[34] The SYS-GMM estimates indicate a speed of convergence of about 7% to 9%. These estimates are very similar to the ones obtained with the PMG estimator for yearly-time spans. They are also close to the GMM estimates obtained by Ederveen *et al.* (2006) in a growth study for 13 EU countries. Caselli *et al.* (1996) also find a high rate of convergence (10% per year) in their study, which they consider as an indication that countries are very close to their steady states and consequently the important differences in output per capita across countries will be explained by differences in their steady-states.

[35] This result is in line with the one obtained when annual data was used. The value of 0.86 was computed dividing the estimated coefficient on *D96EU* by 5. In fact, as here the dependent variable represents the growth over each five-year period, we just need to divide the coefficients by 5 to get the annual impacts on growth. This is the same as estimating the same regressions using $\Delta \ln GDPpc/5$ as dependent variable.

[36] The margin of manoeuvre was also included in the GMM estimations, instead of the dummies. However, as in the case of the FE estimations, its coefficient was never statistically significant (results are not reported here). This supports the idea that the constraints imposed by the fiscal rules over fiscal policy after Maastricht did not affect growth (either positively or negatively).

of the initial output per capita is instrumented with its second lag. As the sample size is not large, reasonable results are expected from this estimator. Indeed, the main findings are not substantially different from the ones obtained with the other estimators.

In sum, the results obtained using five-year time spans corroborate the main conclusion of the yearly-time spans analysis: growth of real GDP per capita in the EU was not negatively affected in the period after Maastricht, i.e. in the period in which fiscal rules were imposed over the EU countries.

2.5. Conclusions

Although some economists have been claiming that the SGP fiscal rules may have affected EU growth negatively, others argue that those rules are necessary to promote fiscal consolidation and economic stability in the EMU, which, in turn, will be beneficial for growth in the long-run. Nevertheless, very little empirical work has been done to clarify this debate. The work presented in this chapter intends to find a clear empirical answer to that issue and, in doing so, it also tries to contribute to the literature with some improvements relative to previous empirical works like, for example, using a different method of estimation (pooled mean group estimation), a dummy for the period in which fiscal rules started to be officially assessed, a margin of manoeuvre indicator and providing a cross-comparison between EU and non-EU countries.

Considering those improvements and using a specific growth equation for both yearly and five-year time spans, this study shows that growth was not negatively affected in the period after Maastricht in the EU. This is true either comparing recent performance of EU countries with their past performance or with the performance of other developed countries. Therefore, this chapter concludes that Maastricht and SGP fiscal rules should not be blamed for harming growth of real GDP per capita in the EU area. On the contrary, evidence shows that, on average, growth is statistically higher in the period in which the fulfilment of the 3% criteria for the deficit started to be officially assessed. Furthermore, this study also presents some evidence favouring the EU fiscal rules for the public deficit and debt.

Even though the results presented in this chapter show that EU fiscal rules may not have affected growth in the EU countries in the post-Maastricht period, evidence from the annual analysis also indicates that an increase in government investment has a positive and significant impact on real output per capita. Therefore, EU authorities should give some special attention to the potential benefits of productive public investment when assessing whether an excessive deficit exists. Otherwise, some countries could find it easier to cut public investment than current expenditures in 'bad' times to accomplish the 3% for the deficit. According to the findings of this study, such behaviour would be prejudicial for output growth. Nevertheless, the results also show that the efforts to reduce current expenditures must not be relaxed, especially in the countries that have been breaking the rule for the deficit in recent years.

It would be interesting to extend the analysis provided in this chapter to the countries that have recently joined to the EU. The study of the impact of the fiscal constraints and institutional changes that they have to face to control their public accounts and to enhance the credibility of their institutions may possibly bring some additional insights to the understanding of the impact of those constraints on their economic performance. One obstacle to do that study comes from the lack of data for the decades of 1970s and 1980s for some of those countries.

Finally, once more data becomes available, another possible extension to this study could be to analyse how the EU countries have been coping with the reformed SGP and what have been its implications for economic growth. In particular, it would be interesting to analyse whether the reformed SGP has continued to promote the necessary balanced budgets in periods of economic expansion and whether it has been more flexible in allowing the required margin of manoeuvre for the EU countries to stimulate growth in periods of economic slowdown or recession. In other words, it would be worthwhile to analyse whether the reformed SGP has been more growth promoting while it tries to keep EU governments' accounts on the track of a balanced budget over the medium-term.

Annex 2.1. Description of the variables and descriptive statistics

Table A.2.1.1. Description of the main variables and respective sources

Dependent variable:

$\Delta \ln GDPpc$ – growth rate of real GDP *per capita* of population aged 15-64 years old at price levels and purchasing power parities (PPP) of 2000.

Convergence variable:

$\ln GDPpc_{t-1}$ – lagged real GDP *per capita* of population aged 15-64 years at price levels and PPP of 2000.

Basic economic growth explanatory variables:

ln*PInv* – the logarithm of the ratio of the real private fixed capital formation to real GDP is used as a proxy for the propensity to accumulate physical capital.

ln*HK* – the stock of human capital is proxied by the logarithm of the average number of years of schooling of the (working-age) population from 25 to 64 years of age.

ln*Pop* – represents the log of population (aged 15-64) growth (i.e. n) plus the constant $g+d$ to which is assigned the value of 0.05 as in Mankiw *et al.* (1992).

Exogenous economic policy variables:

ln*GovI* – the log of the ratio of government (gross) fixed capital formation to GDP (both at market or current prices) is used as proxy for government investment.

ln*GovC* – represents the log of government final consumption expenditure divided by GDP (both at market or current prices).

ln*GovTx* – log of the ratio of direct to indirect government tax revenues (both at market or current prices).

SdInfl – inflation volatility is measured by the standard deviation of the rate of growth in the consumer price index (CPI) computed as a centred three year moving average.

ln*X/M* – the log of the ratio of exports to imports (both at 2000 prices) is a proxy for gains from trade.

Qualitative variables to control for the period of EU fiscal rules:

D92EU – dummy that takes the value of 1 for EU countries for the period 1992-2005 and 0 otherwise.

D97EU – dummy that takes the value of 1 for EU countries for the period 1997-2005 and 0 otherwise.

MgM – indicator for the margin of manoeuvre of fiscal policy, which is defined according to the SGP rules: before Maastricht it is assumed that EU countries have total margin of manoeuvre over fiscal policy => *MgM* =1; after Maastricht the margin of manoeuvre is computed as follows:

MgM = (GBS+3)/3	if GDP growth>-0.75% and -3%<GBS<0%
= 1	if GDP growth < -2% or GBS > 0%;
= 0.5	if -2% < GDP growth < -0.75% and GBS < -3%;
= 0.5*1+0.5*(GBS+3)/3	if -2% < GDP <-0.75% and -3% < GBS <0%;
= 0	if growth GDP>-0.75% and GBS<-3%;

GBS means government budget surplus and 0.5 is a plausible guess for the probability of the deficit not being considered 'excessive' by the European Commission in a situation of moderate recession. To simplify the analysis, this indicator is normalized to the interval [0;1]; 0 means no margin of manoeuvre and 1 means total margin of manoeuvre over fiscal policy.

Sources: OECD *Statistical Compendium*, April 2006 (for all variables except human capital). Data for human capital from 1970 to 1990 was interpolated from five-year observations from De la Fuente and Domenéch (2000). For the period 1996 to 2004 data were obtained from OECD *Education at a Glance*, various issues (1998 to 2006). Missing observations were filled by linear interpolation.

Notes: The panel of countries for which data were collected is the following:

EU countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the UK;

Non-EU countries: Australia, Canada, Iceland, Japan, New Zealand, Norway, Switzerland, and the US.

Table A.2.1.2. Descriptive statistics for the EU and non-EU countries

	EU countries					Non-EU countries				
Variable	**Obs**	**Mean**	**StdDev**	**Min**	**Max**	**Obs**	**Mean**	**StdDev**	**Min**	**Max**
Δln*GDPpc*	510	0.0213	0.0238	-0.0863	0.1050	272	0.0178	0.0233	-0.0770	0.1318
ln*GDPpc*	525	10.2738	0.3001	9.3344	11.2840	280	10.4329	0.2286	9.7696	10.9771
ln*PInv*	537	-1.7140	0.1833	-2.1742	-1.2210	288	-1.7490	0.1871	-2.1969	-1.2350
ln*HK*	490	2.2434	0.2245	1.5831	2.6101	245	2.4640	0.1049	2.1223	2.6325
ln*Pop*	510	-2.8822	0.1018	-3.3093	-2.3671	272	-2.7981	0.1078	-3.1281	-2.3301
ln*GovI*	540	-3.4789	0.3321	-4.5296	-2.5608	268	-3.3626	0.2646	-3.9586	-2.7548
ln*GovC*	540	-1.6685	0.2290	-2.3969	-1.2079	260	-1.7259	0.1966	-2.2760	-1.3323
ln*GovTx*	540	-0.0531	0.4193	-1.3609	0.6358	245	0.1744	0.4660	-1.3414	0.9670
SdInfl	510	1.4813	1.5134	0.0494	11.1136	264	2.0821	3.3104	0.0331	30.3308
ln*X/M*	525	-0.0171	0.1512	-0.5852	0.5442	280	0.0376	0.1890	-0.4304	0.5237
D92EU	540	0.3722	0.4838	0	1					
D97EU	540	0.2500	0.4334	0	1					
MgM	540	0.8133	0.3573	0	1					

Sources: See Table A.2.1.1.

3. An analysis of the causes of excessive deficits in the European Union

3.1. Introduction

Since 1992 the European Union (EU) countries have been compelled to make efforts to actively control their public accounts and to converge in nominal terms. First, the Maastricht Treaty defined budgetary rules – in addition to criteria for inflation reduction, interest rate convergence and exchange rate stability – that countries had to satisfy in order to take part in the Economic and Monetary Union (EMU): the 3% of GDP deficit rule and the 60% of GDP debt rule. Then, these same fiscal rules were reinforced in the Stability and Growth Pact (SGP) for countries in the EMU.

The main justification for using rules to limit the degree of fiscal policy discretion is the fact that governments seem to have an inherent propensity to run excessive deficits and debts. As politicians represent different groups of interest, they tend to demand expenditures in the interest of their supporters, resulting in excessive deficits. Moreover, policymakers are also concerned with their re-election. Therefore, an excessive deficit can result from the tendency to opportunistically manipulate the economy and to loosen fiscal policy before elections.

This problem can be even greater in a monetary union. In the case of the EMU formed by the EU countries, since there is no centralization of the national budgets to accommodate asymmetric shocks, countries would be able to pass some of the costs of a loose fiscal policy to the other members if no fiscal rules were implemented. This would generate higher deficits, growing debts and an increase in the interest rate in the Eurozone, putting pressure on the common monetary policy framework and on price stability. In the limit, it could undermine the project of the monetary union. Thus, if it is important to avoid excessive deficits when a country is not integrated in a monetary union, it is even more important to avoid them when they are forming a monetary union.

Taking into account the problems that may arise from unbalanced public accounts for countries in an EMU, this study tries to find the reasons why EU countries sometimes run excessive deficits. The literature provides a plethora of interrelated economic and political causes for public deficits, but the particular analysis of the determinants of excessive deficits remains practically unexplored. Therefore, this study intends to contribute to the literature with a broad analysis of the economic, political and institutional determinants of an excessive public deficit and, in that way, help to explain why EU countries are sometimes affected by excessive deficits and try to clarify what conditions may help them to avoid such a situation in the future. As this study focuses its attention on a specific group of EU countries, it defines an excessive deficit as a deficit higher than 3% of GDP, in line with the legal concept established by the Maastricht Treaty and later reinforced by the SGP.

The pertinence of this study comes precisely from the fact that in EU, after Maastricht, the main reference for fiscal policy and, in particular, for the public deficit has been the 3% rule for the deficit. With the implementation of this rule by the EU authorities, the analysis of the conditionings of the so called "excessive deficits" has gained a special interest, consequently motivating the analysis provided in this chapter.

Contrary to the traditional literature on public deficits, this study estimates a model for a binary dependent variable (excessive deficit) instead of a model for a continuous variable (public deficit). This kind of analysis permits us to infer more directly the factors that may lead an EU country to break the reference value for the public deficit. Another novelty is the inclusion of political variables in this kind of analysis. Political variables are often used in the study of public deficits but, to our knowledge, no other study has provided so far a detailed analysis of the political conditionings of excessive deficits. This chapter provides such an analysis controlling especially for opportunistic and partisan effects and political fragmentation. Finally, this study also focuses its attention on the effects of the constraints imposed after Maastricht over the fiscal behaviour of governments.

Using a binary choice model over a sample of 15 EU countries for the period 1970-2006, this study provides evidence that a weak fiscal stance, low economic growth, parliamentary elections and majority left-wing governments are important causes of excessive deficits in the EU countries. Moreover, results also indicate that the institutional constraints imposed after Maastricht over EU countries' fiscal policy have been important in reducing the probability of excessive deficits in the EU, especially in small countries and in countries traditionally affected by large fiscal imbalances.

The remainder of this chapter is organized as follows. Section 3.2 presents a review of the literature on the causes of public deficits. Section 3.3 exposes the theoretical framework and the empirical model. The data and the empirical results are analysed in Section 3.4. Finally, Section 3.5 provides a conclusion with the main findings of this study and some guidelines for future research.

3.2. Brief review of the literature on public deficits

The literature on the determinants of public deficits is reviewed in the first part of this section. The second part will be dedicated to the presentation of the few existing studies on the determinants of excessive deficits.

3.2.1. Literature on the causes of public deficits

The literature on fiscal policy considers that some economic variables play an important role in explaining public deficits. These deficits are usually characterised by some degree of persistence and are highly affected by the amount of public debt and by economic performance. Regarding the persistence of the deficits, there is a consensus in the literature that the higher and more persistent is the deficit, the more difficult will be for a country to change that tendency and to generate structural surpluses to avoid a high debt in the future. The persistence is captured by including the lag of the dependent variable (government budget surplus) as an additional regressor in the equation.

The public debt is considered another important determinant of the deficit. Balassone and Francese (2004) and Mink and de Haan (2005) argue that it may have a negative impact on the fiscal balance. A higher debt ratio causes an automatic increase in interest payments, which may result in a worsening of the fiscal balance. On the contrary, Mélitz (2000) and Annett (2006) support the idea that a high debt forces the government to take measures to reduce the deficit and, consequently, this will generate an effective reduction of the deficit. Hence, there is no broad consensus in the literature about the overall effect of the debt ratio on the public deficit.

In terms of macroeconomic conditions, studies are unanimous in concluding that the public deficit decreases when the economy is growing or when the unemployment rate is low. These variables affect the deficit mainly via automatic stabilizers, i.e. through changes in tax revenues and transfers related to unemployment expenditures. Another important determinant of public deficits is the interest rate. Several studies show that a high interest rate has a negative impact on public deficit, a result that is justified by the increase in interest expenditure on public debt.[37]

The effects of the supranational fiscal constrains imposed over the EU countries after 1992 are also under the scope of some papers. For example, Arestis *et al.* (2002), Tujula and Wolswijk (2004) and Annett (2006) find some evidence that the run-up to EMU induced additional fiscal consolidation, but they notice that that fiscal discipline seems to have decreased in the EU after that period.[38]

Political factors like elections, ideological orientation of the government, fragmentation and type of government are considered as another important group of determinants of public deficits. The reason for considering political factors in the analysis of public deficits is related to the literature on political business cycles (PBC).[39] This literature followed two approaches. The first approach – introduced by Nordhaus (1975) and Lindbeck (1976) – stresses that policymakers have a natural motivation to opportunistically manipulate the economy before elections as a way of increasing their probability of re-election. The second approach – a 'partisan' approach developed by Hibbs (1977) – emphasizes that politicians, when in office, take decisions according to their political ideology. In particular, right-wing parties are more concerned with inflation than unemployment, whilst left-wing parties are

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[37] See most of the papers referenced in this section.

[38] National rules were also recently considered by Debrun *et al.* (2008). They show that national fiscal rules tend to affect fiscal performance positively in the EU countries.

[39] For a review of the literature on the political cycles see Alesina *et al.* (1997) and Drazen (2000).

more prone to promote economic growth and to fight unemployment than to stabilize inflation.

These models were updated in the 1980s with the incorporation in their assumptions of rational expectations. According to this reformulation, voters' rationality limits the opportunistic behaviour making the political cycles shorter, less intense and less regular than in the Nordhaus-Lindbeck model.[40] On the partisan side, Alesina (1987) shows that rational expectations restrict the partisan effects to the post-electoral period. Moreover, this model confirms the traditional partisan idea that inflation (unemployment) will be higher (lower) when a left-wing party is in office.

To detect electoral fiscal cycles in the analysis of public deficit, some authors include in their equations a dummy for the election years as suggested by the PBC literature. The idea behind the inclusion of this variable is that just before elections policymakers may spend more and reduce taxes to increase their probability of re-election. Therefore, a higher deficit is expected in the election years.[41]

According to the partisan theory, left-wing governments have traditionally promoted a higher degree of public intervention in the economy. Hence, they should also be more prone to increase expenditures and to generate deficits than right-wing parties. Several authors present evidence supporting this view like, for example, de Haan and Sturm (1994), Borrelli and Royed (1995), Sakamoto (2001), Perotti and Kontopoulos (2002), Sapir and Sekkat (2002) and Mink and de Haan (2005).

Besides taking into account opportunistic and partisan effects, some studies stress the role of political fragmentation in their analyses of the determinants of

[40] One important contribution to the rational opportunist models literature was provided by Rogoff and Sibert (1988).

[41] Tujula and Wolswijk (2004), Mink and de Haan (2005) and Annett (2006) show that elections tend to lead to higher deficits in the EU countries.

public deficits. Economists generally claim that minority governments, governments formed by multiple parties and governments characterized by a short tenure in office tend to run larger fiscal deficits. In a seminal paper in the field, Roubini and Sachs (1989) demonstrate that deficits are more common in industrial democracies when many political parties are present in a ruling coalition. However, in their analysis, they do not make a clear distinction between majority/minority governments and single-party/multi-party governments. This is a problem that weakens their conclusions, as it is noticed by, for example, Edin and Ohlsson (1991), Borrelli and Royed (1995), Sakamoto (2001) and Perotti and Kontopoulos (2002). Therefore, these authors try to address this problem by analysing those two aspects of the political system separately.

The degree of political support that a government enjoys in the parliament is important when unpopular measures like spending cuts or tax increases need to be taken. Minority governments usually cannot take these measures without support from other parties in the parliament. When that support is not obtained those measures have to be postponed and high deficits arise. Deficits may also result from concessions to the other parties to get their support. This is not the case when a majority party is in office because it can pursue its policies without asking for support from other parties. However, empirical evidence on the effects of a majority/minority government on public deficits is mixed. Some authors like, for example, Edin and Ohlsson (1991), Volkerink and de Haan (2001) and Perotti and Kontopoulos (2002) find evidence suggesting that minority governments are more prone to generate deficits than majority governments. Others like de Haan and Sturm (1994), de Haan *et al.* (1999) and Woo (2003) find no evidence supporting this idea.[42] Borrelli and Royed (1995), Sakamoto (2001) and Tujula and Wolswijk (2004) show that deficits can be lower under minority governments. The justification for this evidence rests on the same grounds as the opposite result: as majority governments are able to take unpopular measures to reduce the deficit without needing support from other parties in the parliament, they are also better able to increase deficits than minority governments if they intend to do that.

De Haan *et al.* (1999) and Perotti and Kontopoulos (2002) consider that the distinction between minority and majority may not necessarily capture the notion of fragmentation in decision-making. As a consequence, they emphasize the importance of the number of decision-makers in the government. In fact, some authors believe that the fragmentation of the government is a more important source of public deficits. Roubini and Sachs (1989), Perotti *et al.* (1998), de Haan *et al.* (1999), Annett (2002) and Perotti and Kontopoulos (2002) show that public spending and deficits are higher when coalition governments are in office, that is, when the number of parties in the government is high. These authors argue that coalition governments have a bias towards larger deficits because when multiple parties participate in a coalition they are representing different interests, and to maintain the coalition it is necessary to accommodate those interests by satisfying their budgetary needs. Consequently, as coalition governments have more veto points within their structure and each party can demand expenditures, without fully internalizing their costs, it will be more difficult to apply spending cuts and to control the deficit when

[42] In fact, de Haan and Sturm (1994) argue that "… minority governments are often able to reduce budget deficits, as the Danish experience demonstrates." (de Haan and Sturm, 1994, p. 164).

necessary.[43] However, Edin and Ohlsson (1991) and Sakamoto (2001) found no evidence that the number of parties in office affects negatively governments' ability to reduce deficits.

Tenure in office or political instability – sometimes called fragmentation over time – is considered by some authors as another determinant of public deficits. Grilli *et al.* (1991), de Haan and Sturm (1994) and Annett (2002) find that public deficits tend to be higher when government turnover is higher. Alesina and Tabellini (1987) have already emphasized that when political power alternates frequently between competing parties, the higher will be the deficit and debt bias. However, Borrelli and Royed (1995) and Sakamoto (2001) find no evidence to support this view.

3.2.2. Literature on the determinants of excessive deficits

While the literature on public deficits and debts is abundant, the literature on the causes of excessive deficits is relatively undeveloped. There are only a few studies that really try to analyse some issues related to excessive deficits in the European Union context: Bayar (2001), Hughes-Hallett and McAdam (2003) and Hughes-Hallett and Lewis (2004, 2005). These studies define an excessive deficit as a deficit higher than 3% of GDP, in line with the legal concept established by the Maastricht Treaty. Bayar (2001) focuses his analysis on the economic determinants of an EU country entering into and exiting from an excessive deficit, whilst Hughes-Hallett and Lewis (2004, 2005) are more concerned with the issue of whether the fiscal improvements created in the run-up to EMU have lasted beyond the creation of

[43] Perotti *et al.* (1998), Perotti and Kontopoulos (2002) and Woo (2003) also consider the number of ministers as an important conditioning of public deficits. They show that a large cabinet tends to generate more spending, especially in situations of economic slowdown or fiscal distress.

the Euro-zone. In a different approach, Hughes-Hallett and McAdam (2003) examine how deficit targets can be used to reduce the probability of excessive deficits.

Using a duration analysis over the period 1970-1996 for the 15 EU member states, Bayar (2001) concludes that government receipts and economic growth are important determinants to the likelihood of a country exiting from the state of an excessive deficit, whereas primary expenditures play a central role for the likelihood of a country's entry into a state of excessive deficit. The level of debt also affects both likelihoods but in opposite directions: the higher is the debt, the higher (lower) will be the likelihood of entering into (exiting from) an excessive deficit. Hughes-Hallett and Lewis (2004, 2005) also find important positive effects from the lagged debt and deficit (and a negative effect from the output gap) on the probability of a country exceeding the 3% of GDP for the deficit for the 15 EU countries over the period 1960-2002 using a simple probit model. However, the focus of their analysis is on the fiscal discipline in the post-Maastricht period. They show that it increased until 1997-1998, but eroded thereafter to an extent that, by 2005, there was less discipline than before the Maastricht process has started.[44] Therefore, they conclude that fiscal discipline in the EU was just the product of the threat of a country being excluded from taking part in the Euro-zone. As soon as that sanction was removed (after 1998), countries seemed to relax their consolidation efforts.

Finally, Hughes-Hallett and McAdam's (2003) stochastic simulations for the four largest EU states (Germany, France, Italy and UK) allow them to conclude that

[44] In a study of the conditionings of the public deficit in the post-Maastricht period, Annett (2006) shows that the benefits of the fiscal rules, in terms of making fiscal policy less pro-cyclical, evaporated after the creation of EMU. However, his results are more optimistic than those presented by Hughes-Hallett and Lewis (2004, 2005). Annett (2006) argues that the SGP was successful in contributing to fiscal discipline in some countries like Austria, Belgium, Denmark, Finland, Ireland, the Netherlands, Spain and Sweden.

fiscal targets have to be country-specific and conservative, and fiscal policy has to be forward-looking to keep the probability of excessive deficits below acceptable limits.

A striking point to notice is the fact that none of these studies actually focus their analyses directly on the determinants of an excessive deficit. Hughes-Hallett and McAdam (2003) simply analyse the probability distribution of a country's deficit ratio under a variety of fiscal rules; Bayar (2001) is only concerned with the entry and exit dynamics of an excessive deficit, whilst Hughes-Hallett and Lewis (2004, 2005) are more interested in analysing the issue of fiscal discipline after Maastricht. Moreover, they consider that economic factors are the only conditionings of the likelihood of an excessive deficit. In reality, to deeply understand why excessive deficits may arise, we may also pay attention to the political environment. This is a fact that the few existing studies on excessive deficits have ignored but that this study intends to analyse in detail.

This study goes even further by providing separate analyses for small and large countries and for countries traditionally affected by large deficits. The econometric analysis used in this study is also different from those employed in the previous studies. Here, in contrast to the duration model used by Bayar (2001) and the simple probit model estimated by Hughes-Hallett and Lewis (2004, 2005), a conditional logit model is estimated allowing for country-specific effects. Those effects are not taken into account in the previous studies, which may affect their estimates.

Finally, as the 3% rule for the public deficit has been the main reference for the fiscal policy in the EU over the last decade, this study also intends to shed some light on how that rule affected recent fiscal behaviour or, in other words, how EU countries have been coping with excessive deficits after Maastricht.

3.3. Theoretical framework and empirical estimation technique

Regarding the theoretical literature presented in the previous section, we derived a simple theoretical model to support the analysis of the causes of excessive deficits. The econometric technique used to estimate the model is also described in this section.

Public deficits can be expressed by the following relation:

$$DEF_t = E_t + i_{t-1}DEBT_{t-1} - R_t \,, \tag{3.1}$$

where *DEBT* is the stock of public debt, *E* is government primary expenditure, *i* is the nominal interest rate on the debt (in the end of period *t*-1) and *R* is total government revenues. Expressing the deficit in terms of GDP (*Y*) yields:

$$\frac{DEF_t}{Y_t} = \frac{E_t}{Y_t} + \frac{i_{t-1}DEBT_{t-1}}{(1+g_t)(1+\pi_t)Y_{t-1}} - \frac{R_t}{Y_t} \,, \tag{3.2}$$

where *g* is the growth rate of real GDP, and π is the inflation rate. We assume that a part of the government expenditures to GDP is relatively constant but the other part is highly dependent on two factors: the level of economic activity and the preferences of the government. In fact, expenditures tend to rise when economic activity is slowing due to the increase in unemployment transfers. On the other hand and according to the thoughts of the PBC theory, the ideological preferences of the government and elections may affect the level of government expenditures significantly. The remaining part of the expenditures is assumed constant because it is allocated to items that are necessary to assure the normal working of the public structure like, for example, wages. Revenues to GDP are considered to be dependent on the growth of real GDP. Therefore, equation **(3.2)** can be re-written as follows:

$$def_t = \underbrace{c_1 - \alpha_1 g_t + \gamma_1 ideol_t + \gamma_2 elect_t}_{\text{expenditure function}} + \underbrace{\frac{i_{t-1}}{1+\pi_t} \times \frac{1}{1+g_t} \times debt_{t-1}}_{s_t} - \underbrace{(c_2 + \alpha_2 g_t)}_{\text{revenue function}}, \quad \textbf{(3.3)}$$

where c_1 and c_2 are constants, *ideol* represents the ideology of the government (ranging from a right to a left-wing government, $0 \leq ideol \leq 1$) and *elect* identifies an election; lower case letters stand for the ratio of the deficit and debt to GDP.

To simplify equation **(3.3)**, we start by linearizing the component s_t using a linear Taylor series approximation around 0, which yields: $s_t = c_3 + \theta_1 debt_{t-1} + \theta_2 rir_{t-1} - \alpha_3 g_t + \xi_t$, where c_3 is a constant, *rir* represents the real interest rate (i-π) and ξ_t is the remaining residual. Substituting this in equation **(3.3)** and rearranging, we have:

$$def_t = c + \theta_1 debt_{t-1} + \theta_2 rir_{t-1} - \alpha g_t + \gamma_1 ideol_t + \gamma_2 elect_t + \xi_t = \mathbf{z}'\boldsymbol{\delta} + \xi_t , \quad \textbf{(3.4)}$$

where $\alpha = \alpha_1 + \alpha_2 + \alpha_3$, $\mathbf{z}$ is the vector of the exogenous variables and $\boldsymbol{\delta}$ is the vector of the respective coefficients. This equation shows that the deficit-to-GDP ratio increases with the stock of the debt-to-GDP ratio and real interest rate prevailing in t-1, and decreases with the current real GDP growth rate. It also shows that left-wing governments and elections contribute to increase the deficit.

As this study tries to evaluate the impact of those factors on the probability of a country having an excessive public deficit, this model has to be defined in terms of a probabilistic function. But first it is important to define an excessive deficit. According to both the Maastricht Treaty and the SGP, an excessive deficit is defined as a deficit higher than 3% of GDP.[45] This means that the new dependent variable (*Def3*) will be a dummy variable that takes the value of 1 when general government budget surplus as percentage of GDP (*GBS*) is lower than -3% of GDP, and 0 otherwise. Therefore, the probability of an excessive deficit can then be defined as a function of the basic factors that are conditioning the deficit. As there can be some persistence in the elimination of an excessive deficit, the lag of the deficit (def_{t-1}) is also added to the model, which yields the following generic equation to be estimated:

$$\text{Prob}(Def3 = 1 \mid \mathbf{z}, def_{t-1}) = f(\mathbf{z'}\boldsymbol{\delta} + \rho def_{t-1})\,. \qquad \textbf{(3.5)}$$

Considering that f is a monotonic increasing function, the impact of each exogenous variable on the likelihood of an excessive deficit has the same sign as in equation **(3.4)**.

As the dependent variable used in this analysis is binary, the econometric model chosen to estimate the coefficients of interest is the conditional logit model. This model describes the probability of an event occurring given certain conditionings. In particular, it will be used to explain the probability of a country breaching the 3% of GDP rule for the deficit (or having an excessive deficit), given certain economic and political determinants (**x**). In comparison with the traditional linear specification for the study of the determinants of public deficits, this model has the advantage of allowing for the analysis of an important issue not yet fully analysed in literature but which has a great deal of importance in Europe after

[45] This seems to be a good value of reference because EU countries have been compelled to meet this target either as a convergence criterion to take part in the EMU or, after that, as a requirement of the SGP.

Maastricht: how to avoid excessive deficits, i.e. deficits higher than 3% of GDP. This model can be represented as follows:[46]

$$\text{Prob}(Def3 = 1 \mid \mathbf{x}) = \frac{e^{\mathbf{x}'\boldsymbol{\beta}}}{1+e^{\mathbf{x}'\boldsymbol{\beta}}} = \Lambda(\mathbf{x}'\boldsymbol{\beta}), \qquad \textbf{(3.6)}$$

where $\boldsymbol{\beta}$ is the vector of all parameters to be estimated, $\mathbf{x}=(\mathbf{z},def_{t-1})$ and $\Lambda(\mathbf{x}'\boldsymbol{\beta})$ is the logistic CDF associated with the logit model. The vector of parameters $\boldsymbol{\beta}$ reflects the impact of changes in $\mathbf{x}$ on the probability of excessive deficits.

Whilst Hughes-Hallett and Lewis (2004, 2005) simply rely on the estimation of a pooled probit model, this study implements panel data techniques. The presence of country-specific effects should be controlled for to avoid biased estimates.[47] The structural model for a binary panel data model can then be written as follows:

$$\begin{aligned} &y_{it}^{*} = \mathbf{x}_{it}'\boldsymbol{\beta} + \varepsilon_{it}, \quad i = 1,...,n, \ t = 1,...,T_i, \\ &Def3_{it} = 1 \text{ if } \ y_{it}^{*} > 0, \text{ and 0 otherwise.} \end{aligned} \qquad \textbf{(3.7)}$$

In this case, y^{*} is an unobserved outcome and ε_{it} is an error term. Regarding the assumptions made over the error term, we can have either a random effects model (where $\varepsilon_{it} = \upsilon_{it} + u_i$ and υ_{it} and u_i are independent random variables, u_i has mean 0 and variance equal to σ_u^2 and υ_{it} is normally distributed with mean 0 and variance $\sigma_\upsilon^2 = 1$), or a fixed effects model (where $\varepsilon_{it} = \upsilon_{it} + \alpha_i d_{it}$ and d_{it} is a dummy variable that takes the value 1 for individual *i* in period *t*, and 0 otherwise). Theoretically, the distinction between random and fixed effects relies on the relationship between u_i and $\mathbf{x}_{it}$. If they are not correlated, then we have random effects; if they are correlated,

[46] For details on this and other binary choice models see, for example, Greene (2003, Ch. 21).

[47] Unsurprisingly, the hypothesis of homogeneity of the individual coefficients was rejected in this study.

the model has fixed effects. Considering that, for the period of analysis, the entire population of EU countries is included in the sample, and that each country has particular economic, political and institutional characteristics, it is highly probable that u_i is correlated with the regressors. Hence, fixed effects are assumed to be present in the model.

However, the traditional unconditional fixed effects estimator can be affected by some statistical problems. This estimator relies on the assumption that T_i is increasing for the constant terms to be consistent. But in this formulation T_i is fixed, therefore, the estimators of the constant terms and subsequently the estimator of $\boldsymbol{\beta}$ are not consistent. This is called the incidental parameters problem and it is more severe when T_i is small. A way of avoiding this problem is by using a minimal sufficient statistic for α_i.

According to the literature and considering the dependent variable used in this study, $S_i = \sum_{t=1}^{T_i} Def3_{it}$ is the suggested minimal sufficient statistic for a fixed effects logit model.[48] Hence, the conditional likelihood function can be written as follows:

$$L^c = \prod_{i=1}^{n} \frac{e^{\sum_{t=1}^{T_i} Def3_{it}\mathbf{x}_{it}'\boldsymbol{\beta}}}{\sum_{\sum_t d_{it}=S_i} e^{\sum_{t=1}^{T_i} d_{it}\mathbf{x}_{it}'\boldsymbol{\beta}}}. \qquad \textbf{(3.8)}$$

This equation is now free of the incidental parameters α_i and its maximization can be done by the conventional methods.

[48] Despite sufficient statistics being available for the logit model, they are not available for the probit model. This represents the main reason for the choice of the conditional logit model.

3.4. Empirical results

This section starts by describing the data and the main variables used in the empirical analysis. Then, the empirical results from the estimation of the conditional logit model are presented and analysed.

3.4.1. Data and description of the variables

Regarding the literature on public deficits and the model presented in the previous section, some economic and political variables will be used in the identification of the main causes of an excessive deficit. The economic data were collected on an annual basis from the AMECO Database of the European Commission (May, 2007) for 15 EU countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom) over the period 1970-2006. The main economic variables used as regressors in this study are the following:

- Primary (general) government budget surplus as a percentage of GDP lagged one period (*PrimGBS(-1)*). This variable is included in the equation to account for the persistence of past budgetary imbalances on the likelihood of an excessive deficit.[49] We expect that the higher the primary surplus (deficit) in the previous period, the lower (higher) will be the current probability of an excessive deficit.
- General government gross public debt as a percentage of GDP lagged one period (*Debt(-1)*).[50] This is an important determinant of public deficits and, in the same

[49] *PrimGBS(-1)* is used instead of *GBS(-1)* because this latter variable is highly correlated with government debt (another regressor to be included in the equation). When the interest is discounted from the computation of the deficit, there is no longer that problem. Moreover, the government has greater immediate control over the primary budget than over interest payments.

[50] Some economic variables are lagged one period to avoid any reverse causality or simultaneity bias.

way, of excessive deficits. Regarding our theoretical framework, the higher the public debt, the higher is the share of public expenditures that has to be dedicated to interest payments generated by that debt and, therefore, the higher will be the probability of an excessive deficit. But note that Mélitz (2000) and Annett's (2006) findings indicate that a very high public debt may also force the government to take measures to reduce it by diminishing the deficit. In that extreme case, the likelihood of an excessive deficit might be slightly reduced.

- Annual growth of real GDP at price levels of 2000 (*GRGDP*). As the economic performance of a country greatly affects the public budget through automatic stabilizers, we anticipate that excessive deficits in the EU will be less likely when the economy is growing faster.
- Real long-term interest rate lagged one period (*RIR(-1)*).[51] This variable captures the effects of the interest rate on the real amount of debt to be paid each period. As this amount is accounted in the current budget, the higher the interest rate last year, the higher will be the burden of the debt to be paid this year and, therefore, the higher the public deficit and the probability of excessive deficits arise.

The data for political variables were mainly collected from Armingeon *et al.* (2005) for the period 1970-2004 and the series were updated for 2005 and 2006 using information from the internet website www.electionworld.org (Elections Around the World).[52] The political variables included in the main equation to be estimated in this study are the following:

[51] The GDP deflator is used by our source (AMECO) to obtain this variable from its nominal counterpart.

[52] There are some missing values for Greece (1970-1973), Portugal (1970-1975) and Spain (1970-1976) because during those periods these countries were not ruled by democratic regimes.

- Left-wing government (*Left*) is a dummy variable that takes the value of 1 when the *GovParty* series in Armingeon *et al.* (2005) is equal to 4 or 5, and 0 otherwise. This corresponds to a situation in which there is dominance or hegemony of left-wing parties in the government. Hibbs (1977) suggests that left-wing governments are more prone to fight unemployment and to promote growth. In our model, this behaviour would tend to generate an increase in public expenditures (more transfers and public investment). Hence, we expect that left-wing governments have a higher tendency to create excessive deficits than centre or right-wing governments.
- Election year (*ElectYear*) is a dummy that takes the value of 1 in years of general (parliamentary) elections and 0 in non-election years. According to the PBC theory, we anticipate that excessive deficits will be more likely in election years.
- Minority government (*MinGov*) is a dummy that takes a value 1 when a minority government is in office and 0 if a (single-party or coalition) government has a majority in the parliament. This variable was built using the *gov_type* series from Armingeon *et al.* (2005). Due to the lack of consensus in the literature about the impact of this variable on public deficits, no sign is anticipated for its coefficient.[53]

Two additional variables were included in the equation to control for the period in which the 3% rule for the deficit was implemented in the EU:

- *D92* is a dummy variable that takes a value 1 in the period 1992-2006.
- *D99* is a dummy variable that takes a value 1 in the period 1999-2006.

These dummies are incorporated into the model to control for the period in which fiscal rules were established in the EU. The aim is to capture the behaviour of

[53] By the same reason, we avoided to consider this variable in our theoretical framework.

the EU countries in the post-Maastricht period and in the period following the launch of the Euro. *D92* is included to capture the post-Maastricht effect and *D99* tries to capture any additional effect from the SGP, after the run up for EU countries to assure their place in EMU was over. This latter variable is added to test whether the EU countries have relaxed their efforts to control the deficit after they have assured a place in the EMU.

Besides the inclusion of all these variables in the model, other economic and political variables – more or less related with these – will be considered in the empirical analysis. They will be described once they are included in the equation.[54]

3.4.2. Main economic and political determinants of excessive deficits

The estimation results of the model described in the Section 3.3 are analysed in this section. The first column of Table 3.1 shows the results for the main specification, which includes the economic and political variables previously defined. A more detailed analysis of the economic and political determinants of an excessive deficit in the group of EU countries is presented in the remaining of Table 3.1 and in Table 3.2.[55]

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[54] See Annex 3.1 for a complete description of all variables and Annex 3.2 for the respective descriptive statistics. In Annex 3.2, there is a figure showing the evolution of the public deficit in the EU countries over the period 1970-2006 (Figure A.3.2.1) and two other figures with the distribution of the excessive deficits by country (Figure A.3.2.2) and by year (Figure A.3.3.3), respectively. These figures provide a good indication that public deficits have decreased significantly after Maastricht (especially after the SGP has come into effect), as well as the number of countries in excessive deficit.

[55] Since in the conditional logit the fixed or individual effects are not estimated, it is not possible to compute the respective marginal effects. An alternative way of intuitively interpreting the results from the conditional logit is using an odds-ratio analysis. As the ratio of the probability of an excessive deficit to a not excessive deficit is given by $e^{\mathbf{x'\beta}}$, differentiating this expression with respect to any of the regressors (x_k), we get e^{β_k}, which means that for any unitary change in x_k, the odds will change by a factor of e^{β_k}, holding all other variables constant.

Considering first the results presented in the first column of Table 3.1, we find some degree of persistence in past budgetary imbalances. The results confirm the expectation that the higher and more persistent is the primary deficit (*PrimGBS(-1)*), the more difficult it will be for a country to avoid an excessive deficit. In the second estimation presented in Table 3.1, the effects of the fiscal variables on the probability of an excessive deficit are analysed in more detail. The variable *PrimGBS* was subdivided into its two major components: the primary total expenditure as a percentage of GDP (*PrimTExp*) and the total revenues as a percentage of GDP (*TRevenue*). As expected, the inclusion of these variables in the model, instead of *PrimGBS*, confirms the results shown by Bayar (2001), i.e. that the likelihood of an excessive deficit increases with public expenditures and decreases with government revenues.

The public debt (*Debt(-1)*) is another important determinant of the likelihood of an excessive deficit. Results show that the probability of an excessive deficit increases with the public debt, which confirms our theoretical prediction and is in accord with Balassone and Francese (2004) and Mink and de Haan's (2005) view.[56] Despite this effect being lower than the effect of the primary deficit, it is sufficient to conclude that the automatic effects of an increase in interest payments – due to a higher debt – have an impact on the probability of an excessive deficit that outweighs any government desire to reduce the deficit (and to avoid excessive deficits) when the debt is high.

[56] As an example, results presented in column 1 show that a percentage point increase in *Debt(-1)* will increase the ratio between the probability of an excessive deficit and a not excessive deficit by a factor of around 1.0741 (= $e^{0.0715}$), holding all other variables constant.

Table 3.1. Analysis of the main determinants of an excessive deficit I

Prob(*Def3*=1)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
PrimGBS(-1)	-0.9252 (-8.64)***		-0.8481 (-8.21)***	-0.9642 (-8.16)***	-0.9289 (-8.62)***	-0.9164 (-8.61)***	-0.9434 (-8.50)***
PrimTExp(-1)		0.8267 (8.10)***					
TRevenue(-1)		-0.8476 (-7.46)***					
Debt(-1)	0.0715 (5.64)***	0.1384 (4.00)***	0.0477 (3.92)***	0.0803 (5.79)***	0.0695 (5.45)***	0.0711 (5.64)***	0.0736 (5.68)***
Debt_sq(-1)		-0.0004 (-1.84)*					
GRGDP	-0.3959 (-4.88)***	-0.4402 (-5.14)***		-0.3596 (-4.23)***	-0.4250 (-5.07)***	-0.3935 (-4.96)***	-0.3966 (-4.89)***
UR			0.1853 (2.20)**				
RIR(-1)	0.1071 (1.73)*	0.0470 (0.74)	0.0535 (0.84)	0.0837 (1.29)	0.1409 (2.26)**	0.0982 (1.60)	0.1097 (1.82)*
D92	-1.0318 (-2.25)**	-1.4697 (-3.12)***	-0.7499 (-1.75)*		-1.3313 (-2.82)***	-1.0190 (-2.26)**	-1.1887 (-2.57)***
D9298				0.9952 (1.23)			
D9298t				-0.4933 (-2.91)***			
D99	-1.1978 (-2.42)**	-1.4256 (-2.86)***	-1.1330 (-2.42)**	-2.0985 (-2.20)**	-0.9296 (-1.93)*	-1.2003 (-2.44)**	-1.1421 (-2.33)**
D99t				-0.0786 (-0.48)			
Left	0.8188 (0.035)**	1.0058 (2.51)**	0.8175 (2.18)**	0.9647 (2.37)**		0.7358 (1.92)*	0.6831 (1.79)*
%Right					-0.0139 (-2.53)**		
ElectYear	0.9218 (0.008)***	0.8360 (2.40)**	0.9111 (2.73)***	0.9041 (2.55)**	0.8638 (2.48)**		
PolCycle						-0.5514 (-1.79)*	
YrAfterElect							-0.5063 (-1.15)
2YrAfterElect							-1.0431 (-2.31)**
3YrAfterElect							-0.8030 (-1.75)*
MinGov	-1.0446 (-1.91)*	-0.9854 (-1.77)*	-1.1943 (-2.20)**	-0.9256 (-1.68)*	-1.1647 (-2.13)**	-0.9597 (-1.79)*	-0.9074 (-1.69)*
Log-Likelihood	-115.08	-116.41	-126.65	-110.25	-114.01	-117.06	-115.70
AIC	248.16	254.82	271.30	242.51	246.0151	252.12	253.40
SBIC	286.27	301.39	309.41	289.09	284.12	290.23	299.98
No. Observ.	510	510	510	510	510	510	510

Notes: The *z*-statistics for the estimated coefficients are in parentheses. Significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The coefficients were estimated using a conditional logit fixed effects estimator. AIC=2(-logL+*k*), where *k* is the number of regressors; and SBIC=2(-logL+(*k*/2)log*N*), where *N* is the number of observations. AIC is the Akaike Information Criterion and SBIC is the Schwartz Bayesian Information Criterion.

Sources: See Annex 3.1.

The square of the public debt (*Debt_sq*) is also added to regression 2 with the aim of inferring whether governments' will to reduce the deficit and to avoid excessive deficits decreases when the public debt is very high, as suggested by Mélitz (2000) and Annett (2002). In fact, results seem to confirm that idea, i.e. they show that the probability of an excessive deficit increases as the debt increases, but for high levels of debt that probability tends to decrease. This means that when the debt reaches high values, governments' will to control the deficit is higher than the automatic effect of interest payments. However, the statistical evidence to support this idea is not strong.[57]

The effect of the economic environment is captured by the growth of real GDP (*GRGDP*). When the economy is growing faster, the probability of an excessive deficit is reduced, which means, that a good economic environment is essential for a country to avoid excessive deficits. As the economic cycle affects the public budget largely through automatic stabilizers, then when there is a recession, tax revenues decrease and unemployment benefits push up public expenditures. Hence, the effect of a higher unemployment rate on the probability of an excessive deficit should be significantly positive. Results presented in columns 3, where the unemployment rate (*UR*) is used instead of *GRGDP*, confirm that assumption.[58]

Regarding the effects of the real interest rate (*RIR(-1)*), we find some evidence of the expected negative effect of this variable on the likelihood of an excessive deficit, a result that can be justified by the increase in interest expenditure on public debt.

[57] Additional regressions, not reported here, revealed that the coefficient on *Debt_sq* is not always statistically significant when included in the remaining specifications estimated in this study.

[58] Due to the well-known relation between growth and unemployment rate, we prefer not to include both variables in the same regression. In fact, these variables present a high correlation in this study.

On the effects of the fiscal constraints imposed by Maastricht and by the SGP, results seem to indicate a higher fiscal discipline after Maastricht,[59] and this effect seems to be reinforced in the period after 1999. A contrary view is shared by Tujula and Wolswijk (2004), Hughes-Hallett and Lewis (2004, 2005) and Annett (2006). They claim that fiscal discipline eroded after the run-up to EMU was over. Hughes-Hallett and Lewis (2004, 2005) show that the SGP appears to have reduced the probability of a country violating the 3% limit, but they argue that the inclusion of simple shift dummies in the model may not capture a possible gradual erosion of fiscal discipline. Therefore, they also include in their study time trends for the pre- and post-EMU periods and their results suggest that in each subsequent year under the SGP regime (post-EMU) there was an increasing tendency for EU countries to violate the 3% limit for the deficit. To capture this idea in more detail, we also consider a non-overlapping dummy structure in our analysis, where the first variable is covering the period 1992-1998, i.e. the run-up to EMU (*D9298*) and the other is covering the period after 1999 (*D99*). Additionally, a time trend for each of these periods was included in the specification to control for the gradual (annual) effects of the fiscal discipline (*D9298t* and *D99t*, respectively). The estimation results of such a specification are shown in column 4. Only the coefficients on *D9298t* and *D99* are significant. This means that, on average, the probability of an excessive deficit is not significantly lower after Maastricht than before, but the efforts made by all EU countries to take part in EMU were helpful in gradually reducing that probability until 1998. After 1999, despite the probability of an excessive deficit being lower than before Maastricht, we are not able to identify further significant efforts to

[59] This result is in accord with the evidence provided by Arestis *et al.* (2002) that most EU countries have presented statistically significant reductions in their deficits in the post-Maastricht period.

reduce it. Nevertheless, the results do not indicate either any significant erosion of the efforts made until 1998, in contrast to what is argued by other authors.

The political variables are another important group of determinants of the probability of an excessive deficit. All regressions show evidence of ideological effects, i.e. left-wing governments (*Left*) have a higher propensity to generate excessive deficits than centre/right-wing governments. This result strongly supports the 'partisan' argument that left-wing governments tend to promote a higher degree of public intervention in the economy, caring more about unemployment and growth than inflation. Hence, they are more prone to increase expenditures and to generate deficits than right-wing parties. For the same reasons – and as the results presented in this chapter proved – they are more prone to generate excessive deficits as well.

Results also show that the probability of an excessive deficit tends to increase in election years (*ElectYear*). According to the PBC literature, this evidence indicates that EU governments are trying to influence macroeconomic outcomes before elections by running a loose fiscal policy (more spending and/or tax reductions) in order to increase their probability of re-election. Consequently, this opportunistic behaviour generates a higher propensity for excessive deficits in election years.

Finally, there is some evidence that minority governments (*MinGov*) have a lower propensity to generate excessive deficits than majority governments. Some authors have already noticed a similar result in the analysis of public deficits.[60] As majority governments do not need support from other parties in the parliament to implement their preferred measures – contrarily to minority governments – deficits are more able to increase under their terms in office than under minority

[60] See Borrelli and Royed (1995), Sakamoto (2001) and Tujula and Wolswijk (2004). In fact, as stated by Edin and Ohlsson (1991), some minority EU governments, like successive Danish and Swedish governments, have been successful in avoiding excessive deficits.

governments. As the negative effects of unpopular policies can be more easily imputable to a majority than to a minority government, the former can try to avoid them so as not to lose electoral support. Hence, the propensity to excessive deficits increases when majority governments are in office. According to the results of this study, this opportunism can be even more intense when majority governments are under electoral pressure.

Some additional political variables are also included in the model to add more detail to the important effect of political factors on the probability of a country having a deficit higher than 3% of GDP. In regression 5, we consider the percentage of right-wing parties in the cabinet (*%Right*), instead of *Left*, as a way of controlling more directly for the effects of the relative power that a party has in the government. Results show that the higher is the percentage of right oriented policymakers in the government the lower will be the probability of an excessive deficit, as expected.

On the other hand, the PBC theory not only states that governments try to manipulate the economy right before elections in order to increase their chance of re-election, but also argues that after elections governments will try to correct the fiscal imbalances generated by the electoral period. Therefore, we expect that the probability of an excessive deficit is lower after elections. Results presented in column 6 of Table 3.1 give some support to this expectation. The variable used to control for this idea is a dummy that takes the value of 1 in the first half of the political cycle of a government (*PolCycle*). Results suggest that the propensity for an excessive deficit is lower in the first half of the mandate than in the second. Moreover, results presented in the last column of Table 3.1 show that the efforts to control excessive deficits are especially felt in the second (and third) year(s) after the last election. Thus, our evidence is suggesting that the correction of a substantial fiscal imbalance is not immediate; it takes some time before the measures taken by the new government to control an excessive deficit have visible effects. This evidence represents a new and interesting finding in this field.

The effects of the fragmentation of political power on the likelihood of an excessive deficit are analysed in Table 3.2. The issue of fragmentation over time is considered in the first regression. Some authors consider the tenure in office or political instability as an important determinant of public deficits (Grilli *et al.*, 1991, de Haan and Sturm, 1994 and Annett, 2002). The variable used in this study to capture the effect of the political instability is the number of changes in government per year (*NGovChg*). As it is highly correlated with *ElectYear*, this last variable was dropped from this regression. Results show that the higher instability caused by changes in government is also a cause of excessive deficits.

To analyse in more detail the effect of the degree of government control over the parliament, two dummies were included in the model instead of *MinGov*: one takes the value of 1 when the government is formed by a single party with a majority in the parliament (*MajSPGov*); and the other takes the value of 1 when the government is formed by a coalition with a majority in the parliament (*CoalGov*).

Results confirm the idea that single-party majority governments have a higher propensity for excessive deficits than minority governments. As single-party majority governments have more power to control deficits, they also have more power to satisfy the spending demands of their supporters. This total control over fiscal policy by just one party and the earlier mentioned electoral motivation can make excessive deficits more likely under this kind of government than under minority (or coalition) governments, where there is some control by the other parties to avoid this opportunism.

Table 3.2. Analysis of the main determinants of an excessive deficit II

Prob(*Def3*=1)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
PrimGBS(-1)	-0.9096	-0.9391	-0.9170	-0.9374	-0.9184	-0.9254
	(-8.57)***	(-8.60)***	(-8.53)***	(-8.51)***	(-8.55)***	(-8.58)***
Debt(-1)	0.0707	0.0734	0.0742	0.0715	0.0687	0.0703
	(5.57)***	(5.67)***	(5.73)***	(5.64)***	(5.37)***	(5.31)***
GRGDP	-0.3755	-0.4043	-0.3923	-0.4203	-0.3938	-0.4113
	(-4.64)***	(-4.92)***	(-4.79)***	(-4.71)***	(-4.87)***	(-4.99)***
RIR(-1)	0.1319	0.0974	0.0848	0.1001	0.1151	0.1098
	(2.02)**	(1.55)	(1.31)	(1.56)	(1.83)*	(1.66)*
D92	-1.0271	-0.9688	-0.9822	-0.9873	-0.8970	-1.0887
	(-2.27)**	(-2.09)**	(-2.14)**	(-2.15)**	(-1.93)*	(-2.32)**
D99	-1.0698	-1.2127	-1.2280	-1.3694	-1.2483	-1.3170
	(-2.19)**	(-2.44)**	(-2.45)**	(-2.66)***	(-2.49)**	(-2.54)**
Left	0.8182	0.7292	0.7514	0.5089	1.1857	-.0119
	(2.09)**	(1.83)*	(1.92)*	(1.23)	(2.68)***	(-0.02)
ElectYear		0.9497	0.9429	0.4907	0.9347	0.9819
		(2.71)***	(2.71)***	(1.18)	(2.65)***	(2.78)***
NGovChg	0.6950					
	(2.52)**					
MinGov	-1.0964		-1.2241	-1.2055	-0.4453	-0.8098
	(-1.99)**		(-2.16)**	(-2.16)**	(-0.69)	(-1.25)
MajSPGov		1.4687				-0.3388
		(2.17)**				(-0.40)
CoalGov		0.7109				
		(1.13)				
NPartyGov			-0.3030			
			(-1.33)			
*ElectYear*Left*				1.5307		
				(2.13)**		
*MinGov*Left*					-1.6298	
					(-1.80)*	
*MajSPGov*Left*						2.1297
						(2.48)**
Log-Likelihood	-115.34	-114.50	-114.13	-110.30	-113.43	-111.28
AIC	248.69	249.00	248.25	240.61	246.87	244.56
SBIC	286.80	291.35	290.60	282.89	289.21	291.14
No. Observ.	510	510	510	510	510	510

Notes: See Table 3.1

The idea advanced by De Haan *et al.* (1999) and Perotti and Kontopoulos (2002) that the distinction between minority and majority may not necessarily capture the notion of fragmentation in decision-making is taken into account in regression 3. Here we add to the model a variable that accounts for the number of decision-makers in the government (*NPartyGov*).[61] However, results indicate that the number of parties in the government coalition seems to have no significant effect on the probability of an excessive deficit in the EU.[62] But note that the distinction between majority and minority governments remains relevant, which means that it is the degree of government control over the parliament rather than the number of parties in the coalition that matters to explain excessive deficits in the EU.

The remaining regressions presented in Table 3.2 attempt to provide evidence of some additional effects from the interaction between the determinants of an excessive deficit analysed so far. As no significant effects were detected from the interaction between the economic and political variables – which means that political factors matter in any economic situation – we report only the significant results for the interaction between the political variables. Column 4 provides an interesting result: evidence suggests that left oriented governments are the most responsible for the opportunistic behaviour right before elections; when a left government is in office in the election year, the probability of an excessive deficit is higher than when the government is formed by centre and/or right parties.

Another interesting result regarding left oriented governments comes from regression 5: excessive deficits are greatly associated to left-wing governments with majority in the parliament, but when a left-wing government is in a minority in the

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[61] This variable was obtained from different sources. See Annex 3.1 for details.

[62] Edin and Ohlsson (1991) have previously found no evidence that the number of parties in office affects governments' ability to reduce deficits. Our study also considered specifications with the number of ministers in the government, a dummy for a single party government, the Herfindhal index for the seat shares of all parties in the government, a government fractionalization index (respectively, *HERFGOV* and *GOVFRAC* obtained from Keefer (2005), *The Database of Political Institutions* (DPI2004)) and even a fragmentation index for the distribution of the number of parties in the parliament, but the coefficients on those variables were not significant either, which refrained us from reporting those results.

parliament our results show that its propensity for excessive deficits is significantly lower than when a right oriented minority government is in office. This means that when left governments have total control over the parliament they have the support they need to implement measures to promote growth and to reduce unemployment. As a result, public expenditures will increase as well as the deficit and the probability of an excessive deficit. Due to this propensity to generate excessive deficits, the other (centre and right) parties will be very stringent in supporting minority-left government initiatives. Therefore, minority-left governments have a lower propensity for excessive deficits than right-wing governments.

An additional regression was run for the interaction between *MajSPGov* and *Left*. Results show a significant positive coefficient on that variable (see regression 6). A similar argument to the one advanced above to explain why left-majority governments are more prone to excessive deficits can be used to justify this result: excessive deficits are more likely when left single-party governments with majority in the parliament are in office because they have the power and support they need to implement the policies that are more in accord with their ideology. This represents another important conclusion of this study.[63]

3.4.3. Robustness analysis

Some robustness tests were performed to check whether results are sensitive to the time period considered or to particular specificities of the countries included in the sample. Table 3.3 presents the most interesting results of that robustness analysis,

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[63] Although this study presents only results for the conditional logit model, unconditional logit and probit models using either random or fixed effects were also estimated, but the main conclusions were not significantly affected. Moreover, several heteroscedastic probit models were also run considering different patterns of heteroscedasticity, but none clearly rejected the homoscedasticity hypothesis.

and from which are obtained some new and important contributions to the literature on public deficits for the EU countries.

The first three regressions provide a pertinent analysis for the periods before and after the imposition of the Maastricht constraints. The first regression considers the period before Maastricht, whilst in regressions 2 and 3, the sample is restricted to the period 1992-2006; regression 3 is further restricted to the countries that have already taken part in the EMU. Results show that after Maastricht the probability of an excessive deficit is no longer affected by public debts or real interest rates. The overall trend to reduce the public debt to less than 60% of GDP and the required convergence of interest rates to low and stable values during this period is possibly behind this result. Thus, this indicates that the Maastricht criteria and the SGP fiscal constraints may have indeed been effective in controlling the negative effects of those variables on the likelihood of excessive deficits.

Furthermore, results also indicate that excessive deficits have become less likely after 1999. This evidence contradicts, once again, the view shared by Tujula and Wolswijk (2004), Hughes-Hallett and Lewis (2004, 2005) and Annett (2006) that fiscal discipline in the EU eroded after the run-up to EMU was over.

Regarding the political variables, the most interesting result comes from the coefficient on *NrPartyGov* for the period after Maastricht, especially for the Eurozone countries. Evidence suggests that countries with multi-party governments were more successful in avoiding excessive deficits than single-party governments, probably because the former were more successful in using the (fiscal) rules imposed by a supranational organization to build an internal consensus around the necessity of balancing their public accounts. Moreover, results also reinforce the idea that partisan effects and political opportunism are still alive and well after Maastricht.

Table 3.3. Robustness analysis for the causes of excessive deficits

Prob(*Def3*=1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PrimGBS(-1)	-1.3034	-0.6428	-0.7758	-1.1997	-0.7944	-0.9986	-0.9460
	(-5.00)***	(-4.32)***	(-3.50)***	(-5.07)***	(-6.12)***	(-5.61)***	(-5.72)***
Debt(-1)	0.0599	0.0281	0.0664	0.0763	0.0778	0.0798	0.0769
	(3.03)***	(0.83)	(1.43)	(2.76)***	(4.60)***	(4.12)***	(3.19)***
GRGDP	-0.5018	-0.7895	-0.8851	-0.8070	-0.3266	-0.3376	-0.6907
	(-3.65)***	(-3.45)***	(-3.17)***	(-3.56)***	(-3.57)***	(-3.02)***	(-4.22)***
RIR(-1)	0.2008	0.1717	0.3630	0.3122	0.0252	0.1167	0.0698
	(2.07)**	(0.75)	(1.28)	(2.64)***	(0.27)	(1.26)	(0.42)
D92				-0.6082	-1.6118	-2.0526	-0.8877
				(-0.68)	(-2.62)***	(-2.46)**	(-1.34)
D99		-1.7224	-2.1307	-0.8200	-2.1255	-2.4183	-1.0147
		(-2.17)**	(-2.16)**	(-0.90)	(-2.82)***	(-2.83)***	(-1.31)
Left	1.5550	1.4511	2.8218	2.3473	1.5963	3.2750	-0.2297
	(1.83)*	(1.85)*	(2.68)***	(2.20)**	(2.04)**	(3.49)***	(-0.38)
ElectYear	1.2507	1.0114	1.7641	1.2529	0.9970	0.6448	1.3693
	(2.23)**	(1.87)*	(2.52)**	(1.85)*	(2.15)**	(1.19)	(2.73)***
MinGov	-1.4267	-0.7268	-2.1538	-1.0409	-1.3475	-2.5472	-0.2494
	(-1.48)	(-0.65)	(-1.69)*	(-0.99)	(-1.78)*	(-2.63)***	(-0.24)
NPartyGov	0.1210	-0.5974	-1.3369	-0.8657	0.0517	-0.2587	-0.4155
	(0.33)	(-1.77)*	(-3.02)***	(-1.90)*	(0.17)	(-0.70)	(-1.17)
Log-Likelihood	-39.83	-44.08	-30.18	-34.68	-66.36	-46.30	-56.34
AIC	95.66	106.17	78.36	89.37	152.71	112.60	132.69
SBIC	123.61	134.90	105.45	120.55	191.09	147.32	168.74
No. Observ.	243	180	150	167	343	238	272
Time period	1970-1991	1992-2006	1992-2006	1970-2006	1970-2006	1970-2006	1970-2006
No. Countries	13	12	10	5	10	7	8

Notes: See Table 3.1. Regression 1 considers only the period before Maastricht (1970-1991); Finland and Italy were automatically dropped in this regression due to lack of variability of the dependent variable (Finland never presents an excessive deficit during this period, while Italy is always in a situation of excessive deficit). Regression 2 considers just the period 1992-2006; Regression 3 considers the same period but only the countries that took part in EMU. Denmark, Ireland and Luxembourg were dropped in these two regressions due to lack of variability of the dependent variable; in this case, these countries have never had excessive deficits in the period 1992-2006. Regression 4 includes only the 5 largest EU countries and regression 5 includes the remaining 10 ‘small’ countries. Regression 6 includes only the countries that run excessive deficits in more than half of the years in the period 1970-2006 (Belgium, Greece, Ireland, Italy, Portugal, Spain and the UK), whilst regression 7 presents results for the other countries.

Some authors argue that Maastricht criteria and SGP fiscal constraints are more suited to small countries than to large countries because small countries are more accustomed to external influences over its internal policy. Moreover, as they tend to have less bargaining power, the loss of reputation from violating the fiscal rule is greater.[64] Regressions presented in columns 4 and 5 intend to provide some empirical evidence for that argument – that is, they intend to test if the fiscal constraints have only affected the small countries or whether they have also affected large countries. Column 4 shows the results for the group of the 5 largest EU countries (France, Germany, Italy, Spain and the UK), whilst column 5 presents the results for the other 10 'small' countries. Evidence clearly supports the argument that EU fiscal constraints are more suited for small countries: the coefficients on the dummies for the period in which those constraints were imposed in the EU are highly significant for the group of small countries (see column 4), but insignificant for the group of large countries (see column 5). Therefore, the fiscal constraints were highly effective in reducing the propensity for excessive deficits in the small EU countries but they were ineffective for large countries. This evidence is confirmed by the violation of the SGP criteria for the deficit by France, Germany, Italy and the UK in 2002-2004. Empirical evidence also suggests that fiscal imbalances are more sensitive to interest rate changes in large countries than in small countries.

Next the 15 EU countries are divided into two different groups: the first includes only the countries that run excessive deficits – higher than 3% of GDP – in more than half of the years in the period 1970-2006 (Belgium, Greece, Ireland, Italy, Portugal, Spain and the UK); and the other contains the remaining EU countries (see Figure A.3.2.2 in Annex 3.2 for details). Two regressions were performed, one for each group. Results are presented in columns 6 and 7 and show that Maastricht

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[64] See, for example, Buti and Pench (2004) and Annett (2006). Buti and Pench (2004, p.1027) also argue that the costs of fiscal consolidations tend to be proportionality higher in large than in small countries because small countries "have a stronger incentive to undertake supply-side reforms rather than pursuing an expansionary fiscal policy, since reforms not only boost potential output directly, but also induce inflationary pressure which allows them to gain competitiveness and increase external demand".

criteria and SGP fiscal constraints were far more effective in the group of countries that traditionally present excessive deficits (see column 6) than in the other group (see column 7). Therefore, those fiscal constraints were very important in bringing some discipline to the public accounts of the first group of countries.[65] In addition, partisan effects and majority governments seem to be the major political causes of excessive deficits in the first group, whilst opportunistic behaviour before elections is the main political cause of excessive deficits in the second group.

Other specifications – not presented here – were also rerun excluding one country at a time. Despite the significance of *Left* and *MinGov* being sometimes slightly affected when, respectively, Greece or the UK and Ireland or Spain were excluded from the sample, the results and the main conclusions of this study remained unaffected by the exclusion of any country from the sample.

3.5. Conclusions

Several previous studies have contributed to identifying the factors that influence public deficits (and debts) in both OECD countries and EU countries over the last decades. They all consider that a set of economic, political and institutional factors play a very important role in the understanding of public deficits in industrial democracies. However, the study of the determinants of excessive deficits remains practically unexplored. For that reason, this study tries to contribute to the literature by identifying the main causes of excessive deficits in a group of EU countries.

Estimating a conditional fixed effects logit model over a group of 15 EU countries for the period 1970-2006, this study provides evidence that unfavourable

[65] Nevertheless, this result must be analysed with a grain of salt because part of this positive effect can be the result of some creative accounting. On this issue, see von Hagen and Wolff (2006).

economic conditions, parliamentary elections and political instability, and majority left-wing governments are important causes of excessive deficits in the EU countries, where a deficit is considered excessive when it exceeds 3% of GDP.

The results also indicate that the institutional constraints imposed after Maastricht over the EU countries' fiscal policy have been important in reducing the probability of excessive deficits in the EU, especially in small countries and in countries traditionally characterised by a higher propensity to excessive deficits. Moreover, empirical evidence does not indicate any significant erosion of the fiscal efforts made by the EU countries after they have been accepted in the EMU.

A more detailed analysis of the results provided by this study shows that high public debts are also linked with excessive deficits due to the increase in interest payments, although there is some tentative evidence that huge debts can encourage governments to take measures to correct excessive deficits. These excessive deficits also tend to disappear when the economy is growing at a good pace.

Political variables represent another important group of determinants of the probability of an excessive deficit. This study provides strong evidence of an opportunistic behaviour of policymakers in election years. In fact, EU governments try to influence macroeconomic outcomes before elections by running a loose fiscal policy in order to increase their probability of re-election. Consequently, this opportunistic behaviour generates a higher propensity for excessive deficits in election years. This is the main political cause of excessive deficits in the EU area, especially in countries that are not usually characterised by such fiscal disequilibria. Evidence also suggests that it takes some time for new governments to control public accounts after elections: results show that the probability of an excessive deficit is reduced significantly only two years after the elections.

This study also provides evidence that left oriented governments are the most responsible for the opportunistic behaviour before elections, especially those with a majority in parliament. However, a new result arises from our analysis: if a left government is in a minority, its propensity for excessive deficits is significantly reduced. This is the case because, given the spending reputation of left governments, the other parties will be stringent in supporting minority-left government initiatives.

In sum, this chapter shows that the inclusion of political variables is important to fully explain excessive deficits in the EU. Going a step forward relative to the existing literature and using a different econometric approach, this study provides a detailed analysis of the presence of political opportunism and partisan effects in that context. Elections and majority left-wing governments are two important causes of excessive deficits in the EU, a situation that remains well evident even after the implementation of the EU fiscal constraints. Nevertheless, the evidence provided in this study also emphasises that fiscal constraints are a necessary condition to avoid excessive deficits in a monetary union without a centralized budget.

After analysing the causes of excessive deficits it would be interesting to analyse what factors may condition their duration. Some countries are quick to stabilize their public accounts, but others live with excessive deficits for a long time. Is that because they have a particular preference for excessive deficits? Or, are they unable to take the required measures to correct them? This issue remains unexplored in the literature and represents an appealing opportunity for future research.

Finally, when more data becomes available, it might be worthwhile to extend this study to the countries that have recently joined the EU. That task may possibly bring some additional insights to the understanding of the efforts that they need to make to control their public accounts towards a future adhesion to the Eurozone.

Annex 3.1. Description of the variables and respective sources

Economic Variables:

Def3 – [dependent variable] dummy variable that takes the value of 1 when the government budget surplus (*GBS*) is lower than -3% of gross domestic product (GDP), and 0 otherwise. Source: own computation from *GBS*.

GBS – general government budget surplus as a percentage of GDP at market prices (European Commission excessive deficit procedure). Source: European Commission (2007), AMECO database.

PrimGBS – primary (excluding interest) general government budget surplus as a percentage of GDP at market prices (European Commission excessive deficit procedure). Source: European Commission (2007), AMECO database.

PrimTExp – primary (excluding interest) general government total expenditure as percentage of GDP at market prices (European Commission excessive deficit procedure). Source: European Commission (2007), AMECO database.

TRevenue – general government total revenues as percentage of GDP at market prices (European Commission excessive deficit procedure). Source: European Commission (2007), AMECO database.

Debt – general government consolidated gross public debt as a percentage of GDP at market prices (European Commission excessive deficit procedure). Source: European Commission (2007), AMECO database.

Debt_sq – square of *Debt* ($Debt^2$). Source: own computation from *Debt*.

GRGDP – annual growth of real GDP at price levels of 2000. Source: European Commission (2007), AMECO database.

UR – unemployment rate (Eurostat definition). Source: European Commission (2007), AMECO database.

RIR – real long-term interest rate (deflator: GDP). Source: European Commission (2007), AMECO database.

Political variables:

GovParty – cabinet composition or political orientation of the government. *GovParty* = 1 (hegemony of right-wing parties); 2 (dominance of right-wing parties); 3 (path between left and right); 4 (dominance of left-wing parties); 5 (hegemony of left-wing parties). There is hegemony of left (right) parties in the government when the cabinet is totally composed by left (right) wing parties; when the cabinet is not totally composed by left (right) parties but more than 66.6% are left (right) parties, then there is dominance of left (right) wing parties; finally, when the government is composed by less than 66.6% of left (right) wing parties (but more than 33.3%), then we are in presence of a centre government (path between left and right). Sources: Armingeon *et al* (2005) for the period 1970-2004 and www.electionworld.org for 2005 and 2006.

Left – dummy variable that takes the value of 1 when *GovParty* is equal to 4 or 5, and 0 otherwise. Source: own computation from *GovParty*.

%Right – percentage of right-wing parties in the cabinet. Sources: Armingeon *et al* (2005) for the period 1970-2004 and www.electionworld.org for 2005 and 2006.

ElectYear – election year is a dummy that takes the value of 1 in years of general (parliamentary) elections and 0 in non-election years. Sources: Armingeon *et al* (2005) for the period 1970-2004 and www.electionworld.org for 2005 and 2006.

PolCycle – dummy that takes the value of 1 in the first half of the political cycle of a government. Source: own computation from *ElectYear*.

YrAfterElect, *2YrAfterElect*, *3YrAfterElect* – dummy variables that take the value of 1, respectively, in the year, two years and three years after elections, and 0 otherwise. Source: own computation from *ElectYear*.

NGovChg – number of changes in government per year due to elections, resignation of the Prime-Minister, dissension within government, lack of parliamentary support, or intervention by the head of state. Sources: Armingeon *et al* (2005) for the period 1970-2004 and www.electionworld.org for 2005 and 2006.

GovType – type of government in office. *GovType* = 1 (majority single-party government); 2 (minimal winning coalition); 3 (surplus coalition); 4 (single-party minority government); 5 (multi-party minority government); 6 (caretaker government). Sources: Armingeon *et al* (2005) for the period 1970-2004 and www.electionworld.org for 2005 and 2006.

MajSPGov – dummy variable that takes the value of 1 when the government is formed by a single-party with majority in the parliament (*GovType=1*), and 0 otherwise. Source: own computation from *GovType*.

CoalGov – dummy variable that takes the value of 1 when the government is formed by a coalition with majority in the parliament (*GovType* equal to 2 or 3), and 0 otherwise. Source: own computation from *GovType*.

MinGov – dummy variable that takes the value of 1 when a minority government is in office, i.e. when *GovType* is equal to 4, 5 or 6, and 0 if the (single-party or coalition) government has majority in the parliament. Source: own computation from *GovType*.

NPartyGov – number of parties in the government. Sources: Woldendorp *et al.* (1998) for the period 1970-1995; *The European Journal of Political Research* (several annual issues of political data: 1997-2006 – compiled by Richard Katz, Ruud Koole and Ingrid van Biezen) for the period 1996-2005; The values for Greece, Portugal and Spain over the period 1973-1995 were collected from *The Europa World Yearbook* (1996) and *The Statesman's Yearbook* (several issues from 1974 to 1997); and data for 2006 were obtained from www.electionworld.org.

Control variables for the EU fiscal constraints:

D92 – dummy variable that takes the value of 1 in the period 1992-2006, and 0 in the period 1970-1991.

D99 – dummy variable that takes the value of 1 in the period 1999-2006, and 0 in the period 1970-1998.

D9298 – dummy variable that takes the value of 1 in the period 1992-1998, and 0 over 1970-1991 and 1999-2006.

D9298t – time trend for the period 1992-1998; 0 otherwise.

D99t – time trend for the period 1999-2006; 0 otherwise.

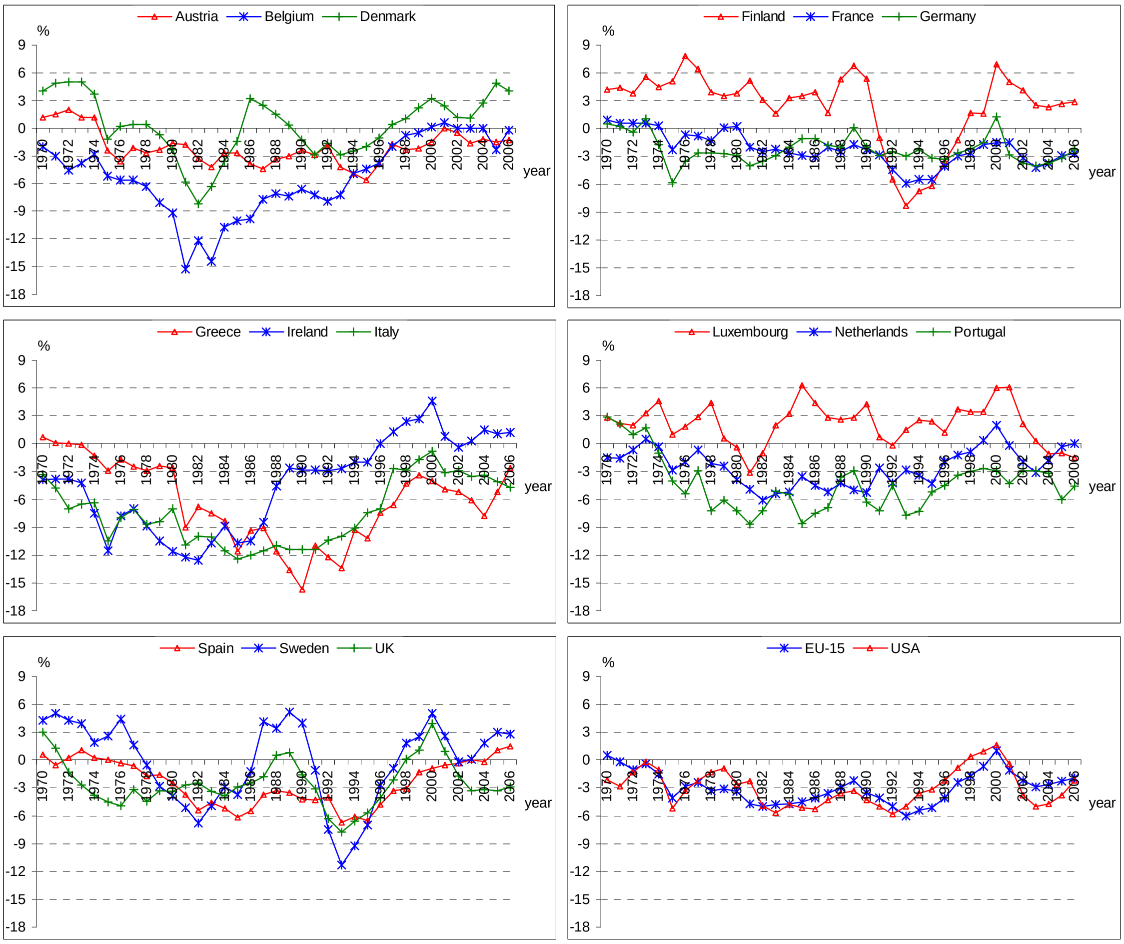
Annex 3.2. Descriptive statistics and the evolution of public deficits in the EU countries

Table A.3.2.1. Descriptive statistics of the variables used in the estimations

Variable	No. Obs.	Mean	Std. Dev.	Minimum	Maximum
Def3	555	0.4036	0.4911	0	1
GBS	555	-2.4665	4.2140	-15.700	7.800
PrimGBS	555	1.4092	3.1846	-7.400	11.600
PrimTExp	555	41.9796	7.8219	18.400	66.700
TRevenue	555	43.4760	8.7091	21.300	62.800
Debt	539	51.9280	29.6923	4.100	133.400
Debt_sq	539	3576.5970	3769.5150	16.810	17795.560
GRGDP	555	2.9179	2.4555	-6.557	12.464
UR	555	6.5052	3.7998	0.5	19.500
RIR	548	2.6922	3.4641	-10.900	11.200
Left	539	0.2783	0.4486	0	1
%Right	539	30.9659	34.9878	0	100
ElectYear	539	0.2876	0.4530	0	1
PolCycle	539	0.4341	0.4961	0	1
YrAfterElect	539	0.2839	0.4513	0	1
2YrAfterElect	539	0.2672	0.4429	0	1
3YrAfterElect	539	0.2319	0.4224	0	1
RSIndex	539	2.5269	1.0686	1	4
GovType	539	2.5269	1.2303	1	6
MajSPGov	539	0.2115	0.4088	0	1
CoalGov	539	0.5584	0.4970	0	1
MinGov	539	0.2301	0.4213	0	1
NPartyGov	539	2.2839	1.3820	1	8
D92	555	0.4000	0.4903	0	1
D99	555	0.2162	0.4120	0	1
D9298	555	0.1838	0.3877	0	1
D9298t	555	0.7568	1.7936	0	7
D99t	555	0.9730	2.1389	0	8

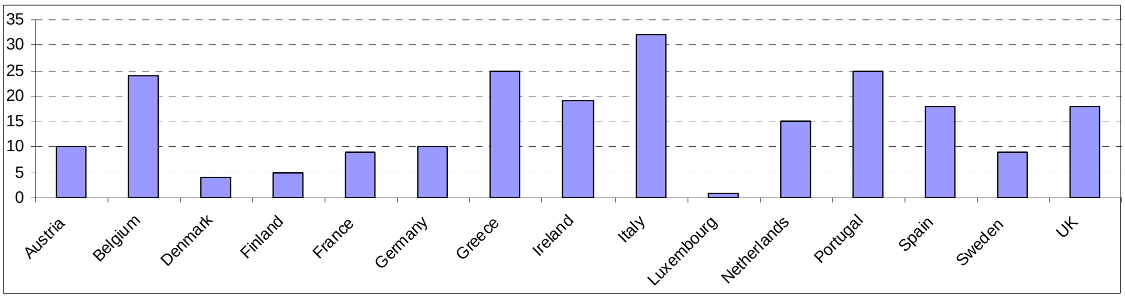
Sources: See Annex A.3.1.

Figure A.3.2.1. Evolution of the government budget surplus (GBS) in the EU countries, EU-area and the United States over the period 1970-2006



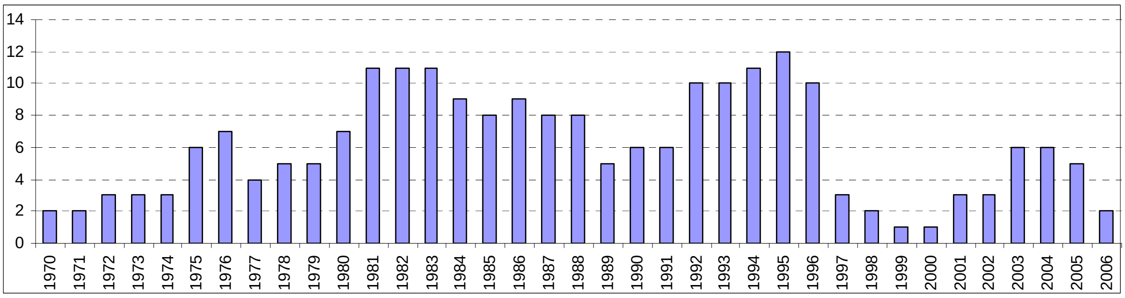
Source: European Commission (2007), AMECO database.

Figure A.3.2.2. Number of times each EU country was in excessive deficit over the period 1970-2006



Source: European Commission (2007), AMECO database.

Figure A.3.2.3. Number of EU countries in excessive deficit by year: 1970-2006



Source: European Commission (2007), AMECO database.

4. The duration of economic expansions and recessions: More than duration dependence

4.1. Introduction

The notion that the economy evolves through periods of expansions and recessions has its foundations in the works of Fisher (1925) and Burns and Mitchell (1946). Expansions, contractions and their turning points were the central focus of their studies: they were the first to analyse the mechanisms by which output alternates between states of expansion and recession, and to study the effect of duration on transition probabilities between those states. The issue of whether business cycles are duration dependent – i.e. whether the likelihood of an expansion or recession ending is dependent on its age – has gained special interest in the last two decades, due to an increase in the average duration of expansions and a decrease in the duration of recessions after World War II (WWII).

One widespread idea in the literature is that the older an expansion or a recession is, the more likely it is to end. This is known as positive duration dependence. Several papers using different methods – like parametric and non-parametric duration models and Markov-switching models – have tried to provide empirical support for this idea. Most have been successful in finding some evidence of positive duration dependence for expansions and recessions. However, little attention has been given to the potential effects of other factors. Even if duration dependence is present, other underlying mechanisms can affect the likelihood of an expansion or recession ending. Making an analogy with human beings (or the natural world in general), it is known that they have a higher propensity to die as they become older (i.e. there is positive duration dependence), but we also know that other factors may affect the likelihood of a person dying or her “duration”, like smoking, diseases, stress, food, pollution, health care, etc. In that sense, this study intends to shed more light on the analysis of the duration of business cycle phases by looking at other factors that can affect the likelihood of an expansion or recession ending, beyond its own length.

Some recent studies using Markov-switching approaches have found that leading or coincident indices can be very useful in predicting the end of an expansion or contraction.[66] Like most studies in this field, they have focused almost exclusively on the US business cycle. This study extends that analysis to a panel of industrial countries, controlling not only for the effect of a composite leading indicator – constructed by the OECD – but also for the effects of some of its components and other potential explanatory factors. Two important components of this indicator will be considered: the spread between long-term and short-term interest rates and the stock market price index. A higher spread reflects the expectation of a future improvement in economic performance, while stock prices are seen as a good indicator of the future profitability of firms. As both contain information (or expectations) about the future behaviour of the economy, they are potential determinants of the duration of the business cycle phases.

Other factors, not considered in the composite leading indicator, will be taken into account as well. For example, the idea raised by Zellner (1990) that the length of the previous phase can have a significant impact on the duration of the next phase will be tested. Another issue to analyse is the economic performance of the European

[66] See Filardo (1994), Filardo and Gordon (1998), Kim and Nelson (1998), Di Venuto and Layton (2005) and Layton and Smith (2007).

Union (EU) countries after fiscal rules were imposed in Europe. Buti *et al.* (1997) and Metz (2005) argue that those rules may have lengthened recessions in the EU because countries are not allowed to run sufficiently large deficits to stimulate the economy. This study will try to test whether this idea has any empirical support.

Additional variables, coming from different strands of the economic literature, are also considered in this study. The economic growth literature considers investment as an important determinant of economic growth. Both private investment and government investment have a positive effect on GDP growth. Therefore, we expect that these variables can help to explain the duration of business cycle phases as well. The price of oil is another factor to be considered. Hamilton (1983, 2005) shows that most of the US recessions after WWII were preceded by increases in its price. This suggests that the duration of expansions can be affected by oil price shocks. Thus, another aim of this chapter is to verify whether that conjecture is confirmed by the data or not. External influences are also controlled for in this study, in particular the spillover effects of the US business cycle on the other economies. This study also analyses whether political conditionings may affect the duration of the business cycle phases. The last issue considered in this chapter is whether the great moderation in output volatility registered in the last two to three decades has affected the duration of expansions and contractions.

Duration models will be used in the analysis of the determinants of the duration of expansions and contractions. To our knowledge, this is the first time that these models have been used to test simultaneously for duration dependence and for the effect of the factors mentioned above on the likelihood of an expansion or contraction ending. This kind of model has already been used to test essentially for duration dependence in the US business cycle phases. This has been the case because their turning-point dates have been well documented by the National Bureau of Economic Research (NBER) for a long time. As the Economic Cycle Research Institute (ECRI) has recently built similar chronologies for other countries, a new branch of research is open for exploration using duration analysis instead of stochastic Markov-switching processes. The main aim of this chapter is to explore that data applying, for the first time, discrete-time duration methods to analyse the issue of duration dependence for expansions and contractions.

Using a duration analysis this study intends to find empirical answers to the following questions: (a) Is positive duration dependence really present in expansions and/or contractions in industrial countries? (b) Are there other factors that can affect the likelihood of an expansion or contraction ending? (c) What are those factors?

Unveiling a little the results of this study, we can say that evidence of positive duration dependence is found for both expansions and contractions in a group of industrial countries. The duration of expansions in those countries is linked to the behaviour of the variables in the OECD composite leading indicator and it is also affected by private investment, the price of oil and peaks in the US economy. The duration of contractions is essentially explained by the duration of the previous phase. Regarding the recent behaviour of the EU business cycle, our evidence does not support the idea that fiscal rules may have lengthened recessions in the EU countries. The political factors did not prove to be important in explaining the duration of the business cycle phases. Finally, the evidence and magnitude of the duration dependence are not significantly affected during the period of great moderation in output volatility, except in the US.

The remainder of this chapter is organized as follows. Section 4.2 provides a review of the literature on business cycle duration dependence. The data and main hypotheses to test are presented in Section 4.3, as well as the econometric model and the empirical results. Finally, Section 4.4 concludes emphasizing the main findings and offering some suggestions for future research.

4.2. Literature on the duration of business cycles

The literature on the duration of business cycles has largely focused on finding an answer to the question: "Are periods of expansion or contraction in economic activity more likely to end as they become older? More technically, do business cycles exhibit positive duration dependence?" (Sichel, 1991, p. 254).[67] Several authors have tried to answer this question using either (parametric and non-parametric) duration models or Markov-switching models. Traditionally, far more interest has been given to the United States business cycle because their turning dates are well documented by the NBER. Nevertheless, other industrial countries – like, for example, France, Germany and the United Kingdom – have also been under the scope of some of those studies.

Non-parametric procedures to test for business cycle duration dependence have not been very successful in finding evidence of duration dependence for economic expansions and contractions.[68] On the other hand, parametric duration models have proved to be more reliable in detecting its presence. According to Sichel (1991), one important advantage of the parametric approach is the fact that parametric techniques have higher power for detecting duration dependence than non-parametric methods. In fact, the small size of the samples for business cycles

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[67] This question is not entirely new. Fisher (1925) had already raised the issue of whether the probability of exiting any phase of the cycle is constant.

[68] See, for example, Diebold and Rudebusch (1990), Diebold *et al.* (1990), Mudambi and Taylor (1995), Mills (2001) and Ohn *et al.* (2004), among others.

may impair the power of the non-parametric tests, making it difficult to detect duration dependence when it exists. Parametric techniques also make it possible to compute estimates of the magnitude of the duration dependence. Another advantage is that they permit testing for additional hypotheses by extending the basic model.

Using a continuous-time Weibull duration model and the NBER monthly chronology for the United States from 1854 to 1990, Sichel (1991) finds significant evidence of positive duration dependence for pre-WWII expansions and post-WWII contractions, but not for the other phases. Diebold *et al.* (1990) also use a Weibull model to test for duration dependence in France, Germany and United Kingdom in the pre-WWII period and reach the same conclusion as Sichel (1991) for that period.

Some authors attempt to apply more flexible continuous-time parametric methods to test for duration dependence. For example, Diebold *et al.* (1993) employ an exponential-quadratic hazard model to business cycle data and essentially reproduce the results obtained by Sichel's (1991). Using a generalized Weibull model, that nests the simple Weibull model, Zuehlke (2003) finds some additional evidence of duration dependence in pre-WWII US contractions, but his model does not improve significantly upon Sichel's (1991) Weibull model in the other cases.

Abderrezak (1998) also uses parametric hazard models to analyse the issue of duration dependence in eleven industrial countries. Instead of considering classical business cycles, this author uses growth cycles.[69] Results from individual-country

[69] For a long period of time after WWII it was difficult to identify contractions in some European countries, so some economists in the 1960s thought that the classical business cycles might be coming to an end. Thus, they started to pay more attention to the increases and decreases in growth rates: so-called growth cycles. The contractions in the 1970s and in the following decades proved that classical business cycles are not dead and that they deserve to be deeply analysed for policy purposes. Even so, some economists are still using growth cycles as an alternative way of studying business cycles.

and pooled regressions show evidence of positive duration dependence in both the whole growth cycles and growth phases (upswings and downswings).

Another strand of the literature has modelled the business cycle as the outcome of a Markov process that switches between two discrete states: expansions and recessions. Contrary to the approaches described above, this method regards the business cycle as an unobserved stochastic process, so that the reference cycle turning-point dates identified by the NBER or the ECRI are not necessary. Hamilton (1989) was the pioneer of this kind of analysis. His model assumes that the likelihood of a country switching from an expansion to a recession (or vice-versa) is not affected by its own duration. However, some later studies relaxed this assumption allowing for state transition probabilities to be duration dependent. Durland and McCurdy (1994) were the first to apply such a refinement using real GNP growth rate series for the US. They provide evidence of duration dependence for recessions but not for expansions after WWII. A similar result is obtained by Kim and Nelson (1998) applying a Bayesian approach to a dynamic factor model and using a new coincident index for the US economy.[70] Lam (2004) extends Durland and McCurdy's (1994) model allowing for: (i) duration dependence not only in transition probabilities but also in mean growth rates; and (ii) heteroscedasticity in the noise component. The main conclusion of this study is that the probability of an expansion ending decreases gradually as the expansion ages, while the probability of contractions ending increases rapidly as the contraction ages.[71]

[70] Also using a Bayesian approach, Iiboshi (2007) finds evidence of positive duration dependence for Japanese expansions and contractions.

[71] Other authors use Markov-switching models to analyse the business cycle but without controlling for duration dependence. For example, Filardo (1994) and Filardo and Gordon (1998) specify time-varying transition probabilities only as a function of an exogenous variable: a leading of index indicators.

Recently, other econometric models have been applied to the study of business cycle dynamics. Di Venuto and Layton (2005) and Layton and Smith (2007) develop a multinomial regime switching logit model to examine the issue of duration dependence in Australian and US business cycles, respectively. As this regime-switching framework models the transition probabilities assuming the ex-post observability of business cycle phases, ECRI and NBER chronologies of the business cycle are used in this analysis. Besides controlling for duration dependence, the model also incorporates movements in some leading indices as explanatory variables. Their findings provide evidence of positive duration dependence for both expansions and contractions and their indicators also show some power in predicting the termination of either phase.

Other papers – not directly concerned with the duration dependency issue – have tried to evaluate the predictive power of binomial models (probits and logits) and some economic indicators in forecasting business cycles. Dueker (1997), Estrella and Mishkin (1998), Chauvet and Potter (2005) and Moneta (2005) use probit models to quantify the predictive power of some financial indicators such as interest rate spreads and stock prices. They show that in some cases these variables can perform better than leading indicators in predicting economic recessions in the US and in the Euro-area.[72] Nevertheless, none of these works undertake a duration analysis; they simply test the effect of those variables on the probability of a recession in order to analyse their (out-of-sample) predictive power. Contrary to these studies, the aim of this study is not to analyse or to predict the timing of recessions but the factors that affect the duration of expansions and recessions. In that sense, this study tests simultaneously for the presence of duration dependence

[72] Also using binomial models and some financial and leading indicators, Sensier *et al.* (2004) find evidence of international influences on the prediction of recessions in some EU countries.

and for the effect of some economic and political variables on the likelihood of an expansion or contraction ending.

As explained above, the studies that implement duration models in the analysis of business cycles only test for duration dependence. Hence, the inclusion of other exogenous variables in that framework represents an extension relative to the previous studies. As some of those variables are time-varying and available only on a periodic basis, we decided to use – for the first time in this kind of analysis – a discrete-time duration model instead of a continuous-time model. Finally, as the ECRI provides business cycle turning-points for a group of market-oriented economies we can now, not only employ duration models instead of Markov-switching models, but also enlarge the study to a panel of industrial countries instead of focusing the analysis exclusively on the US business cycle.

4.3. Empirical analysis

This section provides an empirical analysis of the causes of the end of expansions and contractions. We start by describing the data and the hypotheses to test. The econometric model is presented next. This section concludes with an analysis of the results.

4.3.1. Data and hypotheses to test

The data used in duration analysis consist of spells. In this study, a spell represents the number of periods during which a country is in either an expansion or a contraction. An expansionary spell ends when a business cycle peak is reached whilst a trough in the business cycle indicates the end of a contraction. Therefore, to identify the sequence of these spells over time for a particular country we need to find the peaks and troughs in economic activity. There are several ways of identifying those turning points, like the – already mentioned – NBER and ECRI approaches and Markov-switching models or even the Bry and Boschan (1971) algorithm and GDP growth rules.

In this study, we use the monthly business cycle phase chronology elaborated by the NBER Business Cycle Dating Committee for the US economy and a similar chronology elaborated recently by the ECRI for 20 market-oriented economies for the period 1948-2006.[73] From those 20 countries, we selected for this analysis all the EU countries for which this institute reports data on the business cycle turning points: Austria, France, Germany, Italy, Spain, Sweden and the United Kingdom. Additionally, we also collected data for the other OECD countries (but non-EU members) for which the ECRI reports data: Australia, Canada, Japan, New Zealand, Switzerland and the US. Therefore, this study will analyse a sample of 13 industrial countries.

The ECRI uses the same methodology as the NBER to establish the business cycle dates for these countries. These chronologies represent a set of reference dates – peaks or ends of expansions and troughs or end of contractions – which is agreed upon by a group of experts at either the NBER or the ECRI and based on a system of monthly indicators measuring economic performance. The most important are: real

[73] NBER chronology has been widely used in the literature to examine duration dependence for United States expansions and recessions. On the contrary, due to its recent conception, ECRI chronology provides a new field of data to explore.

personal income, employment, industrial production, sales and monthly estimates of real GDP.[74]

This study considers that a chronology determined by a committee of experts, using a large range of macroeconomic indicators and employing a consistent methodology, is likely to be superior to a method that regards the business cycle as an unobserved stochastic process and that uses a single cycle variable such as GDP, GNP or industrial production to infer the state of the business cycle at a particular moment in time – as is the case when Markov-switching models are used. In the words of Di Venuto and Layton (2005, p. 292), "adopting a single measure of the business cycle fails to capture the many activities that constitute the complex phenomena that is the business cycle."[75] Moreover, using a Markov-switching model over a unique series is more like studying growth cycles than classical business cycles. Thus, the results from a Markov-switching model seem to be better suited to forecast output growth rates than to detect effective business cycles or to evaluate the causes of an expansion or contraction ending. Finally, authors employing Markov-switching models measure the ability and quality of their approach in predicting business cycles turning points (and duration dependence) by comparing their results with the NBER chronology. Since they make such comparisons, they are giving

[74] For more details on the methodologies and chronologies see http://www.nber.org/cycles/main.html and http://www.businesscycle.com/resources/cycles/. The business cycle chronologies for the countries considered in this analysis are presented in Annex (see Table A.4.1.1), which also reports a complete description of the business cycle variables that can be extracted from those chronologies (see Table A.4.1.2).

[75] As already mentioned, besides Markov-switching models, other methodologies could be used to identify the business cycle chronology, such as the rule that considers a recession when the growth of real GDP is negative for two consecutive quarters or more, or the chronology resulting from the application of Bry and Boschan (1971) algorithm to this series. But, these methodologies also rely exclusively on the analysis of a single economic indicator, which may not be enough to provide all the necessary information to capture an effective economic cycle or the real swings in economic activity.

credibility to the work of the NBER Committee. Hence, this study assumes that the dates provided by the NBER for the US and by the ECRI – employing the same methodology as the NBER for other countries – are very reliable.

Given those reasons, we opt for studying the duration of business cycle phases using NBER and ECRI chronologies. In fact, the aim of this study is not to fit a model for predicting turning points but to find real causes for the duration of an expansion or a contraction. Thus, beyond testing just for duration dependence, this study also tests for the impact of other factors on the likelihood of an expansion and contraction ending.

A complete description of the variables used in this study and their respective sources is provided in Annex (see Table A.4.1.2). Due to the unavailability or weak quality of monthly data for some exogenous variables, quarterly data were collected for the 13 countries indicated above covering the period from the first quarter of 1965 to the fourth quarter of 2006. The dependent variables (*Peak* – for the analysis of the duration of expansions – and *Trough* – for the analysis of duration of contractions) take the value of 1 in the quarter that includes the month for which the ECRI has identified a turning point (peak or trough), and 0 otherwise.[76] The variable that measures the duration (*Dur*) of any of the spells (expansions or contractions) is also measured in quarters and plays an important role in detecting the presence of duration dependence. According to the literature, we expect to find empirical evidence of positive duration dependence for both expansions and contractions.

However, not only evidence of positive duration dependence is expected. Some economic indicators are believed to lead economic activity and hence provide a good indication of the future phases of the business cycle. Composite indices that

[76] Note that a peak corresponds to the final quarter of expansion and a trough corresponds to the final quarter of contraction.

incorporate information from a number of different leading indicators and variables have been recently used in some studies to predict phase changes in the business cycle. Some examples are the studies by Filardo (1994), Filardo and Gordon (1998) and Kim and Nelson (1998) for the US using a Markov-switching model and the studies by Di Venuto and Layton (2005) and Layton and Smith (2007) for Australia and the US using a multinomial regime-switching model. They find that leading indicators are important in explaining the transition probabilities between expansions and contractions and that those indicators tend to improve the quality and predictive power of the model. Thus, the first economic variable to be included in our model is a leading indicator, or more precisely a composite leading indicator. As this variable contains information on the expected future behaviour of the economy, we can regard this as the component v_t in our analytical framework. Therefore, we expect that an improvement in this indicator affects negatively (positively) the likelihood of an expansion (contraction) ending. The annualized 6-month rate of change in the composite leading indicator (*CLI*) provided by the OECD Main Economic Indicators is used in this study to capture the effects of a composite of economic variables on the likelihood of a phase change.[77]

[77] Some of the series used by the OECD to compute the composite leading indicator for the majority of countries are: the spread of interest rates, share prices, consumer and business confidence indicators, order books, stocks and labour market indicators. The component series for each country are selected based on the following criteria: economic significance, cyclical behaviour, data quality, timeliness and availability. For further details on the components of this composite indicator for each country and on the methodology used to compute it check the OECD at www.oecd.org/std/cli. We use the annualized 6-month rate of this indicator because, according to the OECD, it is less volatile and tends to provide earlier and clearer signals for future economic performance than the composite leading indicator itself.

Regarding the good performance presented by two of its components – interest rate spreads and stock prices – in predicting economic recessions,[78] we also analyse their effects on the duration of expansions and contractions. The interest rate spread reflects expectations about the economic impact of movements in interest rates, whilst stock price indices reflect the expected discounted values of future dividend payments. To collect their effects, we use the interest rate spread between long-term interest rate on government bonds and short-term interest rates (*Spread*) and the quarterly growth rate of the stock price index (*Stock*). We expect them to be positively (negatively) correlated with the duration of an expansion (contraction).

Other factors, not considered in the composite leading indicator, will be also taken into account. The next hypothesis to test is whether the duration of the previous business cycle phase (*DurPrev*) affects the length of the current phase. This issue was already raised and analysed by Zellner (1990), Sichel (1991) and Abderrezak (1998). Zellner (1990) theorizes that the solid fundamentals resulting from longer expansions may affect the duration of the following contraction. The evidence provided by this author shows that shorter contractions tend to follow longer expansions in the pre-WWII business cycle data for the US. However, neither Sichel (1991) nor Abderrezak (1998) were able to find any significant evidence for this link. Given this mixed evidence, we hope to provide further evidence on this issue.

The economic growth literature shows that private investment, in particular, has a significant positive effect on economic growth. This is the case because investment is affected by 'animal spirits', i.e. if economic agents expect economic activity to slow, investment may indeed slowdown fulfilling that expectation. Regarding this evidence, we expect that when private investment is boosted,

[78] See Dueker (1997), Estrella and Mishkin (1998), Chauvet and Potter (2005) and Moneta (2005).

expansions tend to last longer and recessions tend to be shorter. To investigate this effect we use the growth rate of real private total fixed capital formation (*GPInv*).

Traditionally, Keynesian economists consider that government expenditures are important to stimulate the economy. However, recent studies on economic growth have shown that not all components of government expenditures have that positive effect. In Chapter 2 we show that while public investment is able to stimulate economic activity, unproductive public expenditures like current government consumption are negatively related to output growth (see also Kneller *et al.*, 1999 and Bassanini and Scarpetta, 2001). Hence, we conjecture that the higher public investment is relative to public consumption, the lower (higher) will be the probability of an expansion (contraction) ending. The ratio between government fixed capital formation and government final consumption expenditure (*GovI/C*) is used in this study to account for that effect.[79]

On the supply side, the price of oil is another variable to be taken into account. Hamilton (1983, 2005) shows that most of the US recessions after WWII were preceded by increases in its price and Barsky and Kilian (2004) provide some reasons for a negative relation between the price of oil and output growth. The RBC literature also recognizes that energy price increases have a negative impact on economic activity (Rotemberg and Woodford, 1996 and Finn, 2000). Regarding the arguments advanced by these studies, we expect that the likelihood of an expansion ending may increase with an increase in the price of oil. The oil import price deflated

[79] The ratio of government investment to GDP could instead be used, but the fact that this variable is divided by a variable that reflects greatly the business cycle itself could bias the results. Another alternative would be to divide it by total expenditure, but the lack of quarterly data for that series for some of the countries impeded us from proceeding in that way.

to real values by the GDP deflators of each country (*OilPr*) is used in this study to test for this conjecture.[80]

Sensier *et al.* (2004) have shown that international influences can affect the predictions of recessions in some EU countries. To control for those potential influences, we add to our equation a variable (or proxy for the international business cycle) that takes the value of 1 when the US economy reaches a peak (*PeakUS*) – in the case of expansions – or a trough (*TroughUS*) – in the case of contractions.

Another different issue to analyse is whether there is any relation between the political conditionings and the business cycle. According to the political business cycles literature (see Alesina *et al.*, 1997), policymakers tend to stimulate the economy before elections as a way of affecting the electoral outcome. This literature also emphasizes the idea that left-wing governments are more concerned in promoting economic growth than right-wing parties. In a study for the US economy, Klein (1996) analyses whether these political factors can also be useful in explaining the occurrence of a business cycle turning point. His analysis provides some evidence of political opportunism and ideological effects. To control for those effects, we add the following variables to our equation: a political cycle indicator (*PolCycle*), which measures the proportion of the government term in office that elapses at each quarter; and a dummy variable that takes the value of 1 when a left-wing government is in office during the last year (*GovLeft*). Our expectation is that the probability of an expansion (contraction) ending decreases (increases) as an election is approaching or when a left-wing party is in office.

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[80] The base year is 2000. The oil price was first converted to each national currency using period average nominal exchange rates with the US dollar and then divided by the respective GDP deflators. To make these values comparable between countries, the real oil price is converted again to US dollars at the average exchange rate of 2000. This is equivalent to divide the oil price by the GDP deflator in dollars.

To complete the group of hypotheses to test, this study checks whether the fiscal rules imposed by the Maastricht and Stability and Growth Pact (SGP) have affected the economic performance of the European Union (EU) countries. Buti *et al.* (1997) and Metz (2005) argue that there is a risk that those rules generate longer recessions in the EU because those countries are not allowed to run sufficiently large deficits to stimulate the economy. A simple way of controlling for the effects of those rules on the duration of expansions and contractions in the EU is by including a dummy variable that takes value 1 in the Maastricht and/or SGP periods for the group of EU countries.

4.3.2. Duration models

Duration analysis has been widely used in labour economics to study the duration of periods of unemployment.[81] Due to its properties, this kind of analysis is also suitable for studying the duration of expansions and contractions.[82]

The duration variable is defined as the number of periods – quarters in this study – that a country is in a state of expansion or contraction, depending on which phase is being analysed. If we define T as the discrete random variable that measures the time span between the beginning of an expansion (contraction) and its transition to the other state, the series of data at our disposal (t_1, t_2,…, t_n) will represent the observed durations of each episode of expansion (contraction). The probability distribution of the duration variable T can be specified by the cumulative distribution function: $F(t)=\Pr(T<t)$, which measures the probability of the random variable T being smaller than a certain value t. The corresponding density function is then:

[81] See Allison (1982) and Kiefer (1988) for a review of the literature on duration analysis. The description of the duration models used in this study follows the works of those authors.

[82] For more details, see Section 4.2.

$f(t)=dF(t)/dt$. An alternative function to specify the distribution of T is the survivor function, which is obtained as: $S(t)=\Pr(T\geq t)=1-F(t)$. This function gives the probability that the duration of an expansion (contraction) is greater than or equal to t. A particularly useful function for duration analysis is the hazard function, $h(t)=f(t)/S(t)$, which measures the rate at which expansion (contraction) spells will be completed at duration t, given that they last until that moment. Or in other words, it measures the probability of exiting from a state in moment t conditional on the length of time in that state. From the hazard function we can derive the integrated hazard function, $H(t)=\int_0^t h(u)du$, and then compute the survivor function as follows: $S(t)=e^{-H(t)}$.

The hazard function is very useful to characterize the dependence path of duration. If $dh(t)/dt>0$ when $t=t^*$, then there is positive duration dependence in t^*. This means that the probability of an expansion (contraction) ending in moment t, given that it has reached t, increases with its age. Thus, the longer the expansion (contraction) is, the higher will be the conditional probability of it ending or reaching a peak (trough). An opposite conclusion is reached if the derivative is negative. There will be no duration dependence if the derivative is equal to zero.

The hazard function can be estimated by parametric and non-parametric methods. However, the non-parametric analysis is very limited because: on the one hand, it is not able to provide estimates of the magnitude of the duration dependence when it really exists; and, on the other hand, it does not take into account other variables that can influence the duration of an expansion or recession. In order to avoid this problem, parametric models are proposed to measure the degree of duration dependence and the impact of other variables on the likelihood of an expansion or recession ending.

Some parametric continuous-time duration models have been employed in previous studies on this issue.[83] The functional form that has been used to characterize and parameterize the hazard function is the so-called proportional hazards model:[84]

$$h(t,\mathbf{x}) = h_0(t)e^{\boldsymbol{\beta}'\mathbf{x}}, \qquad \textbf{(4.1)}$$

where $h_0(t)$ is the baseline hazard function that captures the dependency of the data to duration, $\boldsymbol{\beta}$ is a $K\times 1$ vector of parameters to be estimated and $\mathbf{x}$ is a vector of covariates. The baseline hazard also represents an unknown parameter to be estimated. This model can be estimated without imposing any specific functional form to the baseline hazard function, which results in the so-called Cox Model. However, this procedure is not adequate when we study duration dependence. An alternative estimation imposes one specific parametric form for the function $h_0(t)$. The most popular model in the study of the duration of expansions and recessions is the Weibull model, where $h_0(t)=\gamma p t^{p-1}$, with $\gamma>0$ and $p>0$. In this hazard function, γ is essentially a constant term and p parameterizes duration dependence. If $p>1$, the conditional probability of a turning point occurring increases as the phase gets older, i.e. there is positive duration dependence; if $p<1$ there is negative duration dependence; finally, there is no duration dependence if $p=1$. In this last case, the Weibull model is equal to an Exponential model. Therefore, by estimating p, we can test for duration dependence in expansions or contractions. This model can be

[83] See Sichel (1991), Diebold *et al.* (1990), Diebold *et al.* (1993), Abderrezak (1998) and Zuehlke (2003).

[84] This means that the ratio of the hazard rates for any two observations is constant over time.

estimated by Maximum Likelihood and the corresponding log-likelihood function for a sample of $i=1,\ldots,n$ spells (expansions or contractions) can be written as follows:[85]

$$\ln L = \sum_{i=1}^{n}\left[c_i \ln h(t_i, \mathbf{x}_i) + \ln S(t_i, \mathbf{x}_i)\right], \tag{4.2}$$

where c_i indicates when observations are censored. They are censored (c_i=0) if the sample period under analysis ends before we observe the turning point; when the turning points are observed in the sample period they are not censored (c_i=1).

This is the kind of continuous-time duration model that is usually employed in the parametric analysis of duration dependence for expansions and recessions. Nevertheless, these may not be the most adequate models to use in this context. Although the life of an expansion or recession is a continuous-time process, available data are inherently discrete (months or quarters). Allison (1982, p.70) states that when those "discrete units are very small, relative to the rate of event occurrence, it is usually acceptable to ignore the discreteness and treat time as if it was measured continuously. [However,] when the time units are very large – months, quarters, years, or decades – this treatment becomes problematic."[86] Therefore, discrete-time methods are more adequate for the analysis of the duration of expansions and contractions because the available data are always grouped in large discrete-time intervals.[87] Finally, discrete-time duration models have also the advantage of making very easy the inclusion of time-varying covariates in their framework to test for additional hypotheses. For those reasons, this study employs, for the first time,

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[85] See Allison (1982) and Kiefer (1988) for details.

[86] Allison (1982, p. 70).

[87] In their non-parametric analysis for duration dependence, Mudambi and Taylor (1995) and Ohn *et al.* (2004) have already emphasized their preference for a discrete-time approach because the turning points for economic cycles are usually collected and reported at discrete-time intervals.

parametric discrete-time duration models in the study of duration of expansions and contractions for some industrial countries.

To implement discrete-time methods, we can start with a continuous-time model – the proportional hazards model is a sensible choice – and then derive appropriate estimators for data grouped in intervals. A discrete-time (grouped data) version of the proportional hazards model was developed by Prentice and Gloeckler (1978).[88] First, it is assumed that time can only take integer values (t=1, 2, 3,…) and that we observe n independent expansions or contractions (i=1, 2,…,n) beginning at a starting point t=1. The observation continues until time t_i, at which point either an event occurs or the observation is censored. Censoring means that the event is observed at t_i but not at t_i+1. A vector of explanatory variables $\mathbf{x}_{it}$ is also observed and can take different values at different moments in time. The discrete-time hazard rate can then be defined as follows:

$$P_{it} = \Pr\left[T_i = t \mid T_i \geq t, \mathbf{x}_{it}\right], \qquad \textbf{(4.3)}$$

where T is the discrete random variable representing the uncensored time at which the end of an expansion (contraction) occurs. This measures the conditional probability of expansion (contraction) i ending at time t, given that it has not ended yet. Assuming that the data are really generated by the continuous-time proportional hazard model **(4.1)**, Prentice and Gloeckler (1978) show that the corresponding discrete-time proportional hazard function can be given by:

$$P_{it} = 1 - e^{-h_t e^{\boldsymbol{\beta}'\mathbf{x}_{it}}} = 1 - e^{-e^{\theta_t + \boldsymbol{\beta}'\mathbf{x}_{it}}} \Leftrightarrow \ln\left[-\ln(1 - P_{it})\right] = \theta_t + \boldsymbol{\beta}'\mathbf{x}_{it}\,, \qquad \textbf{(4.4)}$$

[88] These models are analysed in detail by Prentice and Gloeckler (1978), Allison (1982), Kiefer (1988) and Jenkins (1995), upon which this part is based.

which is equivalent to the so-called complementary log-log (or cloglog) function, where θ_t (=lnh_t) represents the logarithm of an unspecified (baseline hazard) function of time and the coefficient vector (**β**) is identical to the one in the continuous-time proportional hazards model **(4.1)**. This means that the estimated discrete-time coefficients based on **(4.4)** are also the estimates of the underlying continuous-time model and the coefficient vector is invariant to the length of the time intervals.

The last thing to do before proceeding to the estimation of the model is to specify θ_t. There are several alternative specifications but, given the purpose of this study and to facilitate comparisons with the previous studies, we will consider the discrete-time analogue to the Weibull model for the hazard function (h_t), which yields: $\theta_t = \ln h_t = \alpha + q \ln t$, where q, in this discrete-time case, corresponds (approximately) to p-1 in the continuous-time Weibull model.[89]

Prentice and Gloeckler (1978) and Allison (1982) show that discrete-time log-likelihood function for a sample of i=1,…,n spells can be written as follows:

$$\ln L = \sum_{i=1}^{n}\sum_{j=1}^{t_i} y_{it} \ln\left(\frac{P_{ij}}{1-P_{ij}}\right) + \sum_{i=1}^{n}\sum_{j=1}^{t_i} \ln\left(1-P_{ij}\right), \qquad \textbf{(4.5)}$$

where the dummy variable y_{it} is equal to 1 if spell i (expansion or contraction) ends at time t and 0 otherwise. Hence, this function is the log-likelihood for the regression analysis of binary dependent variables. Substituting P_{ij} by **(4.4)** and using the adequate specification for the baseline hazard function, the model can be estimated.

89 Note that $\ln h_t = \alpha + q \ln t \approx \ln(\gamma p t^{p-1})$, where $\alpha \approx \ln(\gamma p)$ and $q \approx p$-1; the higher is the frequency of the discrete-time series, the closer is q from p-1. Note also that other specifications could be considered: (i) linear in time ($\theta_t = \alpha_0 + \alpha_1 t$); (ii) polynomial in time ($\theta_t = \alpha_0 + \alpha_1 t + \alpha_2^2 t + \ldots$); (iii) piece-wise dummies – one for each particular sub-period of time – where the hazard rate is assumed to be the same within each time-group but different between those groups ($\theta_t = \alpha_0 + \alpha_1 d_1 + \alpha_2 d_2 + \ldots$); (iv) or, when possible, a fully non-parametric specification with one dummy for each value of t for which an event is reported.

4.3.3. Empirical results

The empirical results obtained from the duration analysis of the expansion and contraction episodes that have taken place in a group of industrial countries over the last fifty years are presented in this section. Some descriptive statistics for the duration of expansions and contractions in the sample of 13 industrial countries over the period 1948-2006 are reported in Table 4.1.

The number of spells of expansions and contractions is presented first, followed by the respective mean durations (in quarters). In general, expansions last four to five times longer than contractions. A more detailed analysis shows that the duration of expansions is higher, on average, in the group of EU countries than in the group of non-EU countries, but recessions also tend to last longer in the first group than in the second. This finding is also evident in Figure 4.1, where the distribution of the duration of expansions and contractions in the EU and non-EU countries is depicted. The flatter distribution of the duration of contractions for the EU countries in comparison with the one for non-EU countries is a good indicator of that fact.

Nevertheless, Table 4.1 also shows that after 1992 and, especially, after 1997 the average duration of contractions in the EU countries has decreased substantially, being even lower than in the group of non-EU countries. This simple analysis seems to indicate that the idea advanced by Buti *et al.* (1997) and Metz (2005) that Maastricht and more particularly the SGP may have lengthened recessions in the EU – because countries cannot run sufficiently large deficits to stimulate the economy – may not have any empirical support.[90]

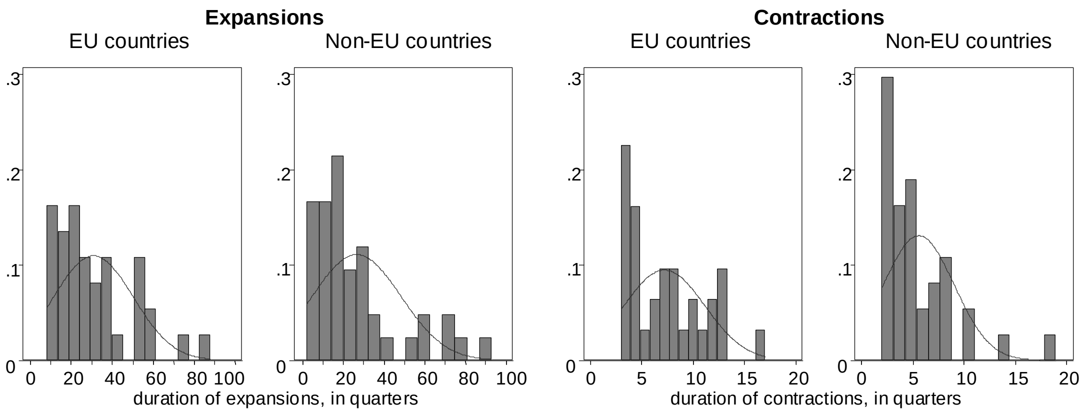
[90] Further empirical evidence on this idea is given below in the parametric duration analysis.

Table 4.1. Descriptive statistics by country, 1948-2006

Country	Duration of Expansions: No. Exp.	Mean	Std. Dev.	Min.	Max.	Duration of Contractions: No. Cont.	Mean	Std. Dev.	Min.	Max.
Austria	6	25.8	15.4	8	51	5	5.0	3.9	3	12
France	7	26.4	17.9	8	61	6	5.2	2.8	3	10
Germany	6	31.5	21.5	13	73	5	9.4	3.0	5	13
Italy	6	29.0	14.3	11	52	5	6.0	3.7	3	12
Spain	3	42.3	11.2	30	52	2	12.5	6.4	8	17
Sweden	5	22.6	18.8	8	53	4	9.8	4.3	4	13
United Kingdom	4	49.5	31.3	15	88	4	6.5	1.7	4	8
EU countries	***37***	***30.8***	***19.4***	***8***	***88***	***31***	***7.2***	***3.9***	***3***	***17***
EU (<1992)	23	29.8	21.1	8	88	20	7.3	4.1	3	17
EU (≥1992)	14	32.5	16.6	8	59	11	7.0	3.7	3	13
EU (≥1997)	10	34.6	18.0	13	59	3	5.3	4.0	3	10
Australia	7	30.3	18.5	13	60	6	4.0	1.3	3	6
Canada	5	42.6	33.5	10	93	4	5.8	1.7	4	8
Japan	5	35.2	34.4	4	76	5	8.0	2.1	5	10
New Zealand	8	17.0	11.1	2	34	7	6.3	5.8	2	19
Switzerland	6	27.0	23.9	5	73	5	8.4	3.4	5	14
United States	11	19.1	11.6	4	40	10	3.4	1.1	2	5
non-EU countries	***42***	***26.4***	***21.8***	***2***	***93***	***37***	***5.6***	***3.5***	***2***	***19***
non-EU (<1992)	29	25.2	22.0	2	93	28	4.9	3.2	2	19
non-EU (≥1992)	13	29.0	21.8	4	69	9	7.7	3.6	2	14
non-EU (≥1997)	11	27.5	18.7	4	60	5	6.6	3.8	2	10
All countries	***79***	***28.5***	***20.7***	***2***	***93***	***68***	***6.3***	***3.7***	***2***	***19***

Notes: See Table A.4.1.1 in Annex. The duration of expansions and contractions is measured in quarters.
Sources: NBER website at http://www.nber.org/cycles/main.html, updated in April 2007;
ECRI website at http://www.businesscycle.com/resources/cycles/, updated in April 2007.

Figure 4.1. Distribution of the duration of expansions and contractions: EU and non-EU countries



Sources: See Table 4.1.

Table 4.2 presents the results of some basic parametric estimations for duration dependence for each of the EU countries and a pooled regression with all EU countries. These regressions do not control for any other exogenous variables. Table 4.3 does the same for non-EU countries and includes an additional pooled regression with all EU and non-EU countries. Two types of duration models are considered in this first parametric analysis: a continuous-time Weibull model and a discrete-time complementary log-log (cloglog) model. The results from the Weibull model are reported to make possible the comparison with the previous studies on duration dependence, especially with the studies for the US. To our knowledge, no other study has yet provided an analysis of duration dependence for other industrial countries over the period after WWII using parametric duration models and classical business cycles. Moreover, this is the first study that uses discrete-time duration methods to analyse the issue of duration dependence for expansions and contractions.[91]

As noticed in the previous section, in the discrete-time model we assume the following specification for the log of the baseline hazard function: $\theta_t = \alpha + q \ln t$, where the estimate of q will correspond (approximately) to the estimate of p-1 in the continuous-time Weibull model. For comparative purposes, it is the estimate of p that is reported for both models. This will measure the magnitude of the duration dependence.

[91] The reasons why this study uses discrete-time duration models were explained in the previous section.

Table 4.2. Basic parametric estimations for duration dependence by country: EU countries

			Expansions		Contractions	
			Constant	***p***	***Constant***	***p***
Austria	Weibull model	Coeff.	-6.953	2.002	-2.776	1.602
		Rob. S.E.	(2.317)	(0.574)	(0.393)	(0.148)
		Boot. S.E.		[0.814]		[1.146]
	Cloglog model	Coeff.	-6.258	2.001	-2.143	1.506
		Rob. S.E.	(2.188)	(0.688)	(0.744)	(0.426)
		Boot. S.E.		[1.418]		[0.429]
France	Weibull model	Coeff.	-6.476	1.850	-3.884	**2.194**$^{+,c}$
		Rob. S.E.	(1.687)	(0.429)	(0.936)	**(0.403)**
		Boot. S.E.		[0.654]		**[0.601]**
	Cloglog model	Coeff.	-5.858	1.849	-3.048	2.167
		Rob. S.E.	(1.616)	(0.495)	(0.951)	(0.568)
		Boot. S.E.		[0.578]		[0.712]
Germany	Weibull model	Coeff.	-7.499	2.023	-9.579	**4.091**$^{+,i}$
		Rob. S.E.	(0.968)	(0.266)	(4.237)	**(1.645)**
		Boot. S.E.		[1.399]		**[1.706]**
	Cloglog model	Coeff.	-6.801	**2.024**$^{+,c}$	-8.175	**4.097**$^{+,c}$
		Rob. S.E.	(3.651)	**(0.422)**	(3.651)	**(1.642)**
		Boot. S.E.		**[0.553]**		**[2.296]**
Italy	Weibull model	Coeff.	-7.021	1.978	-3.807	1.982
		Rob. S.E.	(2.293)	(0.346)	(0.868)	(0.316)
		Boot. S.E.		[0.948]		[0.977]
	Cloglog model	Coeff.	-6.282	1.957	-3.059	1.948
		Rob. S.E.	(1.583)	(0.498)	(0.996)	(0.542)
		Boot. S.E.		[0.608]		[0.728]
Spain	Weibull model	Coeff.	-15.07	3.855	-8.412	3.183
		Rob. S.E.	(7.836)	(2.059)	(5.941)	(1.844)
		Boot. S.E.		[2.082]		[n.a.]
	Cloglog model	Coeff.	-13.43	3.771	-7.255	2.184
		Rob. S.E.	(5.701)	(1.572)	(4.551)	(1.816)
		Boot. S.E.		[3.030]		[1.104]
Sweden	Weibull model	Coeff.	-3.891	1.162	-7.401	3.094
		Rob. S.E.	(0.934)	(0.357)	(4.972)	(1.849)
		Boot. S.E.		[0.737]		[1.772]
	Cloglog model	Coeff.	-3.585	1.104	-6.267	3.093
		Rob. S.E.	(0.838)	(0.261)	(3.857)	(1.740)
		Boot. S.E.		[0.414]		[2.709]
United Kingdom	Weibull model	Coeff.	-6.876	1.650	-11.46	5.860
		Rob. S.E.	(3.145)	(0.649)	(8.142)	(3.904)
		Boot. S.E.		[0.694]		[3.163]
	Cloglog model	Coeff.	-6.352	1.642	-9.605	**5.831**$^{+,i}$
		Rob. S.E.	(2.923)	(0.798)	(6.123)	**(3.274)**
		Boot. S.E.		[0.855]		**[1.619]**
Pooling: EU countries	Weibull model	Coeff.	-7.182	**1.800**$^{+,c}$	-4.508	**2.365**$^{+,i}$
		Rob. S.E.	(0.868)	**(0.190)**	(0.534)	**(0.232)**
	Cloglog model	Coeff.	-6.752	**1.791**$^{+,c}$	-5.280	**2.356**$^{+,c}$
		Rob. S.E.	(0.915)	**(0.215)**	(0.969)	**(0.313)**

Notes: Robust standard errors (Rob. S.E.) are presented for each estimated coefficient (Coeff.). Bootstrap standard errors (Boot. S.E.) are also calculated for the duration dependence parameter *p* to take account of the small sample problem in the country-by-country estimations. These standard errors were obtained from 100 bootstrapped samples of the data for durations. Country dummy variables are used in the pooled estimations.

$^{+}$ indicates that *p* is significantly higher than 1 using 5% one-sided test with bootstrap standard errors (robust standard errors are used for pooling). ***d***, ***c***, and ***i*** indicate, respectively, decreasing, constant and increasing positive duration dependence at a 5% significance level.

n.a. – not available; impossible to compute bootstrap standard errors because only 2 contractions are observed.

Table 4.3. Basic parametric estimations for duration dependence by country: non-EU countries

			Expansions		Contractions	
			Constant	***p***	***Constant***	***p***
Australia	Weibull model	Coeff.	-5.634	1.634	-5.520	**3.705**$^{+,i}$
		Rob. S.E.	(1.299)	(0.381)	(1.147)	**(0.598)**
		Boot. S.E.		[0.446]		**[0.990]**
	Cloglog model	Coeff.	-5.339	1.617	-4.258	**3.771**$^{+,c}$
		Rob. S.E.	(1.141)	(0.344)	(1.200)	**(0.861)**
		Boot. S.E.		[0.405]		**[1.126]**
Canada	Weibull model	Coeff.	-5.145	1.289	-7.789	**4.221**$^{+,i}$
		Rob. S.E.	(1.513)	(0.290)	(0.987)	**(0.987)**
		Boot. S.E.		[0.506]		**[1.858]**
	Cloglog model	Coeff.	-4.828	1.270	-6.402	**4.268**$^{+,c}$
		Rob. S.E.	(1.607)	(0.460)	(2.250)	**(1.283)**
		Boot. S.E.		[0.568]		**[1.659]**
Japan	Weibull model	Coeff.	-4.207	1.106	-11.10	**5.119**$^{+,i}$
		Rob. S.E.	(2.100)	(0.421)	(4.579)	**(1.908)**
		Boot. S.E.		[0.710]		**[1.923]**
	Cloglog model	Coeff.	-3.983	1.068	-9.475	5.133
		Rob. S.E.	(1.805)	(0.558)	(4.033)	(1.933)
		Boot. S.E.		[4.793]		[2.623]
New Zealand	Weibull model	Coeff.	-4.078	1.359	-2.616	1.350
		Rob. S.E.	(1.557)	(0.472)	(0.447)	(0.219)
		Boot. S.E.		[0.491]		[0.709]
	Cloglog model	Coeff.	-3.635	1.304	-2.103	1.237
		Rob. S.E.	(1.247)	(0.496)	(0.633)	(0.324)
		Boot. S.E.		[0.747]		(0.349)
Switzerland	Weibull model	Coeff.	-4.940	1.398	-6.590	2.937
		Rob. S.E.	(1.510)	(0.366)	(1.221)	(0.506)
		Boot. S.E.		[0.771]		[1.626]
	Cloglog model	Coeff.	-4.559	1.383	-5.517	**2.942**$^{+,c}$
		Rob. S.E.	(1.414)	(0.440)	(1.521)	**(0.714)**
		Boot. S.E.		[0.510]		**[0.868]**
United States	Weibull model	Coeff.	-5.546	**1.779**$^{+,c}$	-4.889	**3.680**$^{+,i}$
		Rob. S.E.	(1.234)	**(0.325)**	(1.052)	**(0.628)**
		Boot. S.E.		**(0.368)**		**[0.678]**
	Cloglog model	Coeff.	-4.808	1.725	-3.622	**3.757**$^{+,i}$
		Rob. S.E.	(1.228)	(0.433)	(0.963)	**(0.778)**
		Boot. S.E.		[0.596]		**[0.763]**
Pooling: Non-EU countries	Weibull model	Coeff.	-5.630	**1.455**$^{+,d}$	-5.697	**2.564**$^{+,i}$
		Rob. S.E.	(0.976)	**(0.165)**	(0.854)	**(0.318)**
	Cloglog model	Coeff.	-3.918	**1.420**$^{+,d}$	-3.633	**2.544**$^{+,c}$
		Rob. S.E.	(0.633)	**(0.200)**	(0.695)	**(0.376)**
Pooling: All countries	Weibull model	Coeff.	-6.653	**1.596**$^{+,d}$	-6.445	**2.468**$^{+,i}$
		Rob. S.E.	(0.785)	**(0.130)**	(0.777)	**(0.197)**
	Cloglog model	Coeff.	-5.879	**1.575**$^{+,d}$	-2.629	**2.453**$^{+,i}$
		Rob. S.E.	(0.811)	**(0.151)**	(0.461)	**(0.244)**

Notes: See Table 4.2.

Robust and bootstrap standard errors are also reported for each individual estimate of that coefficient. Bootstrap standard errors are calculated to take into account the small sample size problem.[92] A one-sided test with bootstrap standard errors is used to infer the presence of positive duration dependence. However, in general, the qualitative conclusions are not significantly affected if robust standard errors are used instead.

Evidence of positive duration dependence in expansions is found only for Germany and the United States, which means that in these countries the likelihood of an expansion ending increases with its age. These results support the recent evidence provided by Zuehlke (2003), Lam (2004) and Layton and Smith (2007) for the US economy. Contractions also exhibit positive duration dependence in Germany and the United States as well as in France, the UK, Australia, Canada, Japan and Switzerland. In the particular case of the US economy, this study confirms the results obtained by Sichel (1991) and Zuehlke (2003) and by the Markov-switching approaches.

The lack of evidence of duration dependence for the other countries might be due to the small sample size of expansions and contractions, which may impair the power of the *t*-test. Notice that the standard errors tend to be very high in some cases, making difficult to detect duration dependence when it may really exist. A way of circumventing this problem is to pool all the countries in a single regression. This will increase the power of the test and provide more consistent estimates for duration dependence. Three separate pooled-estimations were performed: one for the group of

[92] These standard errors were obtained from 100 bootstrapped samples of the data for durations. More replications were attempted, but either the results are not significantly affected or, for some countries, it was not possible to compute them due to lack of variability (note that we are considering no more than 4 to 6 observations for most of the countries in the case of the Weibull specification).

EU countries, other for the non-EU countries and another for all countries.[93] As expected, results provide evidence of significant positive duration dependence in all cases. This means that, in general, expansions and contractions in industrial countries are indeed more likely to end as they become older.

Another striking result is the fact that when positive duration dependence is detected, the estimated parameter p tends to be higher for contractions than for expansions. This may indicate that the probability of expansions and contractions ending evolves at different rates as their age increases. The analysis of the second derivative of the (baseline) hazard function ($h_0(t)=\gamma p t^{p-1}$) shows that, in presence of duration dependence ($p>1$), this function increases at a decreasing, constant or increasing rate if, respectively, $p<2$, $p=2$ or $p>2$. This means that we can detect the presence of decreasing, constant or increasing positive duration dependence by testing if p is lower, equal or higher than 2. We start by testing for the presence of constant positive duration dependence using a 10% two-sided test.[94] The symbol ***c*** next to the estimated parameter indicates when this hypothesis is not rejected. Otherwise, we perform 5% one-sided tests to detect if we are in presence of decreasing (***d***) or increasing (***i***) positive duration dependence. Results provide some evidence that the probability of expansions and contractions ending evolves at different rates when positive duration dependence is detected in both phases. As expansions become older the probability of ending increases at a decreasing or constant rate, while for contractions it increases, in most of the cases, at an increasing rate. This is an interesting finding that complements the evidence provided by Lam (2004) for the US economy using a Markov-switching approach and that helps to

[93] Country dummies are included in all pooled estimations to control for individual country effects.

[94] Bootstrap standard errors are used for the individual-country estimations (when positive duration dependence is detected); robust standard errors are used in the pooled regressions.

explain the observed tendency for longer expansions and shorter contractions during the last half century.

Analysing the duration of business cycles phases based exclusively on their age can generate an omitted variables problem because we might be ignoring the effects of other variables that may also help to explain business cycles phase changes. Thus, in addition to the length of a phase, we will include in the model some variables that are expected, according to some literature, to affect the business cycle behaviour as well. As the available data is grouped in discrete-time intervals and most of those covariates are time-varying, only results from the estimation of the cloglog model are presented. The fact that the cloglog model has greater flexibility to include discrete time-varying covariates is an important advantage of this model over the continuous-time Weibull specification and one reason for being used in this study. Finally, the inclusion of more variables will consume degrees of freedom making the individual-country estimations unfeasible in some cases. Due to this and the small sample problem mentioned above, we opted to pool all countries in a single regression. To provide a comparative analysis, some estimation results will also be presented for the samples of EU and non-EU countries.

The estimation results for a specification including additional exogenous variables are presented in Table 4.4 and Table 4.5. Results are presented first for the panel of all countries and then for the samples of EU and non-EU countries, respectively. Before proceeding with the analysis of those results, it is important to clarify two points. First, the estimated coefficient reported for the variable on the logarithm of the duration of an expansion or contraction (*LnDur*) now corresponds to the parameter q ($\approx p$-1) in the specification for the log of the baseline hazard function. Therefore, testing for the null hypothesis (H_0: q=0) on this coefficient is the same as testing for duration dependence: a significantly positive coefficient indicates the presence of positive duration dependence. Second, all economic variables are lagged one period to take into account for simultaneity problems, delays in reporting some economic data and to better identify their impact on the likelihood of a phase ending.[95]

The first aspect to emphasize is the fact that despite the inclusion of other exogenous variables in the model, positive duration dependence remains an important factor to explain the duration of expansions and contractions in industrial countries. Moreover, contractions still present evidence of increasing positive duration dependence, whilst constant positive duration dependence is found for expansions.

The first additional variable to be included in the model is the annualized 6-month rate of change of the composite leading indicator (*CLI*). The coefficient associated with this variable shows the expected sign and has a strong predictive power in anticipating the end of expansions but it is not very important in explaining the end of contractions. Results show that an improvement in this indicator (or in its components) – that reflects current expectations about the future economic behaviour – has a positive impact on the duration of expansions. This result reinforces the findings of Di Venuto and Layton (2005) and Layton and Smith (2007) for Australia and the US.[96]

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[95] The Schwartz Bayesian Information Criterion (SBIC) is also reported to provide a comparative indication of the quality of each specification in describing the reality. A lower value is associated with a better description of the reality.

[96] This result is also consistent with some recent RBC literature that uses multiple equilibrium models. As in these models beliefs (or expectations) are regarded as self-fulfilling, the economy can enter into recession simply because economic agents have become pessimistic (see, for example, Jaimovich, 2007).

Table 4.4. Main determinants of the duration of expansions and contractions I

Expansions	**All countries**					**EU countries**		**Non-EU countries**	
LnDur	0.583***	0.709***	0.714***	0.796***	0.877***	1.201***	1.453***	0.830**	0.720*
	(3.13)$^{\boldsymbol{d}}$	(3.02)^{c}	(3.03)^{c}	(3.17)^{c}	(3.57)^{c}	(3.79)^{c}	(5.06)^{c}	(2.20)^{c}	(1.68)^{c}
CLI(-1)	-0.235***	-0.233***	-0.227***	-0.219***	-0.189***	-0.170***	-0.161***	-0.316***	-0.287***
	(-7.34)	(-6.44)	(-6.42)	(-6.32)	(-5.33)	(-4.89)	(-4.26)	(-4.43)	(-3.61)
DurPrev		-0.038	-0.039	-0.052	-0.104	-0.184***	-0.255***	0.253	0.188
		(-0.46)	(-0.50)	(-0.65)	(-1.10)	(-2.64)	(-2.77)	(1.42)	(1.37)
GPInv(-1)					-0.126*		-0.199**		0.007
					(-1.86)		(-2.17)		(0.06)
GovI/C(-1)					-0.045		-0.143**		0.027
					(-0.88)		(-2.00)		(0.48)
D_EU92			-0.571						
			(-1.10)						
D_EU97				-1.422**	-1.771**	-1.737***	-2.725***		-0.153
				(-1.99)	(-2.38)	(-2.16)	(-2.75)		(-0.20)
Log-L	-184.7	-167.2	-166.4	-164.0	-140.1	-85.80	-76.76	-71.34	-56.31
SBIC	480.9	452.1	457.9	453.1	409.7	245.6	239.8	202.0	182.4
N. Obs.	1698	1567	1567	1567	1327	838	761	729	566
N. Peaks	49	44	44	44	38	24	23	20	15
Contractions									
LnDur	1.410***	1.688***	1.720***	1.781***	1.812***	1.551***	1.483***	2.364**	2.813*
	(4.69)^{c}	(4.65)^{i}	(4.80)^{i}	(4.67)^{i}	(4.02)^{i}	(3.66)^{c}	(3.36)^{c}	(2.53)^{c}	(1.71)^{c}
CLI(-1)	0.044	0.059*	0.053	0.051	0.041	0.072	0.076	0.020	0.003
	(1.11)	(1.66)	(1.54)	(1.40)	(1.05)	(1.31)	(1.28)	(0.42)	(0.05)
DurPrev		0.030***	0.028***	0.030***	0.030**	0.036**	0.028	0.027**	0.029*
		(3.15)	(2.84)	(3.10)	(2.30)	(2.10)	(1.49)	(2.28)	(1.73)
GPInv(-1)					-0.067		-0.050		-0.061
					(-0.99)		(-0.44)		(-0.89)
GovI/C(-1)					0.015		0.025		0.030
					(0.20)		(0.23)		(0.27)
D_EU92			0.483						
			(0.85)						
D_EU97				0.984	1.320	0.806	1.073		
				(1.22)	(1.44)	(1.00)	(1.15)		
Log-L	-120.2	-114.9	-114.3	-114.1	-97.96	-66.62	-64.49	-46.45	-32.02
SBIC	328.2	323.3	328.1	327.6	298.5	191.8	197.9	137.5	110.3
N. Obs.	348	348	348	348	298	206	200	142	98
N. Troughs	50	50	50	50	44	28	27	22	17

Notes: The coefficients were estimated using the complementary log-log model, where the coefficient on the duration dependence variable *LnDur* (q) is identical to p-1. A constant and individual country dummies are included in all regressions and the presence of any pattern of heteroscedasticity and autocorrelation is controlled for by using robust standard errors; the z-statistics for the estimated coefficients are in parentheses; significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. ***d***, ***c***, and ***i*** indicate, respectively, decreasing, constant and increasing positive duration dependence at a 5% significance level. The Schwartz Bayesian Information Criterion is computed as follows: SBIC=2(-logL+(k/2)log$N$), where k is the number of regressors and N is the number of observations. Due to lack of quarterly data for private and government investment, Switzerland is excluded from the sample of non-EU countries when *GPInv* and *GovI/C* are included.

Table 4.5. Main determinants of the duration of expansions and contractions II

Expansions	**All countries**					**EU countries**		**Non-EU countries**	
LnDur	0.886***	0.860***	0.888***	0.414***	0.618**	1.384***	1.508***	0.987**	0.322
	(3.63)^{c}	(3.22)^{c}	(3.04)^{c}	(3.32)	(2.26)^{c}	(3.88)^{c}	(3.38)^{c}	(2.05)^{c}	(0.93)
CLI(-1)	-0.143***	-0.131***	-0.129***	-0.072***		-0.127**		-0.250***	
	(-3.85)	(-3.39)	(-3.27)	(-4.18)		(-2.40)		(-3.21)	
Spread(-1)					-0.447***		-0.366***		-0.745***
					(-3.87)		(-2.58)		(-5.95)
Stock(-1)					-0.043**		-0.042		-0.075***
					(-2.36)		(-1.76)		(-2.87)
DurPrev	0.011	0.019	0.022	0.009	0.015	-0.146	-0.191*	0.330**	0.161**
	(0.11)	(0.20)	(0.22)	(0.24)	(0.18)	(-1.45)	(-1.74)	(2.50)	(2.05)
GPInv(-1)	-0.154**	-0.129*	-0.131*	-0.055	-0.022	-0.209**	-0.304**		
	(-2.60)	(-1.72)	(-1.72)	(-1.43)	(-0.32)	(-2.06)	(-2.12)		
GovI/C(-1)	-0.008	0.004	-0.003	-0.005	-0.011	-0.123	-0.176*		
	(-0.18)	(0.12)	(-0.09)	(-0.32)	(-0.30)	(-1.25)	(-1.73)		
OilPr(-1)	0.018***	0.017**	0.017**	0.007***	0.013***	0.012	0.015*	0.020**	0.011*
	(2.62)	(2.39)	(2.31)	(2.60)	(3.32)	(1.46)	(1.78)	(2.19)	(1.74)
PeakUS		1.546***	1.549***	0.859***	0.978*	1.773***	1.402**		
		(3.03)	(3.00)	(3.02)	(1.89)	(2.83)	(2.16)		
PolCycle			-0.854	-0.499	-0.828	-0.378	-0.180	-0.950	-1.085
			(-1.36)	(-1.61)	(-1.40)	(-0.47)	(-0.21)	(-1.13)	(-1.40)
GovLeft			0.395	0.054	0.563	0.589	1.191*	2.351*	1.848
			(0.70)	(0.23)	(1.30)	(0.79)	(1.77)	(1.94)	(1.34)
D_EU97	-1.021	-0.971	-1.034*	-0.593**	-0.849	-1.992*	-2.338*		
	(-1.42)	(-1.41)	(-1.47)	(-2.10)	(-1.17)	(-1.79)	(-1.77)		
Log-L	-133.1	-112.6	-111.6	-4408.2	-121.7	-69.35	-62.51	-65.26	-72.17
SBIC	402.8	360.0	372.0	9142.1	399.4	251.5	243.8	108.4	229.3
N. Obs.	1327	1200	1200	1188	1206	761	733	658	692
N. Peaks	38	33	33	33	36	23	21	19	24
H_0: Exogen.				0.6123					
Contractions									
LnDur	1.817***	1.627***	1.775***	1.934***	1.697***	1.595***	1.661***	2.240**	1.319***
	(3.93)^{i}	(4.28)^{i}	(4.12)^{i}	(4.47)^{i}	(4.66)^{i}	(3.20)^{c}	(3.34)^{c}	(2.18)^{c}	(2.83)^{c}
CLI(-1)	0.042	0.080**	0.084**	0.056		0.072		0.058	
	(1.02)	(2.10)	(2.23)	(1.56)		(1.10)		(1.02)	
Spread(-1)					0.266*		0.380*		0.087
					(1.76)		(1.86)		(0.72)
Stock(-1)					0.025*		0.016		0.018
					(1.76)		(0.98)		(0.92)
DurPrev	0.030**	0.030**	0.027***	0.028***	0.020**	0.023	0.029	0.029**	0.022**
	(2.26)	(2.96)	(2.73)	(2.92)	(2.11)	(1.07)	(1.25)	(2.55)	(2.06)
GPInv(-1)	-0.067								
	(-0.98)								
GovI/C(-1)	0.015								
	(0.20)								
OilPr(-1)	0.001					-0.002		0.009	
	(0.07)					(-0.23)		(0.51)	
TroughUS		0.660	0.619			-0.164			
		(1.28)	(1.22)			(-0.20)			
PolCycle			-0.299			-0.064		-0.838	
			(-0.58)			(-0.07)		(-1.20)	
GovLeft			-1.139*	-1.197*	-1.880***	-0.734		-1.719	
			(-1.83)	(-1.90)	(-3.21)	(-0.94)		(-1.36)	
D_EU97	1.321	0.824	0.875	1.150	0.984	0.953	0.909		
	(1.44)	(1.06)	(1.22)	(1.60)	(1.39)	(1.12)	(1.07)		
Log-L	-97.96	-103.8	-100.9	-111.1	-105.1	-63.79	-52.84	-43.41	-58.88
SBIC	304.2	306.0	311.7	327.5	320.2	207.1	167.1	146.2	168.5
N. Obs.	298	327	327	348	326	201	167	141	159
N. Troughs	44	44	44	50	51	27	25	22	26

Notes: See Table 4.4. Results presented in column 3 for expansions were obtained from an instrumental variables probit model where *OilPr(-1)* was instrumented with its 2nd, 3rd and 4th lags. The *p*-value of the Wald test for exogeneity is also reported. This test is described in Wooldridge (2002, pp. 472-477) and it simply asks whether the error terms in the structural equation and the reduced-form equation for the endogenous variable are correlated. The US is excluded from the sample when *PeakUS* or *TroughUS* are included in the model.

Next we test whether the duration of the previous phase (*DurPrev*) affects the length of the current phase. The results show that shorter contractions tend to be preceded by longer expansions in the period after WWII.[97] This is a result that complements the findings of Zellner (1990) for the pre-war period and that contradicts the lack of evidence found by Sichel (1991) and Abderrezak (1998) on this matter. In economic terms, this means that the vigorous economic activity and the solid fundamentals that characterize longer expansions tend to have significant vestiges in subsequent contractions, making their durations shorter. On the other hand, no solid evidence is found in the opposite direction. The sample of EU countries presents some indication of a positive relation between the duration of previous contractions and the duration of current expansions, but the sample of non-EU countries presents a negative relation.[98] However, the coefficient of interest is not always statistically significant. This lack of significant statistical evidence is well reflected in the estimations for the sample of all countries. Therefore, this study concludes that the impact of the duration of previous contractions on the duration of current expansions is not significant.

Regarding the effects of private and public investment on the likelihood of an expansion or contraction ending, only private investment presents some significant power in explaining the duration of expansions, especially in the group of EU countries. Results show that when private investment is boosted the likelihood of an

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[97] For example, considering the regressions for the group of all countries, when the duration of the previous contraction increases by a quarter the hazard rate of an expansion ending increases by a factor of approximately $e^{0.030}$=1.0305, i.e. by about 3.05%, *ceteris paribus*.

[98] This means that longer recessions leave a long way for EU countries to run before they reach their full potential again; on the contrary, the deterioration they cause in the economic fundamentals in the non-EU countries makes the subsequent expansion shorter.

expansion ending decreases. Government investment does not present any significant impact on the duration of expansions or contractions; only the duration of EU expansions seems to be affected by this variable, but the sensitivity analysis provided below will confirm the lack of strong statistical significance of this variable in any case.[99]

Results presented in Table 4.5 show that the price of oil is an important variable in explaining the duration of expansions in the industrial countries. As expected, when the price of oil increases the likelihood of an expansion ending increases significantly. As some recent literature suggests that the price of oil can be endogenously determined along with the state of the economy,[100] we also estimate an instrumental variables probit model (ivprobit) where the lag of the oil price is instrumented with its second, third and fourth lags.[101] Nevertheless, the test for exogeneity does not reject the hypothesis that the lag of the oil price is exogenously determined. Moreover, the statistical significance of the main variables is not affected and the oil price remains an important factor for an expansion ending. This means that using the lag of the oil price, we are already avoiding simultaneity problems and, consequently, we can rely on the results from the simple cloglog model, which is the best model to employ for a discrete-time duration analysis.

[99] *GPinv* and *GovI/C* are excluded in some regressions for the sample of non-EU countries due to the clear lack of significance demonstrated by those variables in that sample. In fact, the RBC theory has already pointed out that fiscal shocks, in particular, tend to be too small to be a significant source of fluctuations to the business cycle (see Rebelo, 2005).

[100] See, for example, Barsky and Kilian (2004) and Chen *et al.* (2007).

[101] Other lag combinations were tried, but results were not significantly affected. As there is no available procedure to include instrumental variables in a cloglog model, we opted to use an alternative specification for the discrete-time hazard rate given by the normal distribution density function (probit) for which there is a ready procedure to deal with instrumental variables.

Finally, it is worth mentioning that, despite several attempts, the price of oil has never proved important to explain the end of contractions.

There is also some evidence that when the US economy reaches a peak (and enters into recession), the likelihood of an expansion elsewhere ending increases. Thus, this study provides evidence sustaining the idea that international spillovers, in particular from the US economy, affect the probability of other industrial countries entering into recession.[102] Nevertheless, the end of a contraction in the US does not seem to affect the propensity of a contraction ending in the other industrial countries.

Contrary to expectations and to the results provided by Klein (1996) for the US economy, no clear evidence of political effects was found in this study: the political cycle does not affect the business cycle; only contractions seem to be marginally affected by the ideology of the party in the government, but this result is not robust, as will be demonstrated in the sensitivity analysis provided below. Therefore, these results indicate that the political environment has not proved to be very important to explain the duration of expansions or contractions in industrial countries.

To control for the argument advanced by Buti *et al.* (1997) and Metz (2005) that the Maastricht and SGP fiscal rules may have lengthened recessions, two dummy variables are used. The first takes the value of 1 in the period after Maastricht, i.e. after 1992, for the sample of EU countries (*D_EU92*) and the other takes the value of 1 for the same group of countries in the SGP period, i.e. in the period in which the fulfilment of the 3% criteria for the public deficit is to be officially assessed (*D_EU97*). This period started in 1997 with the assessment of the

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[102] As the coefficient on *PeakUS* or *TroughUS* is never significant in the sample of non-EU countries, they are excluded from the regressions presented for this group to avoid the loss of US data in the sample.

countries that would take part in the Economic and Monetary Union. Thus, this dummy takes into account the impact of the SGP rules since they really came into effect, i.e. since the 3% fiscal rule had to be really accomplished, otherwise sanctions can be imposed. Results indicate that recessions in the group of EU countries are not significantly longer in the period in which the Maastricht and SGP fiscal constraints are imposed. Moreover, we find some evidence that the likelihood of an expansion ending is lower after 1997 in that group of countries.[103] Given these results and the fact that no significant differences are found for the group of non-EU countries in the same periods, this study concludes that Maastricht and SGP fiscal rules were not harmful for economic activity in the EU, contrary to the concerns raised by Buti *et al.* (1997) and Metz (2005).[104]

The composite leading indicator (*CLI*) has been used to collect the effects of current expectations about the future behaviour of the economy. However, following the suggestion of Dueker (1997), Estrella and Mishkin (1998), Chauvet and Potter (2005) and Moneta (2005) that some financial components of the leading indicators, like the interest rate spreads and the stock prices, can perform as well as those indicators in predicting recessions, we include those variables instead of *CLI* in the last regression presented in Table 4.5 for each group of countries. Results show that the interest rate spread (*Spread*) is, as expected, negatively (positively) related to the likelihood of an expansion (contraction) ending. A higher spread signals that

[103] However, we must analyse these results with a grain of salt because they can be partially influenced by the fact that some countries, like France and Germany, have decided to breach the 3% of GDP rule for the deficit, to avoid a deeper economic slowdown, when they were hit by the 2001-2003 recession. On the other hand, the number of cycles for the period after Maastricht is yet small – in comparison with the number of cycles we find in the time span used for the period before Maastricht – which hinders a more balanced analysis.

[104] This conclusion is in accord with the findings presented in Chapter 2.

economic agents expect a better economic performance in the future, therefore, the likelihood of an expansion (contraction) ending decreases (increases). Central banks can play an important role on this matter by trying to make the necessary interest rate adjustments to keep the economy out of a recession. Despite not being evident in the sample of EU countries, the influences of the stock market on the economic behaviour are important as well, especially in periods of expansion. A decrease in stock market capitalization – which may reflect a future decrease in the profits of the companies and the expectation of an economic slowdown – increases the hazard rate of an expansion ending. In general, the conclusions of this study are not affected by the use of these variables instead of *CLI*.[105]

Although these components of the *CLI* have proved to be important in explaining the duration of business cycle phases, an important problem arises when they are used instead of *CLI*: an omitted variables problem. The *CLI* is collecting the effects of more variables than simply the interest rate spreads and the share prices, like consumer and producer confidence indicators, order books, stocks and labour market indicators. To avoid the loss of important information that is provided by all these variables, we prefer to rely on the results obtained with *CLI* in the equation.

4.3.4. Robustness analysis

A robustness analysis is provided in this section for the three groups of countries. The effects of duration dependence, *CLI* and duration of the previous phase are controlled for in any case, because these variables have proved to be the most important determinants of the duration of both expansions and contractions.

[105] Several experimental ivprobit regressions, not reported here, were also run controlling for possible simultaneity problems, where these variables – and even *CLI*, *GPInv* and *GovI/C* – were instrumented with some of their lags, but the exogeneity hypothesis was never clearly rejected in any of the cases.

The effects of the variables that have proved significant in explaining the duration of expansions or contractions in the three samples are also controlled for. Using these parsimonious specifications, we analyse the robustness of the results obtained so far to changes in some assumptions. The results of the robustness analysis are presented in Table 4.6.

So far we have assumed that expansions and contractions can hypothetically have a length from one quarter to the maximum observable in our sample. However, the NBER and ECRI usually do not consider a phase of expansion or contraction with less than five months. Therefore, studies that use monthly data to analyse duration dependence truncate expansions and contractions to a minimum duration. This means that the hazard rate must be identically zero for months one to five and some non-zero value thereafter.

As this study uses quarterly data we would be tempted to truncate the duration of expansions and contractions for the first two quarters (the equivalent to six months). However, there are some examples in our sample in which the phases have a length of 2 quarters: two recessions in the US (2/1980-7/1980 and 8/1990-3/1991); one recession in New Zealand (11/1997-5/1998); and one expansion in New Zealand (4/1986-9/1986). As a result, a minimum duration of three (or more) quarters cannot be considered when quarterly data is being used. The alternative is to consider a minimum phase of at least two quarters. Columns 1, 4 and 7 in Table 4.6 present the results of a regression where the duration of expansions and contractions were truncated to a minimum of two quarters, i.e. assuming that the hazard rate is zero in the first quarter of each phase.

Table 4.6. Robustness analysis for the duration of expansions and contractions

Expansions	All countries			EU countries			Non-EU countries		
LnDur	0.811***			1.264***			0.666		
	(2.74)			(4.32)			(1.21)		
D_Dur1		-2.072***			-3.379***			-1.788*	
		(-2.69)			(-4.09)			(-1.73)	
D_Dur2		-1.538**			-2.746***			-2.193*	
		(-2.06)			(-3.06)			(-1.65)	
D_Dur3		-0.746			-1.242			-1.649	
		(-1.07)			(-1.45)			(-1.42)	
D_Dur4		0.277			-0.212			0.554	
		(0.47)			(-0.26)			(0.57)	
Dur			-0.028**			-0.038**			-0.044**
			(-2.35)			(-2.47)			(-2.08)
CLI(-1)	-0.133***	-0.137***	0.151***	-0.128**	-0.132**	0.143***	-0.290***	-0.273***	0.278***
	(-3.33)	(-3.56)	(4.02)	(-2.48)	(-2.55)	(3.21)	(-3.63)	(-4.20)	(4.13)
DurPrev	-0.021	-0.024	-0.043	-0.134	-0.216**	0.086	0.236*	0.329**	-0.297*
	(-0.22)	(-0.19)	(-0.53)	(-1.34)	(-1.99)	(0.97)	(1.78)	(2.15)	(-1.82)
GPInv(-1)	-0.129*	-0.126*	0.104	-0.217**	-0.210**	0.199*			
	(-1.71)	(-1.68)	(1.33)	(-2.08)	(-2.11)	(1.76)			
GovI/C(-1)	-0.006	-0.007	-0.007	-0.075	-0.091	0.058			
	(-0.16)	(-0.15)	(-0.22)	(-0.97)	(-1.16)	(0.85)			
OilPr(-1)	0.017**	0.017***	-0.017***	0.012	0.013	-0.013**	0.017*	0.022**	-0.020**
	(2.36)	(2.49)	(-2.79)	(1.59)	(1.57)	(-1.96)	(1.78)	(2.08)	(-1.96)
PeakUS	1.548***	1.418***	-1.785***	1.787***	1.642***	-2.181***			
	(3.03)	(2.75)	(-3.22)	(2.89)	(2.65)	(-3.11)			
D_EU97	-0.953	-1.170*	0.833	-1.679*	-1.981**	1.402*			
	(-1.39)	(-1.66)	(1.28)	(-1.70)	(-2.04)	(1.69)			
Log-L	-112.4	-111.1		-69.70	-67.38		-67.06	-64.20	
SBIC	359.6	378.2		238.9	254.2		199.0	194.9	
N. Obs.	1200	1200		761	761		658	658	
N. Peaks	33	33		23	23		19	19	

Contractions									
LnDur	1.682***			1.309***			2.122*		
	(3.34)			(2.56)			(1.92)		
D_Dur1		-5.161***			-3.477***			-4.508**	
		(-2.70)			(-2.79)			(-2.10)	
D_Dur2		-3.820**			-3.004**			-2.201	
		(-2.12)			(-2.46)			(-1.19)	
D_Dur3		-3.583**			-2.384**			-1.984	
		(-2.04)			(-2.34)			(-1.17)	
D_Dur4		-2.251						-1.56	
		(-1.48)						(-1.07)	
Dur			-0.330***			-0.288***			-0.380**
			(-3.23)			(-3.39)			(-1.96)
CLI(-1)	0.063*	0.073*	-0.055	0.082	0.060	-0.068	0.026	0.037	-0.042
	(1.71)	(1.76)	(-1.23)	(1.44)	(0.99)	(-1.10)	(0.52)	(0.72)	(-0.76)
DurPrev	0.027***	0.021**	-0.027**	0.034**	0.019	-0.023	0.026**	0.021**	-0.026**
	(2.84)	(2.29)	(-2.44)	(2.03)	(1.20)	(-1.34)	(2.23)	(2.03)	(-2.05)
GovLeft	-1.175*	-0.873	0.840						
	(-1.89)	(-1.65)	(1.31)						
D_EU97	1.062	0.432	-0.953	0.745	0.451	-0.860			
	(1.45)	(0.57)	(-1.14)	(0.92)	(0.59)	(-1.02)			
Log-L	-109.7	-119.2	-206.3	-65.76	-70.01	-140.4	-46.03	-48.65	-116.4
SBIC	324.7	361.3	668.1	190.1	209.3	459.3	136.7	156.8	359.8
N. Obs.	348	348	1479	206	206	961	142	142	799
N. Troughs	50	50		28	28		22	22	

Notes: See Table 4.4. In columns 1, 4 and 7 the duration of expansions and contractions is truncated assuming that transitions to these states are observed only if the new state survives at least 1 quarter. In columns 2, 5 and 8 piece-wise specifications are used to characterize the baseline hazard function. The estimates presented in columns 3, 6 and 9 are from a multinomial regime-switching logit specification *à la* Layton and Smith (2007).

Our main results are not significantly or qualitatively affected. In practice, results in this kind of study have not proved sensitive to the choice of this minimum observable duration and the qualitative conclusions tend to be identical in any case.[106] Therefore, there is no practical advantage in complicating the analysis with such a small truncation, especially in a study in which quarterly data has been used.

Next we relax the specification for the baseline hazard function. We have considered a specification that corresponds to the discrete-time analogue of the Weibull model to facilitate the comparisons with the previous studies. However, a piece-wise specification can also perform well in detecting duration dependence. In this case, a group of dummies that account for the passage of the time during each phase is created – one for each particular sub-period of time – where the hazard rate is assumed to be the same within each time-group but different between those groups. Five time dummies were created for both expansions and contractions and the first four were included in the list of independent variables instead of *LnDur*.[107] The main conclusions of this study are not affected with the inclusion of those dummies: the significance of the economic variables remains generally unaffected as well as the evidence of positive duration dependence for expansions and contractions. Most of the dummies are significant and their magnitude (in absolute

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[106] On this aspect, see Sichel (1991) and Layton and Smith (2007).

[107] Those dummies were created as follows: (i) For expansions, we have to create four two-year dummies (*D_Dur1*, *D_Dur2*, *D_Dur3*, and *D_Dur4*) and an additional fifth dummy (*D_Dur5*) that takes the value of 1 when the length of an expansion is higher than 8 years. The creation of yearly or quarterly dummies was not possible in this case because these would totally predict the value of the dependent variable given that there are some years or quarters for which no expansion has ended. (ii) For contractions, four similar year dummies were created and the fifth dummy takes the value of 1 when the length of a contraction is higher than 4 years. As in the case of expansions, quarterly dummies are not appropriate. In the group of EU countries *D_Dur4* for the duration of contractions was automatically excluded from the sample because they totally predict the value of the dependent variable. For more details on the creation of these kind of piece-wise dummies, see Allison (1982).

terms) decreases with the passage of time, which confirms that both expansions and contractions in industrial countries are more likely to end as they become older. In the case of non-EU countries that trend is less clear but, even so, we still cannot ignore that evidence of positive duration dependence exists.[108]

The last estimations presented in Table 4.6 were obtained using a version of the multinomial regime-switching logit model (MRS logit) recently implemented by Layton and Smith (2007). In this model the log-likelihood function is defined as follows:

$$\ln L = \sum_{t=1}^{T} \Big\{ h_t^A \ln\big[\Lambda(\theta_1, Z_t)\big] + h_t^B \ln\big[1 - \Lambda(\theta_1, Z_t)\big] + h_t^C \ln\big[1 - \Lambda(\theta_2, Z_t)\big] + h_t^D \ln\big[\Lambda(\theta_2, Z_t)\big] \Big\} \quad \textbf{(4.6)}$$

where t is the time, h_t^A is a dummy variable that takes value 1 when the economy is in an expansion and 0 otherwise, h_t^B is a dummy variable that takes value 1 in the quarter in which the economy reaches a peak (transition from an expansion to a recession) and 0 otherwise, h_t^C is a dummy variable that takes the value of 1 in the quarter in which the economy reaches a trough (transition from a recession to an expansion) and 0 otherwise, h_t^D is a dummy variable that takes value 1 when the economy is in a recession and 0 otherwise. This means that only one element of the vector h_t takes value 1 at each point in time, while all the other three are zero. Moreover,

$$\Lambda(\theta_j, Z_t) = \left(1 + e^{-\left(\alpha_j + \delta_j Dur_t + \boldsymbol{\beta}'_j \mathbf{x}_{it}\right)}\right)^{-1}, \quad \textbf{(4.7)}$$

[108] Other specifications for the baseline hazard function were considered, but, in any case, the main conclusions of this study were not significantly affected by the choice of that function.

where j=1 for expansions and j=2 for contractions. Given this logistical functional form, the estimated coefficients will have a symmetric sign relative to the ones obtained with a cloglog model. For example, if the coefficient on the duration variable (*Dur*) is negative (positive) then the phase exhibits positive (negative) duration dependence. This is due to the fact that we are now focusing the analysis on the probability of remaining in a particular business cycle phase instead of the probability of that phase ending.

Results from the MRS logit reinforce the evidence of positive duration dependence for expansions and contractions in the group of industrial countries and in any of its sub-samples. Those results also confirm that the transition probabilities for expansions and contractions are driven not only by duration dependence but also by changes in some economic fundamentals of the economy.

4.3.5. Duration dependence and the "Great Moderation"

A final analysis considers whether the coefficient on duration dependence has changed during the sample period considered in this study. According to Summers (2005), the volatility in economic activity in most industrial countries has decreased significantly over the last two to three decades. This phenomenon is known in the literature as "the Great Moderation". Thus, our final task is to analyse whether the coefficient on duration dependence was affected by that phenomenon.

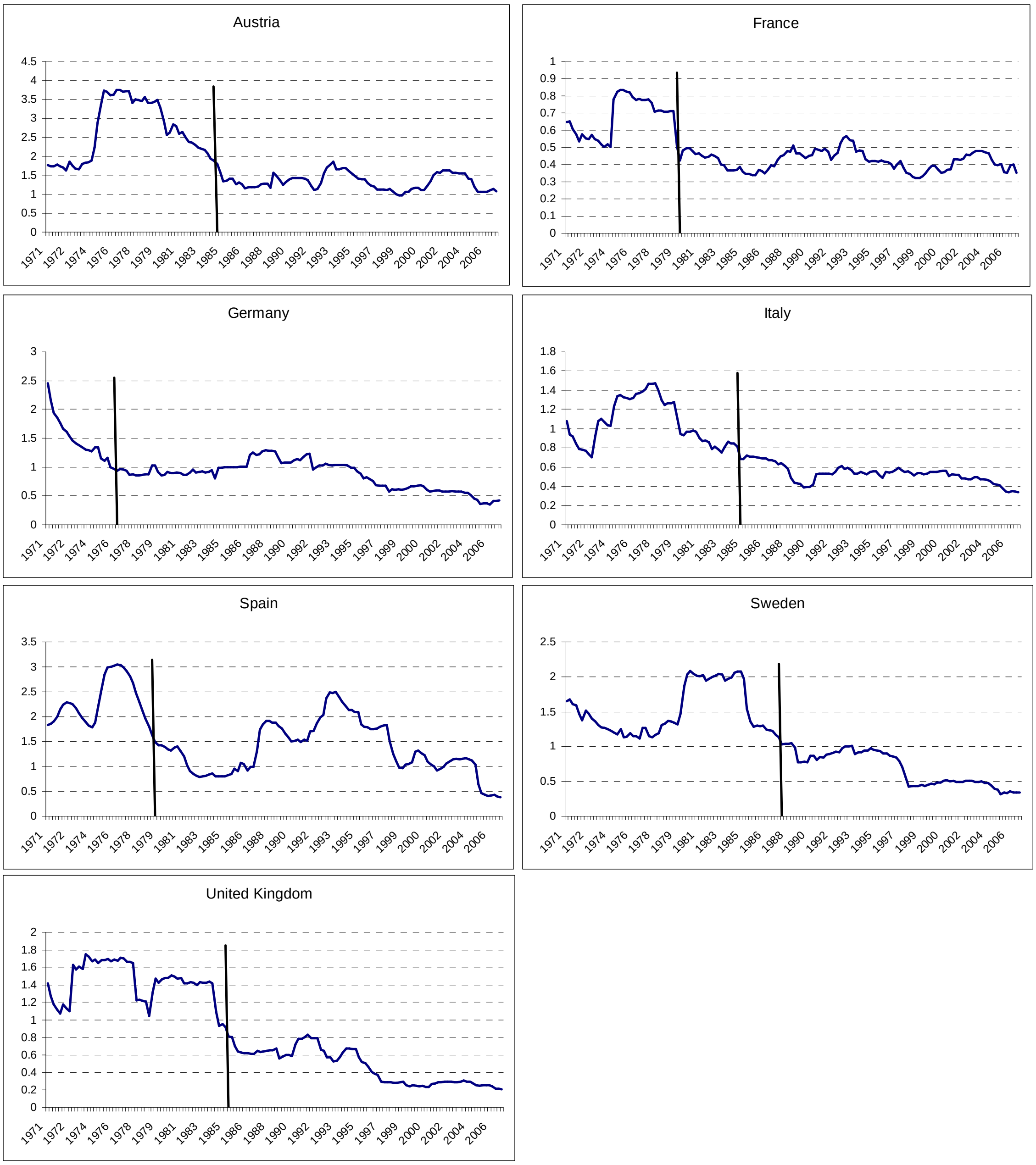
We follow Blanchard and Simon (2001) and Summers (2005) to establish the periods of "Great Moderation" (GM) for each of the countries used in our sample. First, we compute the rolling standard deviation of quarterly real output growth (measured at a quarterly rate) for each country. The measure of output is chain-weighted GDP obtained from the OECD Economic Outlook statistics for the period

1966Q1-2006Q4. As in Blanchard and Simons (2001), we use a window of 20 quarters so that the standard deviation in quarter *t* is the estimated standard deviation over quarters *t*-19 to *t*. Therefore, the first observations for the standard deviation start in the beginning of the 1970s. Figure 4.2 and Figure 4.3 present the volatility of real GDP growth for the group of EU and non-EU countries, respectively.

The GM period is identified next as the period during which the standard deviation of real GDP growth is consistently below its average for the period analysed, which resulted in the following threshold dates or starting dates for the GM period for each country: Austria (1984Q3), France (1980Q1), Germany (1976Q3), Italy (1984Q4), Spain (1979Q3), Sweden (1988Q1), United Kingdom (1985Q2), Australia (1987Q4), Canada (1987Q4), Japan (1975Q2), New Zealand (1991Q2), Switzerland (1980Q2) and United States (1987Q1). In fact, as we can observe in Figure 4.2 and Figure 4.3, after these dates all countries present a significant and clear decrease in output volatility.

A dummy variable is then built to separate the pre-GM and GM periods for each country (*D_GM*): it takes the value of 1 in the GM period (i.e. in the period of low-volatility in output) and 0 otherwise. To check whether there were any significant changes in the duration dependence coefficient between those two periods, we multiply this dummy with the duration dependence variable (*LnDur*∗*GM*) and include it in the model. We expect that a decrease in output volatility should correspond to a decrease (increase) in the likelihood of an expansion (contraction) ending as it gets older.

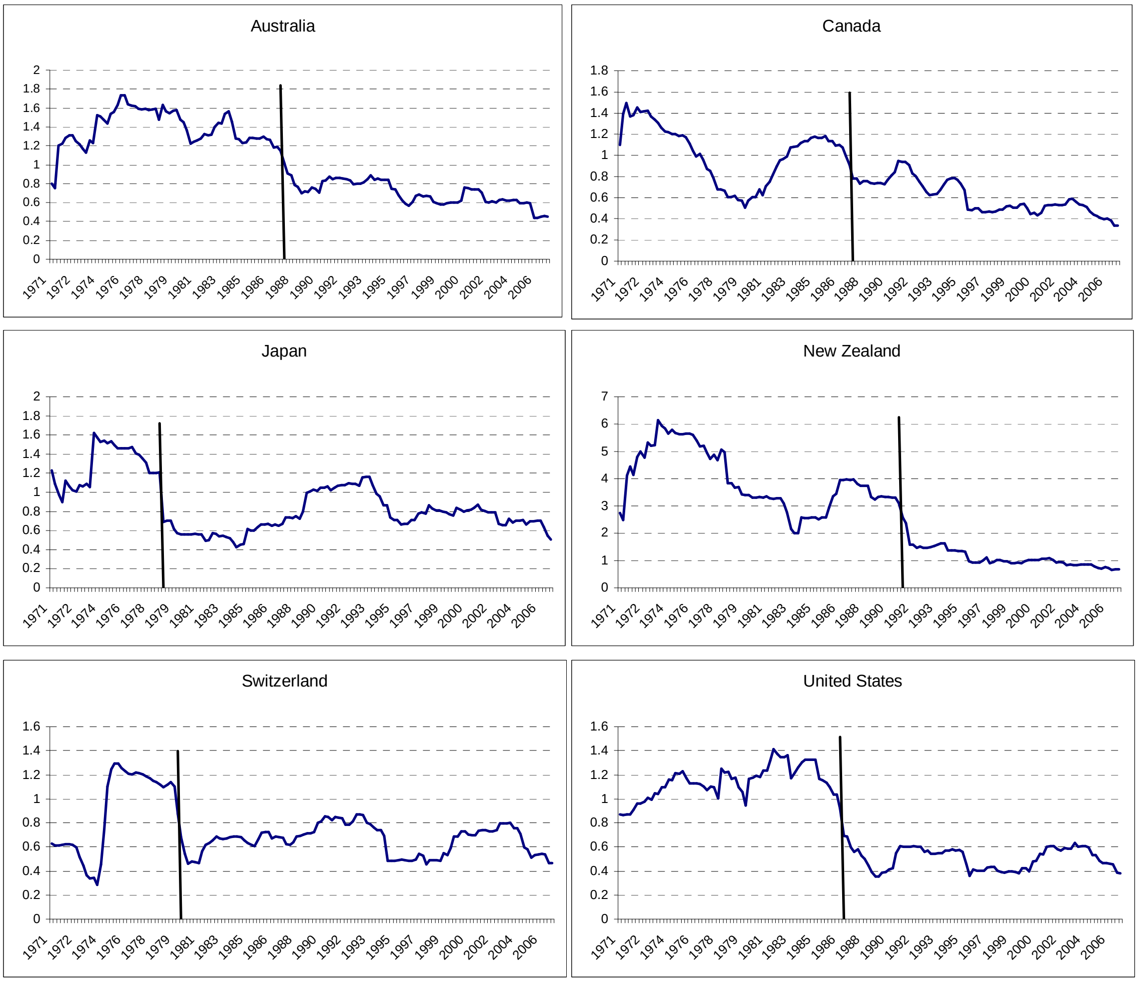
Figure 4.2. Volatility of real GDP growth: EU countries



Notes: The series correspond to the standard deviation of real GDP growth over the previous 20 quarters. The vertical line indicates the threshold between high-volatility and low-volatility in output growth. The GM periods are identified as the periods of low-volatility in output growth that stand on the right-hand side of the vertical line for each country. Those periods are characterized by a volatility of real GDP growth below its period-average.

Source: OECD Economic Outlook.

Figure 4.3. Volatility of real GDP growth: non-EU countries



Notes and Source: See Figure 4.2.

Descriptive statistics presented in Table 4.7 for the groups of EU, non-EU and all countries show that the mean duration of both expansions and contractions has increased slightly during the GM period. The differences between the pre-GM and GM periods are not very large, but, in the case of the duration of contractions, they suggest the possibility of an effect contrary to the one expected. To see whether that is really the case, we proceed with an econometric analysis identical to the one implemented in the previous sections, but where we consider the possibility of a change in the duration dependence coefficient between the Pre-GM and GM periods.

Table 4.7. Descriptive statistics for the Pre-GM and GM periods

	Duration of Expansions					Duration of Contractions				
	Exp.	Mean	Std Dev	Min	Max	Cont.	Mean	Std Dev	Min	Max
All countries(before GM)	40	27.0	24.2	2	93	40	5.3	2.7	2	13
All countries (GM period)	39	30.0	16.5	4	69	28	7.8	4.5	2	19
EU (before GM)	16	30.5	24.4	8	88	16	6.6	3.4	3	13
EU (GM period)	21	31.1	15.1	8	59	15	7.9	4.4	3	17
Non-EU (before GM)	24	24.7	24.2	2	93	24	4.4	1.6	2	8
Non-EU (GM period)	18	28.7	18.4	4	69	13	7.8	4.8	2	19
US (before GM)	8	14.9	9.4	4	35	8	3.6	1.1	2	5
US (GM period)	3	30.3	10.0	20	40	2	2.5	0.7	2	3

Notes: See Table 4.1 and Table A.4.1.1 in Annex. The duration of expansions and contractions is measured in quarters.

Estimation results for the panels of all countries, EU countries and non-EU countries are presented in Table 4.8. The first regressions for each group report the results from a simple specification where we only compare if the coefficient on duration dependence has significantly changed during the period of low-volatility in economic activity. Results indicate no significant changes for both expansions and contractions, for which identical evidence of positive duration dependence is again found in both the pre-GM and GM periods. In fact, the coefficient on *LnDur* (for the pre-GM period) is statistically identical to the duration dependence coefficient for the GM period (q_1+q_2). This evidence remains valid even when we add the variables that have proved to be consistently significant and important in explaining the duration of expansions and contractions. The inclusion of the dummy *D_GM* in the model (see column 3 for each group) has also confirmed the lack of significant differences in the duration of expansions and contractions between the pre-GM and GM periods.[109]

[109] The variables *LnDur**GM* and *D_GM* are not included together in the same regression because they are highly correlated.

Table 4.8. Duration dependence and the "Great Moderation"

Expansions	All countries			EU countries			Non-EU countries		
LnDur	0.608***	0.664***	0.627***	0.794***	0.725***	0.705**	0.482**	0.862**	0.805**
	(3.92)	(2.89)	(2.80)	(3.76)	(2.69)	(2.57)	(2.22)	(1.96)	(1.99)
*LnDur*GM*	-0.077	-0.078		-0.014	-0.011		-0.123	-0.090	
	(-0.82)	(-0.62)		(-0.10)	(-0.07)		(-0.96)	(-0.53)	
CLI(-1)		-0.157***	-0.157***		-0.149***	-0.148***		-0.271***	-0.270***
		(-4.68)	(-4.74)		(-3.04)	(-3.70)		(-3.89)	(-3.89)
DurPrev								0.292	0.295
								(1.62)	(1.61)
GPInv(-1)		-0.119*	-0.118*		-0.227**	-0.225**			
		(-1.72)	(-1.71)		(-2.41)	(-2.36)			
OilPr(-1)		0.011***	0.011***		0.011***	0.011***		0.033*	0.035**
		(2.76)	(2.70)		(2.68)	(2.53)		(1.91)	(2.03)
PeakUS		1.661***	1.663***		1.912***	1.910***			
		(3.61)	(3.62)		(3.75)	(3.71)			
D_GM			-0.295			-0.233			-0.128
			(-0.73)			(-0.46)			(-0.24)
q_1+q_2	0.532***	0.587**		0.780***	0.715**		0.358*	0.772**	
	(3.36)	(2.40)		(3.09)	(2.20)		(1.72)	(2.03)	
Log-L	-297.7	-163.2	-126.8	-138.7	-85.10	-84.96	-158.5	-66.58	-66.67
SBIC	686.1	375.0	374.9	326.3	257.3	257.0	361.9	204.5	204.7
N. Obs.	2242	1252	1252	1141	813	813	1101	658	658
N. Peaks	66	36	36	30	26	26	36	19	19
Contractions									
LnDur	1.446***	1.640***	1.698***	1.347***	1.501***	1.414***	1.545***	2.070**	2.453***
	(4.99)	(3.99)	(4.77)	(3.80)	(3.30)	(3.68)	(3.27)	(1.96)	(2.70)
*LnDur*GM*	0.012	0.114		0.017	-0.149		-0.001	0.569	
	(0.05)	(0.35)		(0.05)	(-0.44)		(-0.01)	(1.20)	
CLI(-1)		0.052	0.055*		0.097*	0.097*		-0.006	-0.005
		(1.28)	(1.67)		(1.76)	(1.77)		(-0.12)	(-0.09)
DurPrev		0.031***	0.030***		0.034**	0.033**		0.033***	0.031***
		(3.09)	(3.07)		(2.24)	(2.12)		(2.74)	(2.62)
D_GM			0.133			-0.283			0.792
			(0.25)			(-0.45)			(1.03)
q_1+q_2	1.458***	1.754***		1.365***	1.351***		1.544***	2.639**	
	(5.83)	(4.68)		(3.96)	(3.30)		(4.25)	(3.10)	
Log-L	-158.3	-114.7	-114.8	-77.67	-67.00	-67.00	-80.56	-46.43	-45.72
SBIC	407.6	328.9	329.1	204.0	192.6	192.6	203.8	140.4	141.0
N. Obs.	430	348	348	223	206	206	207	142	142
N. Troughs	68	50	50	31	28	28	37	22	22

Notes: See Table 4.4. The *z*-statistics for the estimated coefficients are in parentheses; robust standard errors are used to compute the *z*-statistics. q_1+q_2 is the coefficient that results from the sum of the estimated coefficients for *LnDur* and *LnDur*GM* and represents the duration dependence coefficient for the GM period.

Regarding these results, we conclude that the general decrease in output volatility in the industrial countries over the last 20 to 30 years has not affected significantly the duration of their contractions and expansions or, more precisely, the duration dependence coefficient.[110] In general, the expansions and contractions observed in group of the industrial countries analysed in this study are still showing evidence of positive duration dependence during the GM period, i.e. they remain as likely to end as they become older as before the GM period.

However, a particular country deserves a special analysis: the United States. First, it is the country that has received more attention in the literature regarding the decrease in output volatility. Second, this is the only country in our sample that reports a reasonable number of business cycle turning points (ten) for proceeding with a basic comparative analysis for the GM period.

Looking simply at the duration of expansions and contractions for the period after WWII in the US (see Table 4.7), we observe an (expected) increase in the duration of expansions and a decrease in the duration of contractions in the GM period. Thus, the decrease in output volatility seems effectively to correspond to longer expansions and shorter contractions in this country, contrary to what was found in the analysis for the panel of industrial countries.

The results from the estimation of a basic specification for the US including the variables *LnDur*GM* and *D_GM* are reported in Table 4.9. The evidence confirms our expectations for this country: first, expansions are no longer duration dependent (q_1+q_2 is not significant) during the GM period; moreover, the likelihood that they end has decreased significantly during that period (see coefficient on

[110] Additional experimental regressions (not reported here) considering the pre-GM and GM periods separately have not shown any substantial differences in the duration dependence coefficient between the two periods either. Moreover, results were not sensitive to small changes in the threshold dates. In one of our experiments we even used the dates of GDP volatility reduction or switch to low volatility considered by Summers (2005) for: Australia (1984Q3), Canada (1988Q1), France (1976Q3), Germany (1971Q3), Italy (1980Q2), Japan (1975Q2), United Kingdom (1982Q2) and United States (1984Q4). Results are shown in Table A.4.1.3 in Annex, but they remain quite similar to the ones presented in Table 4.8.

D_GM); second, contractions now present a higher duration dependence coefficient (q_1+q_2), meaning that the GM period has contributed to increase the propensity of a contraction ending as its gets older; at the same time, the coefficient on *D_GM* shows that contractions are shorter now than before the GM.[111]

Table 4.9. Duration dependence and the "Great Moderation" in the U.S.

	Expansions		Contractions	
LnDur (q_1)	1.083**	1.056**	3.281***	3.490***
	(2.28)	(2.21)	(3.34)	(3.55)
*LnDur*GM* (q_2)	-0.409*		2.595*	
	(-1.65)		(1.68)	
D_GM		-1.459**		1.934**
		(-1.98)		(2.03)
q_1+q_2	0.674		5.877***	
	(1.23)		(2.62)	
Log-L	-36.79	-36.33	-12.63	-12.81
SBIC	89.50	88.60	35.84	36.20
N. Obs.	202	202	34	34
N. Peaks	10	10	-	-
N. Troughs	-	-	10	10

Notes: See Table 4.4 and Table 4.8. The *z*-statistics computed from robust standard errors are in parentheses.

Thus, for the particular case of the US, we have evidence that the decrease in output volatility has indeed contributed to smooth the fluctuations in economic activity, making expansions longer and contractions shorter in this country. But, that does not seem to be the case for the other countries, which may indicate that the "moderation" in their output volatility was not, in general, as "great", sharp and stabilising as in the US.

[111] These results should be analysed with a small grain of salt due to the small number of business cycle turning points available. This is also the reason for estimating a basic specification only, i.e. a specification without additional regressors. Nevertheless, results were not sensitive to small changes in the threshold date. For example, considering the threshold reported by Summers (2005) for the US (1984Q4), no significant changes are found in the results (see Table A.4.1.4 in Annex).

4.4. Conclusions

The study of the duration of business cycle phases has essentially concentrated on testing for the presence of positive duration dependence, i.e. whether expansions and contractions are more likely to end as they become older. Duration analysis and Markov-switching models have been the most common approaches used in literature to test for duration dependence. The majority of studies have analysed this issue for the US business cycle and most of them have been successful in finding some evidence of positive duration dependence for expansions and contractions.

However, little attention has been given to the potential effects of other economic processes. In fact, even if duration dependence is present, other underlying mechanisms can affect the likelihood of an expansion or recession ending. As a way of filling that gap in the literature, this study considers a leading indicator and some economic and political variables in the analysis of the duration of business cycle phases.

Using for the first time a discrete-time duration model in the analysis of the duration of expansions and contractions, this chapter shows that duration dependence is not the only factor that can explain the duration of a business cycle phase. Positive duration dependence is found for both expansions and contractions, but the duration of expansions is also significantly lengthened by a positive behaviour of the variables in the OECD composite leading indicator. Two of its components (the interest rate spread and the stock market price index) contribute greatly to this outcome. The duration of contractions is essentially explained by the duration of the previous expansion, which indicates that the vigorous economic activity and the solid fundamentals that characterize longer expansions tend to have significant vestiges in subsequent contractions, making them shorter.

The likelihood of an expansion ending is also affected by the behaviour of private investment, the price of oil and by external influences. The evidence provided by this study shows that the duration of expansions tends to increase when private investment accelerates, reflecting the idea that when economic agents are confident about the future path of the economy, they end up fulfilling that expectation by investing more. The price of oil is another variable that is commonly related to the occurrence of important recessions after WWII, especially in the 1970s. This study finds empirical evidence regarding this relation and shows that when the price of oil increases the likelihood of an expansion ending also increases significantly. As the energy resources that firms need to operate become more expensive – and oil is an important one – their profits tend to decrease, generating an economic slowdown and, subsequently, a recession.

There is also some evidence that when the US economy reaches a peak (and enters into recession), the likelihood of an expansion ending increases substantially in the other industrial countries. No evidence of a similar effect is found when the US economy exits from a contraction. Political conditionings have not proved to be as important as economic factors to explain the duration of the business cycle phases and no support was found to the idea that fiscal rules have lengthened recessions in the EU. Finally, the "Great Moderation" in output volatility corresponds to a period in which evidence of positive duration dependence disappears for expansions and increases for contractions in the US economy. However, evidence also shows that such result cannot be generalized to the panel of countries analysed in this study.

Summarizing all these results, we conclude that the duration of expansions and contractions is not only affected by their actual age, but also by the behaviour of other economic factors, some of which encompass the expectations of the economic agents about the future trend of the economy. Moreover, contractions tend to present evidence of increasing positive duration dependence, whilst constant positive duration dependence is found for expansions, which means that the probability of a contraction ending increases more rapidly with its age than an expansion.

In this study we analyse the determinants of the duration of the classical business cycle phases. As the ECRI also provides data for growth cycles for the countries analysed in this study, an interesting extension would be to test whether the conclusions obtained for the classical business cycles can also be obtained using growth cycles.

Finally, instead of using ECRI classical business cycles or growth cycles, we could implement an algorithm to identify the business cycle turning points using, for example, a GDP, GNP or industrial production series. Such a procedure would allow us to study the behaviour of the business cycle phases in other countries, especially in the EU countries for which the ECRI does not provide data on the business cycle turning points. This would provide a more complete analysis for the group of EU countries. A drawback of this procedure is the fact that as we have to rely on a single series to identify the turning points, we may not be doing an effective analysis of the duration of *classical* expansions and contractions.

Annex 4.1. Business cycle chronologies, description of the variables and robustness checks

Table A.4.1.1. Business cycle chronologies, 1948-2006

EU countries			Non-EU countries		
	Peak	**Trough**		**Peak**	**Through**
Austria	August 1974	June 1975	**Australia**	June 1951	September 1952
	February 1980	January 1983		December 1955	August 1956
	April 1992	June 1993		December 1960	September 1961
	May 1995	March 1996		June 1974	January 1975
	January 2001	December 2001		June 1982	May 1983
				June 1990	December 1991
France	November 1957	April 1959	**Canada**	May 1953	June 1954
	July 1974	June 1975		October 1956	February 1958
	August 1979	June 1980		April 1981	November 1982
	April 1982	December 1984		March 1990	March 1992
	February 1992	August 1993			
	August 2002	May 2003			
Germany	March 1966	May 1967	**Japan**	-	December 1954
	August 1973	July 1975		November 1973	February 1975
	January 1980	October 1982		April 1992	February 1994
	January 1991	March 1994		March 1997	July 1999
	January 2001	August 2003		August 2000	April 2003
Italy	January 1964	March 1965	**New Zealand**	June 1966	March 1968
	October 1970	August 1971		April 1974	March 1975
	April 1974	April 1975		March 1977	March 1978
	May 1980	May 1983		April 1982	May 1983
	February 1992	October 1993		November 1984	March 1986
				September 1986	June 1991
				October 1997	May 1998
Spain	March 1980	May 1984	**Switzerland**	April 1974	March 1976
	November 1991	December 1993		September 1981	November 1982
				March 1990	September 1993
				December 1994	September 1996
				March 2001	March 2003
Sweden	October 1970	November 1971	**United States**	November 1948	October 1949
	July 1975	November 1977		July 1953	May 1954
	February 1980	June 1983		August 1957	April 1958
	June 1990	July 1993		April 1960	February 1961
				December 1969	November 1970
				November 1973	March 1975
				January 1980	July 1980
				July 1981	November 1982
				July 1990	March 1991
				March 2001	November 2001
United Kingdom	-	August 1952			
	September 1974	August 1975			
	June 1979	May 1981			
	May 1990	March 1992			

Notes: Chronologies for the United States, Canada, Australia and Germany start in 1948, but for the other countries (and due to lack of data) the ECRI could not identify peaks and troughs for some years after 1948. The time periods considered by the ECRI for each of the other countries are the following: Austria (1962-2006), France (1953-2006), Italy (1956-2006), Spain (1969-2006), Sweden (1969-2006), United Kingdom (1951-2006), Japan (1953-2006), New Zealand (1962-2006), and Switzerland (1956-2006).

Sources: NBER website at http://www.nber.org/cycles/main.html, updated in April 2007;
ECRI website at http://www.businesscycle.com/resources/cycles/, updated in April 2007.

Table A.4.1.2. Description of the variables and respective sources

Business cycle variables

Peak	Dummy variable that takes the value of 1 in the quarter in which a business cycle peak is reached, and 0 otherwise (*dependent variable*).
Trough	Dummy variable that takes the value of 1 in the quarter in which a business cycle trough is reached, and 0 otherwise (*dependent variable*).
BCExpan	Dummy variable that takes the value of 1 when a country is in expansion and 0 when the country is in contraction.
BCContr	Dummy variable that takes the value of 1 when a country is in contraction and 0 when the country is in expansion.
Dur	Variable that measures the duration of the event (expansion or contraction), in quarters.
LnDur	Logarithm of the variable *Dur*.
DurPrev	Duration of the previous phase, in quarters.
PeakUS	Dummy variable that takes the value of 1 in the quarter in which a peak in the US business cycle is reached, and 0 otherwise.
TroughUS	Dummy variable that takes the value of 1 in the quarter in which a trough in the US business cycle is reached, and 0 otherwise.

Sources: ECRI (April, 2007) and NBER (April, 2007).

Economic variables

CLI	OECD composite leading indicator: 6-months rate of change at annual rate.
Spread	Interest rate spread which is equal to long-term interest rate on government bonds (10-year government bonds) minus short-term interest rate (3-month inter-bank rates).
Stock	Quarterly growth rate of the stock price index (in percentage).
GPInv	Quarterly growth rate of real private total fixed capital formation (in percentage).
GovI/C	Government fixed capital formation divided by government final consumption expenditure.
OilPr	Crude oil import price deflated to real values using the GDP deflators of each country (base year: 2000), in USD per barrel. The oil price was first converted to each national currency using period average nominal exchange rates with the US dollar and then divided by the respective GDP deflators. To make these values comparable between countries, the real oil price is converted again to US dollars at the average nominal exchange rate of 2000.

Sources: OECD Main Economic Indicators (data obtained from the International Statistical Yearbook database, update: May 2007) and OECD Economic Outlook (data obtained from the OECD Statistical Compendium database, update: May 2007).

Political variables

PolCycle	Political cycle indicator: it measures the phase of the political cycle, i.e. the proportion of the government term in office that elapsed at each quarter; the required dates of elections to compute this variable were collected from Armingeon *et al.* (2005) for the period 1960-2004 and updated for 2005 and 2006 with data from http://www.electionworld.org.
GovLeft	Dummy variable that takes the value of 1 if a left-wing government is in office during the last year, and 0 otherwise; this variable was computed from the variable *GovParty* in Armingeon *et al.* (2005); a government is labelled as left-wing when *GovParty* is equal to 4 or 5; data from the site http://www.electionworld.org was also used to update this variable.

Table A.4.1.3. Estimates for the Great Moderation using Summers' (2005) thresholds

Expansions	**All countries**			**EU countries**			**Non-EU countries**		
LnDur	0.584***	0.639***	0.632***	0.777***	0.697**	0.748**	0.467**	0.881**	0.791**
	(3.76)	(2.70)	(2.59)	(3.46)	(2.38)	(2.30)	(2.17)	(2.14)	(2.06)
*LnDur*GM*	-0.021	0.001		0.083	0.133		-0.098	-0.142	
	(-0.22)	(0.01)		(0.55)	(0.77)		(-0.78)	(-0.90)	
CLI(-1)		-0.158***	-0.158***		-0.154***	-0.151***		-0.272***	-0.271***
		(-4.56)	(-4.60)		(-3.52)	(-3.53)		(-3.89)	(-3.91)
DurPrev								0.290	0.293
								(1.60)	(1.58)
GPInv(-1)		-0.117*	-0.117*		-0.234**	-0.232**			
		(-1.68)	(-1.69)		(-2.38)	(-2.36)			
OilPr(-1)		0.012***	0.011***		0.013***	0.012***		0.031*	0.035*
		(2.85)	(2.73)		(2.82)	(2.64)		(1.84)	(1.89)
PeakUS		1.664***	1.661***		1.940***	1.927***			
		(3.65)	(3.65)		(3.89)	(3.85)			
D_GM			-0.074			0.207			-0.422
			(-0.16)			(0.34)			(-0.88)
q_1+q_2	0.563***	0.640**		0.860***	0.830**		0.368*	0.739**	
	(3.53)	(2.41)		(3.14)	(2.24)		(1.80)	(1.96)	
Log-L	-285.6	-127.1	-127.1	-131.3	-84.72	-85.00	-153.1	-66.38	-66.43
SBIC	686.9	375.4	375.4	325.9	256.5	257.1	362.3	204.1	204.2
N. Obs.	2242	1252	1252	1141	813	813	1101	658	658
N. Peaks	66	36	36	30	26	26	36	19	19
Contractions									
LnDur	1.954***	1.874***	1.678***	1.551***	1.665***	1.426***	2.342***	2.514***	2.363**
	(5.57)	(4.24)	(4.59)	(3.29)	(3.10)	(3.60)	(5.16)	(2.62)	(2.56)
*LnDur*GM*	-0.580**	-0.322		-0.266	-0.367		-0.816***	-0.293	
	(-2.33)	(-0.93)		(-0.64)	(-0.81)		(-3.24)	(-0.58)	
CLI(-1)		0.075*	0.074*		0.106*	0.112*		0.034	0.021
		(1.95)	(1.86)		(1.86)	(1.86)		(0.64)	(0.38)
DurPrev		0.027***	0.027***		0.033**	0.029*		0.023*	0.026**
		(2.87)	(2.71)		(2.31)	(1.91)		(1.66)	(2.13)
D_GM			-0.489			-0.797			-0.022
			(-0.77)			(-0.86)			(-0.03)
q_1+q_2	1.374***	1.552***		1.286***	1.298***		1.526***	2.281**	
	(5.21)	(4.10)		(3.80)	(3.18)		(3.78)	(2.29)	
Log-L	-154.0	-114.1	-114.3	-77.26	-66.50	-66.29	-75.55	-46.26	-46.45
SBIC	398.9	327.7	328.1	203.2	191.6	191.2	193.8	142.1	142.5
N. Obs.	430	348	348	223	206	206	207	142	142
N. Troughs	68	50	50	31	28	28	37	22	22

Notes: See Table 4.4, Table 4.8 and footnote 110.

Table A.4.1.4. Estimates for the GM in the U.S. using Summers'(2005) threshold

	Expansions		**Contractions**	
LnDur (q_1)	1.090**	1.052**	3.281***	3.490***
	(2.40)	(2.33)	(3.34)	(3.55)
*LnDur*GM* (q_2)	-0.460*		2.595*	
	(-1.81)		(1.68)	
D_GM		-1.618**		1.934**
		(-2.20)		(2.03)
q_1+q_2	0.629		5.877***	
	(1.14)		(2.62)	
Log-L	-36.36	-35.78	-12.63	-12.81
SBIC	88.64	87.49	35.84	36.20
N. Obs.	202	202	34	34
N. Peaks	10	10	-	-
N. Troughs	-	-	10	10

Notes: See Table 4.4, Table 4.8, Table 4.9 and footnote 111.

5. Can central banks' monetary policy be described by a linear (augmented) Taylor rule or by a nonlinear rule?

5.1. Introduction

Since the establishment, by Taylor (1993), of the linear algebraic interest rate rule that specifies how the Federal Reserve (Fed) of the United States (US) adjusts its Federal Funds rate to inflation and the output gap, several papers have emerged to test the validity of that rule for other countries and time periods.

Some studies have recently extended the Taylor rule by considering the effects of other variables in the conduct of monetary policy. One important extension is related to the inclusion of asset prices and financial variables in the rule.[112] This issue has caused a huge discussion in the literature: while some authors consider it important that central banks target asset prices, others disagree. To contribute to this discussion, we ask whether the basic Taylor rule could instead be augmented with an alternative variable that collects and synthesises the information from the asset and financial markets, i.e. whether central banks are targeting the relevant economic information contained in a group of financial variables and not simply targeting each financial variable *per se*. Thus, the first aim of this chapter is to estimate a linear Taylor rule for the Eurozone, US and United Kingdom (UK) augmented with a financial conditions index that captures the relevant economic information contained in some financial variables. The main innovation is that instead of relying on

[112] See, for example, Bernanke and Gertler (1999, 2001), Cecchetti *et al.* (2000), Chadha *et al.* (2004) and Driffill *et al.* (2006).

particular asset prices or financial variables, like other studies do, the index built in this chapter synthesises the relevant information provided by those variables in a single variable where the weight of each asset and financial variable is allowed to vary over time. In fact, the central bank may not be targeting a particular asset or financial variable all the time, but it is possible that it may target it in some occasions, i.e. when, for some reason, it acquires particular economic relevance. Thus, synthesising the information from several assets and financial variables in a weighted index permits to extract the particular economic relevance of each variable at each point in time and, therefore, to put together an amount of information that is more likely to be targeted by the central bank at any time.

The results from the estimation of a linear Taylor rule indicate that the European Central Bank (ECB) targets the information contained in the financial conditions index developed in this study, but the Fed and Bank of England (BOE) are not doing so; they only take into account one or two financial variables and clearly do not target asset prices. This is an interesting result that might help us to understand part of the story behind the recent credit crunch.

The traditional Taylor rule is an optimal policy rule that is derived from the minimization of a symmetric quadratic central bank's loss function assuming that the aggregate supply function is linear. However, in reality, this may not be the case and the central bank can have asymmetric preferences – i.e. it might assign different weights to negative and positive inflation and output gaps in its loss function – therefore, following not a linear but a nonlinear Taylor rule. Only very recently some studies started to consider these asymmetries or nonlinearities in the analysis of monetary policy.[113] This dissertation extends the analysis into two areas not yet explored by those studies. First, it applies, for the first time, a nonlinear model to the study of the ECB's monetary policy, where the presence of asymmetries is taken into account directly in the structure of the model. This procedure will permit an answer to the following questions: Can the ECB's monetary policy be characterized by a nonlinear Taylor rule, or more precisely, is the ECB reacting differently to levels of inflation above and below the target? Does the ECB attempt to hit the inflation target precisely or keep inflation within a certain range? Second, this study also extends the nonlinear specification of the Taylor rule with the financial conditions index used in the linear estimations to check whether, after controlling for nonlinearities, the ECB and the other two central banks are still (or not) reacting to the information contained in that index.

The results of the estimation of the nonlinear smooth transition regression model are very interesting. First, they show that the ECB's monetary policy is best described by a nonlinear monetary rule than by a linear Taylor rule: it only reacts actively to inflation when it is above 2.5%; and it only starts to react to the business cycle when inflation is stabilised, i.e. well below 2.5%. Although this estimated threshold is slightly higher than the official target of 2%, this is an empirical result that confirms quite remarkably the main principles of the ECB's monetary policy. Second, the results also show that the ECB – contrary to the other central banks – continues to consider the information contained in the financial index even after nonlinearities are controlled for. Third, we find weak evidence to reject the linear model for the US. However, we find enough evidence to reject it for the UK, where

[113] See Martin and Milas (2004), Taylor and Davradakis (2006), Assenmacher-Wesche (2006), Surico (2007a, 2007b) and Petersen (2007).

the BOE seems to be pursuing a target range of 1.8%-2.4% for inflation rather than the current official point target of 2%.

The remainder of this chapter is organized as follows: Section 5.2 presents a brief review of the literature on the Taylor rule. The specification used to estimate the linear Taylor rule is described in Section 5.3; this section also presents the data and analyses the empirical results of the estimation of that specification. The model used to estimate the nonlinear Taylor rule is presented and analysed in Section 5.4, as well as the results of its estimation. Section 5.5 emphasises the main findings of this chapter and concludes.

5.2. A brief review of the literature on the Taylor rule

This section intends to provide a brief review of the literature on the Taylor rule, emphasizing the main contributions that motivate the analysis presented in this chapter.

In its original form, the Taylor rule assumes that central banks use past or current values of inflation and output gap to set up the interest rate. However, in practice, they tend to rely on all available information – concerning the expected evolution of prices – when defining the interest rate. For that reason, Clarida *et al.* (1998, 2000) suggest the use of a forward-looking version of the Taylor rule where central banks target expected inflation and the output gap instead of past or current values of these variables. That practice allows the central bank to take various relevant variables into account when forming its forecasts.[114] They demonstrate its advantages in the analysis of the policy behaviour of the Fed and other influential

[114] Clarida *et al.* (1998, 2000) also suggest to include an interest rate smoothing in the estimation of the Taylor rule. The reasons for its inclusion are discussed below in the description of the model.

central banks. Fourçans and Vranceanu (2004) and Sauer and Sturm (2007) also stress the importance of considering a forward-looking Taylor rule in the analysis of the ECB's monetary policy.[115]

Some studies extend this linear rule by considering the effect of other variables in the conduct of monetary policy. For example, Fourçans and Vranceanu (2004) present some evidence of an ECB response to the exchange rate deviations from its average. A similar result is found by Chadha *et al.* (2004) for the Fed, Bank of England and Bank of Japan and by Lubik and Schorfheide (2007) for the central banks of Canada and England. Considering the role of money supply in the ECB reaction function, Fendel and Frenkel (2006) and Surico (2007b) conclude that it does not affect the ECB's behaviour directly but it is a good instrument to predict future inflation.

The role of asset prices is an important issue considered in some studies. However, no consensus was reached about whether the central bank should or should not target this kind of variables. Cecchetti *et al.* (2000), Borio and Lowe (2002), Goodhart and Hofmann (2002), Chadha *et al.* (2004) and Rotondi and Vaciago (2005) consider it important that central banks target asset prices and provide strong support and evidence in that direction. On the contrary, Bernanke and Gertler (1999, 2001) and Bullard and Schaling (2002) do not agree with an ex-ante control over asset prices. They consider that once the predictive content of asset prices for inflation has been accounted for, monetary authorities should not respond to movements in asset prices. Instead, central banks should act only if it is expected that

[115] However, on the other hand, Arestis and Chortareas (2006) are sceptical about characterizing the ECB's monetary policy in terms of a linear Taylor rule, mainly because the ECB's perception about the equilibrium real interest rate may have changed over its (short) life.

they affect inflation forecast or after the burst of a financial bubble in order to avoid damages to the real economy.

On the other hand, Driffill *et al.* (2006) analyse the interactions between monetary policy and the futures market in the context of a linear reaction function. They find evidence supporting the inclusion of futures prices in the central bank's reaction function as a proxy for financial stability. The issue of financial stability is also investigated by Montagnoli and Napolitano (2005). They build and use a financial conditional indicator that includes the exchange rate, share prices and house prices in the estimation of a Taylor rule for some central banks. Their results show that this indicator can be helpful in modelling the conduct of monetary policy. Considering these developments, our first aim is simply to estimate a linear Taylor rule for the Eurozone, US and UK, where the information from some financial variables is accounted for to shed some more light on its (un)importance.

In all the studies mentioned so far, the Taylor rule is considered as a simple linear interest rate rule that represents an optimal policy-rule under the condition that the central bank is minimising a symmetric quadratic loss function and that the aggregate supply function is linear. However, in reality, this may not be the case and the central bank can have asymmetric preferences and, therefore, follow a nonlinear Taylor rule. If the central bank is indeed assigning different weights to negative and positive inflation and output gaps in its loss function, then a nonlinear Taylor rule seems to be more adequate to explain the behaviour of monetary policy.[116] However, only recently the literature has started to consider nonlinear models or asymmetries in the analysis of monetary policy. Asymmetries in monetary policy can result from a nonlinear macroeconomic model (Dolado *et al.*, 2005), nonlinear central bank

[116] Additional reasons to consider a nonlinear reaction function are provided by Bordo and Jeanne (2002) and Chadha *et al.* (2004).

preferences (Dolado *et al.*, 2000, Nobay and Peel, 2003, Ruge-Murcia, 2003 and Surico, 2007a) or both (Surico, 2007b). In particular, Surico (2007b) studies the presence of nonlinearities in the ECB monetary policy for the period January 1999-December 2004, estimating a linear GMM model resulting from the derivation of a loss function with asymmetric preferences and considering a convex aggregate supply curve. He finds that output contractions imply larger monetary policy responses than output expansions of the same size, but no asymmetric response is found for inflation. With more data available and using a different model – more precisely, a nonlinear model – we expect to find evidence of an asymmetric response of the ECB to inflation as well.

The nonlinear monetary policy rule used in our analysis takes into account the asymmetries in the macroeconomic model and in the central bank preferences implicitly and generalizes the Taylor rule in the tradition of Clarida *et al.* (1998, 2000). Instead of simply relying on a linear model, *à la* Surico (2007b), where the asymmetries are accounted for by using products and cross products of inflation and output gap or by a separate analysis for inflation above or below the target, this study estimates a nonlinear model for monetary policy where the presence of asymmetries is taken into account directly in the structure of the model. Besides analysing monetary policy asymmetries, this procedure will permit an answer to the question of whether a central bank follows a point target or a target range for inflation.

Some studies have applied Markov-switching models to the study of monetary policy asymmetries or nonlinearities (Kaufmann, 2002, Altavilla and Landolfo, 2005, Assenmacher-Wesche, 2006). All find evidence of asymmetries, especially regarding the phases of the business cycle. In other words, they find that monetary authorities tend to have a different behaviour during recessions and expansions. Only Assenmacher-Wesche (2006) presents evidence of an asymmetric behaviour of monetary authorities (Fed, Bundesbank and BOE) to inflation above or below their targets. However, as these models assume that the regime switches are exogenous and driven by an unobservable process, it is not able to account for the intuition behind the nonlinear central bank behaviour. Like the linear models referred to above and used to capture asymmetries in the monetary policy, Markov-switching models are not able to establish whether a central bank follows a point target or a target range for inflation. Finally, it does not allow for a smooth transition between regimes, which is an important drawback and a considerable departure from reality especially when inflation-regimes are considered. In that case, regime transitions are not generally sudden but smooth.

Bec *et al.* (2000) use a smooth transition autoregressive specification to model monetary policy in the US, Germany and France allowing for monetary policy to vary between periods of booms and slumps. They find relevant evidence of a nonlinear behaviour of monetary authorities regarding the phases of the business cycle. Our study adopts a different perspective. Instead of focusing on nonlinearities from the output gap, we allow for monetary policy changes between periods of high and low inflation. Note that inflation is actually the most important variable targeted by the central banks analysed in this study, especially for the ECB and UK whose main objective is precisely to promote price stability. Furthermore, contrary to Bec *et al.* (2000), we allow for the possibility of interest rate smoothing.

To our knowledge, only Martin and Milas (2004) and Petersen (2007) have deeply focused their attention on models that allow for a smooth transition from a state of high inflation to a state of low inflation (and vice-versa) in the context of the Taylor rule. These models seem to provide a better framework to explain nonlinear policy behaviours because as they allow for endogenous regime switches – in contrast to the Markov-switching model – they offer economic intuition to understand the nonlinear policy behaviour of a central bank. Furthermore, they have the advantage of being capable of explaining why and when a central bank has changed its policy rule.

Martin and Milas (2004) apply a nonlinear quadratic logistic smooth transition model to the BOE's monetary policy. They concentrate their analysis on the policy of inflation targeting set up in 1992 and find evidence of nonlinearities in the conduct of monetary policy over the period 1992-2000.[117] They show that the UK monetary authorities attempt to keep inflation within a range rather than pursuing a point target and tend to react more actively to upward than to downward deviations of inflation away from the target range. The only shortcoming of the paper is that they do not provide a test for the adequacy of the model, i.e. the authors do not test the validity of their nonlinear model against a linear one or against other nonlinear alternatives. This is a key issue that we will cover in this study.

More recently, Petersen (2007) applies a simple logistic smooth transition regression model to the monetary policy of the Fed over the period 1985-2005 using a basic Taylor rule and finds the presence of nonlinearities: once inflation approaches a certain threshold, the Fed begins to respond more forcefully to inflation. However, Petersen (2007) does not take into account the degree of interest rate smoothing or the possibility of the Taylor rule being forward-looking. Therefore, a nonlinear

[117] Using a simple threshold autoregressive model, i.e. without allowing a smooth transition between high and low inflation regimes, Taylor and Davradakis (2006) also find evidence of nonlinearities in the conduct of monetary policy by the BOE over the period 1992-2003. In particular, they find that UK monetary authorities tend to react more actively to inflation when it is above target.

analysis considering those aspects in the Fed behaviour is needed.[118] We will provide such an analysis and extend the nonlinear monetary rule with other variables, like the ones that provide information on the financial conditions. Furthermore, using data for the Eurozone, this study will be, to our knowledge, the first to apply a nonlinear model with smooth regime transition to the study of the ECB's monetary policy.

5.3. Specification and estimation of the linear Taylor rule

A basic linear Taylor rule is specified and estimated in this section. We start by describing the rule in its contemporaneous and forward-looking versions. Then we proceed with its estimation for the Eurozone, the US and the UK. In Section 5.4 we will consider the case of a nonlinear rule.

5.3.1. The linear Taylor rule

The following rule was proposed by Taylor (1993) to characterise the monetary policy in the US over the period 1987-1992:

$$i_t^* = \bar{r} + \pi^* + \beta(\pi_t - \pi^*) + \gamma(y_t - y_t^*). \qquad \textbf{(5.1)}$$

This rule regards the nominal short-term interest rate (i^*) as the monetary policy instrument and assumes that it should rise if inflation (π) rises above its target (π^*) or if output (y) increases above its trend or potential value (y^*). Therefore, β indicates the sensitivity of interest rate policy to deviations in inflation from the

[118] Qin and Enders (2008) also consider such a model among the several (linear) models that they estimate for the Fed and where they allow for interest rate smoothing and forward-looking behaviour. Their aim is simply to examine the in-sample and out-of-sample properties of linear and nonlinear Taylor rules for the US economy. However, unlike Petersen (2007), they did not find evidence of significant nonlinearities in the Fed's behaviour during the period 1987-2005.

target and γ indicates the sensitivity of interest rate to the output gap. In equilibrium, the deviation of inflation and output from their target values is zero and, therefore, the desired interest rate (i^*) is the sum of the equilibrium real rate ($\bar{r}$) plus the target value of inflation.[119]

Taylor's (1993) original rule considers the deviation of inflation over the last four quarters from its target. However, in practice, central banks do not tend to target past or current inflation but expected inflation. For that reason, Clarida *et al.* (1998) suggest the use of a forward-looking version of the Taylor rule. This version allows the central bank to take various relevant variables into account when forming its inflation forecasts. Therefore, according to Clarida *et al.* (1998, 2000), the central bank's desired level for interest rate (i^*) depends on the deviation of expected inflation k periods ahead (in annual rates) from its target value and the expected output gap p periods ahead, which yields the following forward-looking Taylor rule:[120]

$$i_t^* = \bar{r} + \pi^* + \beta[E_t(\pi_{t+k} \mid \Omega_t) - \pi^*] + \gamma E_t[(y_{t+p} - y_{t+p}^*) \mid \Omega_t], \qquad \textbf{(5.2)}$$

where E is the expectations operator and Ω_t is a vector including all the available information for the central bank at the time it sets the interest rate.

According to the 'Taylor principle', for the monetary policy to be stabilizing the coefficient on the inflation gap (β) should exceed unity and the coefficient on the output gap (γ) should be positive. A coefficient greater than unity on the inflation gap means that the central bank increases the real rate in response to higher inflation,

[119] According to Clarida *et al.* (1998, 2000), both the equilibrium real rate and the inflation target are assumed to be constant.

[120] Although empirically motivated, this rule can also be obtained from the central bank's loss function under the assumption that the evolution of the economy is described by the New-Keynesian model. Annex 5.1 shows how the monetary rule can be derived in such a framework.

which exerts a stabilizing effect on inflation; on the other hand, β<1 indicates an accommodative behaviour of interest rates to inflation, which may generate self-fulfilling bursts of inflation and output. A positive coefficient on the output gap means that in situations in which output is below its potential a decrease in the interest rate will have a stabilizing effect on the economy.

A common procedure when estimating monetary policy reaction functions is to control for the observed autocorrelation in interest rates. This is usually done by assuming that the central bank does not adjust the interest rate immediately to its desired level but is concerned about interest rate smoothing. Several theoretical justifications are advanced in the literature for the inclusion of interest rate smoothing in the Taylor rule, like the fear of disruptions in the financial markets, the existence of transaction frictions, the existence of a zero nominal interest rate lower bound or even uncertainty about the effects of economic shocks. Thus, if the central bank adjusts interest rates gradually towards the desired level, the dynamics of adjustment of the current level of the interest rate to its target is generically given by:

$$i_t = \left(1 - \sum_{j=1}^{n} \rho_j\right) i_t^* + \sum_{j=1}^{n} \rho_j i_{t-j} \quad \text{with} \quad 0 < \sum_{j=1}^{n} \rho_j < 1, \tag{5.3}$$

where the sum of ρ_j captures the degree of interest rate smoothing and j represents the number of lags. The number of lags in this equation is generally chosen on empirical grounds so that autocorrelation in the residuals is absent.

Defining $\alpha = \bar{r} - (\beta - 1)\pi^*$, $\tilde{y}_{t+p} = y_{t+p} - y^*_{t+p}$ and inserting equation **(5.3)** into **(5.2)**, assuming that the central bank is able to control interest rates only up to an independent and identically distributed stochastic error (u), yields the following equation:

$$i_t = \left(1 - \sum_{j=1}^{n} \rho_j\right)\left[\alpha + \beta E_t(\pi_{t+k} \mid \Omega_t) + \gamma E_t(\tilde{y}_{t+p} \mid \Omega_t)\right] + \sum_{j=1}^{n} \rho_j i_{t-j} + u_t, \qquad \textbf{(5.4)}$$

which is the specification that is usually estimated in the literature. This rule can be easily extended to include an additional vector of other *m* explanatory variables (***x***) that may potentially influence interest rate setting. To do that we just need to add $\theta' E_t(x_{t+q} \mid \Omega_t)$ to the terms in square brackets in **(5.4)**, where θ is a vector of coefficients associated with the additional variables.[121] Eliminating the unobserved forecast variables from this equation, the policy rule can be rewritten in terms of realized variables:

$$i_t = \left(1 - \sum_{j=1}^{n} \rho_j\right)\left[\alpha + \beta \pi_{t+k} + \gamma \tilde{y}_{t+p} + \theta' x_{t+q})\right] + \sum_{j=1}^{n} \rho_j i_{t-j} + \varepsilon_t, \qquad \textbf{(5.5)}$$

where the error term ε_t is a linear combination of the forecast errors of inflation, output, the vector of additional exogenous variables and the disturbance u_t.[122]

Equation **(5.5)** will be estimated by the generalized method of moments (GMM). According to Clarida *et al.* (1998, 2000), this method is well suited for the econometric analysis of interest rate rules when the regressions are run on variables that are not known by the central bank at the decision-making moment. To implement this method, the following set of orthogonality conditions is imposed:

$$E_t\left\{ i_t - \left(1 - \sum_{j=1}^{n} \rho_j\right)\left[\alpha + \beta \pi_{t+k} + \gamma \tilde{y}_{t+p} + \theta' x_{t+q}\right] + \sum_{i=1}^{n} \rho_j i_{t-j} \middle| v_t \right\} = 0, \qquad \textbf{(5.6)}$$

[121] Note that *q* can be zero, positive or negative depending on the kind of additional variable(s) considered.

[122] For further details, see Clarida *et al.* (1998, 2000).

where $\boldsymbol{v}_t$ is a vector of (instrumental) variables within the central bank's information set at the time it chooses the interest rate and that are orthogonal with regard to ε_t. Among them we may have a set of lagged variables that help to predict inflation, the output gap and the additional exogenous variables, together with other contemporary variables that should not be correlated to the current disturbance u_t. An optimal weighting matrix that accounts for possible heteroscedasticity and serial correlation in ε_t is used in the estimation. Considering that the dimension of the instrument vector $\boldsymbol{v}_t$ exceeds the number of parameters being estimated, some overidentifying restrictions must be tested in order to assess the validity of the specification and the set of instruments used. In that context, Hansen's (1982) overidentification test is implemented: under the null hypothesis the set of instruments is considered valid; the rejection of orthogonality implies that the central bank does not adjust its behaviour to the information about future inflation and output contained in the instrumental variables. Since in that case some instruments are correlated with $\boldsymbol{v}_t$, the set of orthogonality conditions will be violated, which leads to a rejection of the model.

In practice, to proceed with the estimation of equation **(5.5)**, we consider the following reduced form:

$$i_t = \phi_0 + \phi_1 \pi_{t+k} + \phi_2 \tilde{y}_{t+p} + \varphi' x_{t+q} + \sum_{i=1}^{n} \rho_j i_{t-j} + \varepsilon_t, \qquad \textbf{(5.7)}$$

where the new vector of parameters is related to the former as follows: $(\phi_0, \phi_1, \phi_2, \varphi)' = \left(1 - \sum_{i=1}^{n} \rho_j\right)(\alpha, \beta, \gamma, \theta)'$. Therefore, given the estimates of the parameters obtained from **(5.7)**, we can recover the implied estimates of α, β, γ, and θ and the respective standard errors by using the delta method. Following Clarida *et al.* (1998), we consider the average of the observed real interest rate over the period in analysis as the equilibrium real interest rate. Hence, we can obtain an estimate of the implicit inflation target pursued by the central bank as follows: $\hat{\pi}^* = (\bar{r} - \hat{\alpha})/(\hat{\beta} - 1)$.

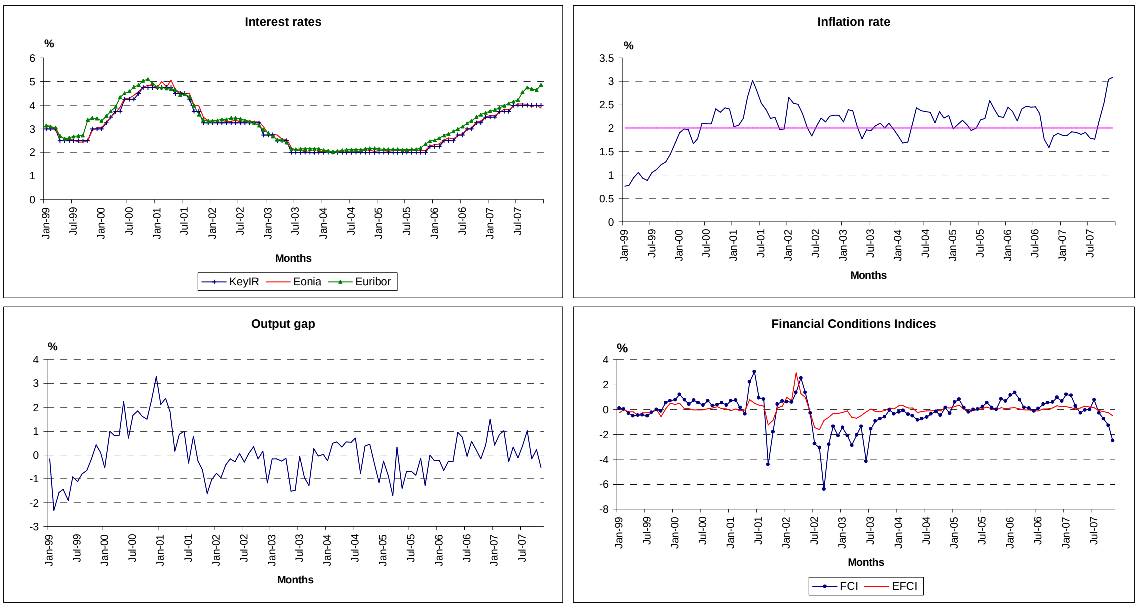
5.3.2. Data, variables and additional hypotheses to test

The data used in this study are monthly[123] and mostly obtained from the statistics published by the three central banks analysed here: ECB Statistics, Fred II for the Fed and BOE Statistics. Other sources are used, especially for data on the additional exogenous variables that we will consider in this study. A detailed description of all variables used in this analysis and respective sources is provided in Annex (see Table A.5.2.1). Figures 5.1 to 5.3 show the evolution of the main variables considered in this study for the analysis of the monetary policy followed by each central bank.

The sample covers the following periods: January 1999-December 2007 for the Eurozone, which corresponds to the period during which the ECB has been operating; October 1982-December 2007 for the US, a period that starts after what is considered in the literature as the 'Volcker's disinflation'; and October 1992-December 2007 for the UK, the period during which the BOE has been operating under inflation targeting.

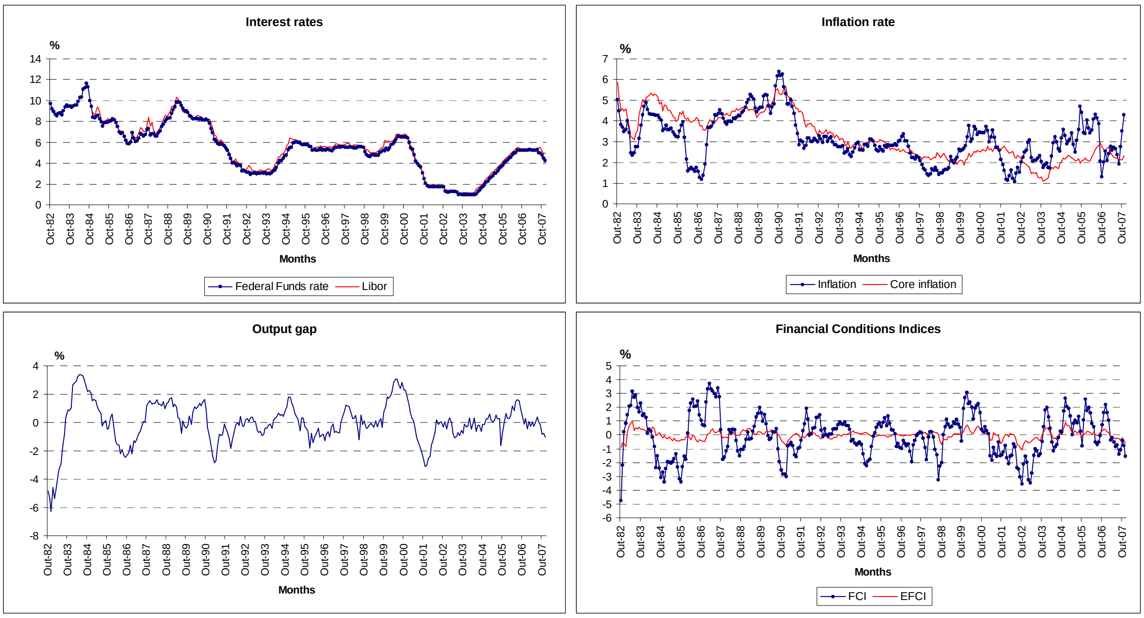
[123] The data are monthly because very few years of observations are available so far for the ECB. We could try to use quarterly data, but in that case we would end up with a small number of observations. As the GMM estimator tends to generate biased estimates in small samples, we prefer to use the more abundant monthly frequencies.

Figure 5.1. Evolution of the main variables used in the estimation of the monetary rule: Eurozone (Jan. 1999 – Dec. 2007)



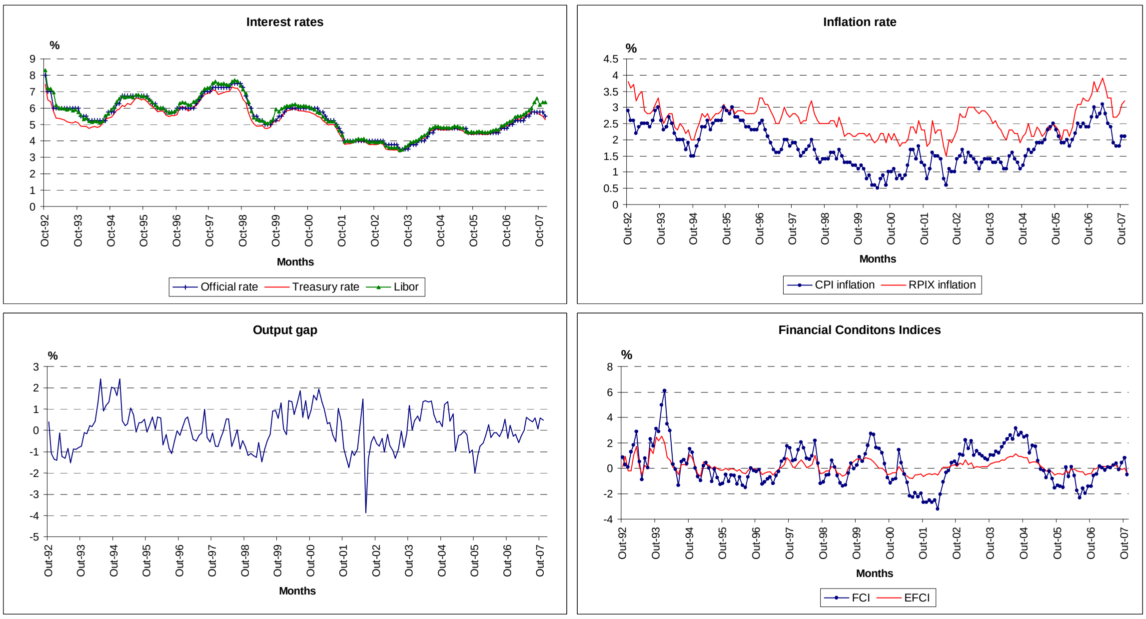
Sources: See Table A.5.2.1

Figure 5.2. Evolution of the main variables used in the estimation of the monetary rule: US (Oct. 1983 – Dec. 2007)



Sources: See Table A.5.2.1.

Figure 5.3. Evolution of the main variables used in the estimation of the monetary rule: UK (Oct. 1992 – Dec. 2007)



Sources: See Table A.5.2.1.

We consider several measures of interest rates and inflation. However, in the estimations we decided to choose the ones that have been followed more closely by each central bank and that permit an easy comparison of the estimation results between the three economies. For the Eurozone we use the Euro overnight index average lending rate (*Eonia*) as the policy instrument, which is the interest rate more directly related to the key interest rate (*KeyIR*) and that does not suffer from the discrete oscillations observed in the later (see Figure 5.1). The inflation rate is the annual rate of change of the harmonized index of consumer prices (*Inflation*), which is the main reference for the ECB monetary policy. The effective Federal Reserve funds rate (*FedRate*) is used in the estimation of the Taylor rule for the US. The inflation variable is the core inflation rate (*CoreInfl*), which excludes food and energy and that is considered as the definition of inflation that the Fed has been closely following (see Petersen, 2007). For the UK we use the three-month Treasury bill rate (*TreasRate*) as the nominal interest rate, which according to Martin and Milas (2004) and Figure 5.3 has a close relationship with the (various) official interest rate instruments used in the period analysed. The inflation rate variable is the annual rate of change of the consumer price index (CPI), which is the main current reference for the BOE's monetary policy.[124] Independently of the measures used for the interest rate or inflation, Figures 5.1 to 5.3 show that both variables have remained relatively stable and at low levels during almost all the period considered for each of the three economies analysed in this study. In all three cases, the output gap (*OutpGap*) is constructed by calculating the percentage deviation of the (log) industrial production index from its Hodrick-Prescott trend.[125] Figures 5.1 to 5.3 also illustrate its evolution over time.

For the estimation of the ECB monetary rule, we also consider the role of money supply. The primary objective of the ECB is price stability or, more precisely, to keep inflation below but close 2% over the medium term. However, its mandate is also based on an analytical framework based on two pillars: economic analysis and monetary analysis.[126] The output gap is used in our model to capture the behaviour of the economy; to control for the role of money we include in the model the growth rate of the monetary aggregate M3 (*M3*). In theory, we expect the ECB to increase the interest rate when *M3* is higher than the reference value of 4.5% defined by this

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[124] The former measure of inflation targeted by the BOE, i.e. the inflation rate computed from the retail price index excluding mortgage interest payments (RPIX inflation), will also be considered in the robustness analysis for the BOE's monetary policy.

[125] Industrial production is used as proxy for output because monthly data for GDP are not available, in particular, for the ECB. For the Fed and BOE we can find some monthly estimates for real GDP. Even so and regarding the unavailability of monthly GDP series for the ECB, we prefer to use, not estimates, but the data effectively observed and provided by the industrial production index (as a proxy for output) for comparative purposes.

[126] For details on the two-pillar approach see, for example, Arestis and Chortareas (2006).

institution for the growth of money. Whether this variable has indeed been targeted by the ECB or not is not clear and has been a matter of huge discussion to which this analysis tries to contribute.[127]

Financial variables and asset prices represent another group of variables that have recently been considered in the specification of the Taylor rule for the analysis of the behaviour of central banks. In this study we consider the effects of those variables not *per se* but including them in an index in which each of them will have a different weight. The weight depends on the relative economic importance of each variable at each particular moment in time. Thus, the next step is devoted to the construction of a financial conditions index (*FCI*) designed to capture misalignments in the financial markets. Some monetary and financial indices have been used in the literature as a measure of the stance of monetary policy and aggregate demand conditions. Therefore, it is expected that such indices can be able to capture current developments in the financial markets and give a good indication of future economic activity. Those indices may also contain some useful information about future inflationary pressures, which can then be taken into account by central banks in their reaction functions. Usually, the *FCI* is obtained from the weighted average of short-term real interest rate, real effective exchange rate, real share prices and real property prices.[128] The first two variables measure the effects of changes in the monetary policy stance on domestic and external demand conditions, whilst the other two collect wealth effects on aggregate demand.

In this analysis, besides computing the *FCI* we also construct a new and extended *FCI* (*EFCI*) from the weighted average of the real effective exchange rate, real share prices and real property prices plus credit spread and futures interest rate

[127] On this discussion see, for example, Fendel and Frenkel (2006) and Surico (2007b).

[128] See Goodhart and Hoofmann (2001).

spread.[129] Following Montagnoli and Napolitano (2005), we use a Kalman Filter algorithm to determine the weight of each asset. This procedure allows those weights to vary over time. Goodhart and Hoofmann (2001) propose other methodologies to compute financial indices – like the estimation of a structural VAR system or the simple estimation of a reduced-form aggregate demand equation – in which they assume that the weight associated with each variable is fixed. However, in reality, it is more likely that the economic agents' portfolios change with the business cycles. Hence, this study relaxes the assumption of fixed weights and allows for the possibility of structural changes over time. Moreover, we extend the *FCI* proposed in those two studies by considering the two additional financial variables indicated above. From the central bank's point of view, those variables may contain further relevant information regarding markets stability and expectations. The credit spread is considered as a good leading indicator of the business cycle and of financial stress; and the changes in futures interest rate spread provide an indication of the degree of volatility in economic agents' expectations that the central bank aims to reduce.[130]

To consider the importance of financial variables in the conduct of monetary policy, we extend Rudebusch and Svensson's (1999) model by adding those variables to the intertemporal equilibrium condition (which yields equation **(5.9)** below).[131] The general result is a simple backward-looking version of the model in which the economy is defined by the following two equations:

$$\pi_t = a_0 + \sum_{i=1}^{m_1} a_{1,i}\pi_{t-i} + \sum_{j=1}^{m_2} a_{2,j}\tilde{y}_{t-j} + \mu_t^s, \qquad \textbf{(5.8)}$$

[129] As the real interest rate is already incorporated in the monetary rule discussed above, it is not included in the construction of our *EFCI*.

[130] See Driffill *et al.* (2006) for the use of these two variables in the estimation of a Taylor rule for the US.

[131] For further details, see Goodhart and Hoofmann (2001) and Montagnoli and Napolitano (2005).

$$\tilde{y}_t = b_0 + \sum_{k=1}^{p} b_k \tilde{y}_{t-k} + \sum_{l=1}^{q} b_l rir_{t-l} + \sum_{i=1}^{5}\sum_{j=1}^{n_i} b_{ij} x_{i,t-j} + \mu_t^d, \qquad \textbf{(5.9)}$$

where *rir* is the de-trended real interest rate[132] and the financial variables (x) are the deviation from the long run equilibrium of, respectively:[133] the real exchange rate (*REER_gap*), where the foreign currency is in the denominator; real stock prices (*RStock_gap*); real house prices (*RHPI_gap*); the credit spread (*CredSprd*), computed as the spread between the 10-year government benchmark bond yield (*Yield10yr*) and the interest rate return on commercial corporate bonds; and the change in the spread (*ΔFutSprd*) between the 3-month interest rate futures contracts in the previous quarter (*FutIR*) and the current short-term interest rate. All these variables produce valuable financial information that can be compressed into a simple indicator and then included in the central banks' monetary rule to test whether and how they react to this information when they are setting up the interest rate.[134]

Allowing for the possibility that the parameters are evolving over time, this means that an unobservable change in any coefficient b_{ijt} can be estimated employing the Kalman filter over the state-space form of equation **(5.9)**:

$$\begin{aligned} \tilde{y}_t &= X\beta_t + \mu_t \qquad &\text{(measurement equation)} \\ \beta_t &= F\beta_{t-1} + \omega_t \qquad &\text{(transition equation)}, \end{aligned} \qquad \textbf{(5.10)}$$

where the error terms are assumed to be independent white noises with variance-covariance matrices given by $Var(\mu_t) = Q$ and $Var(\omega_t) = R$, and with $Var(\mu_t \omega_s) = 0$, for all t and s. X is the matrix of explanatory variables plus a

[132] The real interest rate is obtained by subtracting the inflation rate from the nominal short-term interest rate.

[133] The long run equilibrium values are computed using the Hodrick-Prescott filter.

[134] Unit root and stationarity tests reported below in Table 5.1 show that all these variables are stationary, as required, for the three economies.

constant; all variables are lagged one period. The state vector β_t contains all the slope coefficients that are now varying over time. As it is assumed that they follow a random walk process, the matrix *F* is equal to the identity matrix. The Kalman filter allows us to recover the dynamics of the relationship between the output gap and its explanatory variables. This recursive algorithm estimates the state vector β_t as follows:

$$\beta_{t|t} = F\beta_{t|t-1} + H_{t-1}X(X'H_{t-1}X + Q)^{-1}(\tilde{y}_{t-1} - X'F\beta_{t-1|t-1}), \qquad \textbf{(5.11)}$$

where $H_{t-1} = FP_{t-1|t-1}F' + R$, $P_{t|t} = H_{t-1} - H_{t-1}X(X'H_{t-1}X + Q)^{-1}ZH_{t-1}$ (which is the mean square error of β_t) and $\beta_{t|t-1}$ is the forecast of the state vector at period *t*, given the information available at the previous period (*t*-1). Using this filter we can now recover the unobservable vector of time-varying coefficients. The weights attached to each variable are then obtained as follows: $w_{x_{i,t}} = |\beta_{x_{i,t}}| \Big/ \sum_{k=1}^{5} |\beta_{x_{k,t}}|$, where $\beta_{x_{i,t}}$ is the estimated coefficient of variable x_i in period *t*. Hence, the extended financial conditions index at time *t* is computed as the internal product of the vector of weights and the vector of the five financial variables described above, i.e. $EFCI_t = w'_{x_t} \cdot x_t$.

The *EFCI* is then included in the monetary rule defined for each central bank. As this variable contains valuable information about the financial health of the economy, as well as information about future economic activity and future inflationary pressures, we expect a reaction of the central bank to changes in this variable. In particular, we expect an increase in interest rates when this indicator improves; on the contrary, more restrictive financial conditions would require an interest rate cut. Using such an index we are avoiding the critique formulated by some authors that central banks should not target asset prices. Central banks may not do that directly and at any time for each asset, but this study intends to show that they can extract some additional information from the evolution of those assets, as well as from other financial variables, when setting interest rates. Finally, as the economic relevance of these variables changes over time, we are also allowing for the possibility of central banks giving different importance to them over time.[135]

A final note regarding the data goes to the kind of data used: we use ex-post revised data. Orphanides (2001) claims that estimated policy reactions based on ex-post revised data can provide misleading descriptions of monetary policy. For that reason, he suggests the use of real-time data in the analysis of monetary policy rules, i.e. data that are available at the time the central bank takes its decision on the interest rate. However, Sauer and Sturm (2007) show that the use of real-time data for the Eurozone instead of ex-post data does not lead to substantially different results. In fact, as the quality of predictions for output and inflation has increased in the last few years, it is natural that those differences are less significant and less problematic nowadays, especially in the case of the Eurozone, which represents here the main object of study. For that reason we rely essentially on ex-post data in this analysis. However, in the robustness analysis we will provide some results with real-time inflation and output gap data for the Eurozone obtained from the ECB Monthly Bulletins.[136] As industrial production is the variable that is more frequently revised, we also try to overcome the revised-data problem in the three economies by including in the model an alternative variable that provides good information regarding the state of the economy but that does not suffer from revisions: the economic sentiment indicator (*EcoSent*). This variable is obtained from surveys on

[135] For a picture of the evolution of the *FCI* and *EFCI* over time, see Figures 5.1 to 5.3.

[136] See Sauer and Sturm (2007) for details on the construction of real-time data for the Eurozone.

consumers and firms designed to collect their opinion about the general economic situation (output, unemployment, prices, etc) for next year.

5.3.3. Empirical results

Before proceeding with the estimation of the model it is important to consider some issues. First, the sample period must be sufficiently long to contain enough variation in inflation, output and *EFCI* to identify the slope coefficients. Analysing Figures 5.1 to 5.3 and the descriptive statistics provided in Annex (Tables A.5.2.2 to A.5.2.4), we conclude that the output gap presents sufficient volatility in the three economies, but the low volatility of inflation for the Eurozone and UK suggests that the interest rate response to inflation must be carefully analysed since it may only represent the behaviour of the ECB and BOE in a period of relative inflation stability. The low volatility of *EFCI* in the three economies analysed also requires that we consider the results for this variable with a grain of salt.

Second, it is necessary that the variables included in the estimated model are stationary. Unit root and stationarity tests for the variables considered in this study are presented in Table 5.1.

Due to the low power and poor performance of these tests in small samples, we report the results of two different unit root tests (Dickey-Fuller, 1979 and Ng-Perron, 2001) and the results of the KPSS (1992) stationarity test to see whether the power is an issue. For the Eurozone, the power of unit root tests seems to be an issue. Due to the small sample period, they are unable to reject the unit root in some of the variables. However, the KPSS test is able to provide some evidence of stationarity for all variables (except *M3*) for the Eurozone. Most variables have also proved to be stationary for the UK and US.[137]

Table 5.1. Unit root and stationarity tests

	Eurozone			United States			United Kingdom		
	DF	**NP**	**KPSS**	**DF**	**NP**	**KPSS**	**DF**	**NP**	**KPSS**
Eonia	-0.604	-1.425	0.321^{+}						
Euribor3m	0.215	-0.868	0.295^{+}						
FedRate				-1.887	-0.547	1.450			
TreasRate							-4.425*	-0.864	0.730^{+}
Inflation	-2.723*	0.117	0.432^{+}				-2.718*	-1.246	0.482^{+}
CoreInfl				-2.277	-0.250	1.990			
OutpGap	-4.881*	-3.869*	0.095^{+}	-3.599*	-1.141	0.035^{+}	-6.210*	-5.136*	0.044^{+}
M3	1.593	0.529	0.927						
FCI	-4.236*	-3.512*	0.160^{+}	-4.711*	-1.640*	0.043^{+}	-4.430*	-3.346*	0.109^{+}
EFCI	-4.754*	-2.700*	0.048^{+}	-5.346*	-1.876*	0.033^{+}	-4.923*	-4.141*	0.214^{+}
REER_gap	-2.901*	-1.439	0.142^{+}	-4.509*	-2.429*	0.032^{+}	-3.579*	-2.006*	0.156^{+}
RStock_gap	-2.219	-2.457*	0.156^{+}	-4.791*	-2.460*	0.038^{+}	-3.989*	-3.305*	0.071^{+}
RHPI_gap	-2.368	-1.992*	0.087^{+}	-2.822*	-1.877*	0.031^{+}	-2.959*	-2.441*	0.050^{+}
CredSprd	-1.452	-1.175	0.157^{+}	-2.808*	-0.800	0.187^{+}	-1.227	-1.204	0.169^{+}
ΔFutSprd	-7.352*	-4.707*	0.229^{+}	-14.22*	-1.159	0.165^{+}	-9.625*	-0.812	0.195^{+}
EcoSent_gap	-1.678	-2.236*	0.067^{+}	-5.605*	-3.337*	0.062^{+}	-2.705*	-1.750*	0.027^{+}
RT_Inflation	-2.647*	-0.264	0.208^{+}						
RT_OutpGap	-3.951*	-2.475*	0.076^{+}						
1% crit.value	-3.507	-2.580	0.739	-3.456	-2.580	0.739	-3.482	-2.580	0.739
5% crit.value	-2.889	-1.980	0.463	-2.878	-1.980	0.463	-2.884	-1.980	0.463
10%crit.value	-2.579	-1.620	0.347	-2.570	-1.620	0.347	-2.574	-1.620	0.347

Sources: See Table A.5.2.1.

Notes: DF=Dickey-Fuller (1979) unit root test; NP=Ng-Perron (2001) unit root MZt test (the MZa, MSB and MPT tests yield similar results); KPSS=Kwiatkowski-Phillips-Schmidt-Shin (1992) stationarity test. The automatic Newey-West bandwidth selection procedure is used in the NP and KPSS tests and, in both cases, the autocovariances are weighted by the Bartlett kernel.

* unit root is rejected at a significance level of 10% => stationarity.

$^{+}$ stationarity is not rejected at a significance level of 10%.

The results of the estimation of the Taylor rule for the Eurozone for the period January 1999-December 2007 are reported in Table 5.2. The *t*-statistics are presented in parentheses and for each regression we compute the estimate of the implicit inflation target pursued by the ECB (π*). The adjusted R^2, Durbin-Watson

[137] The evidence is very weak to support the stationarity hypothesis for the interest rate and inflation for the US. Nevertheless, considering a longer time period we are able to find evidence of stationarity for those two variables. On this issue, see also Petersen (2007).

(DW) statistic for autocorrelation and the Schwartz Bayesian Information Criterion (SBIC) are also reported for each regression. The first column presents the results of a Taylor rule in the spirit of Taylor (1993), i.e. without allowing for either a forward-looking behaviour of the central bank or interest rate smoothing. Despite the estimates for *OutpGap* and π^* being reasonable, the results indicate that this simple model is unable to capture the reaction of the ECB to the inflation rate. This means that the ECB's monetary policy is not characterized by a basic linear Taylor rule. But it can be described by a monetary rule that takes into account future expectations – besides past and current information. Hence, we proceed with the estimation of a forward-looking Taylor rule for the Eurozone.

A generalized method of moments (GMM) estimator is used to estimate the forward-looking Taylor rule with interest rate smoothing. One lag of the interest rate is sufficient to eliminate any serial correlation in the error term (see DW statistic). The horizons of the inflation and output gap forecasts were chosen to be, respectively, one year (k=12) and 3 months (p=3). These horizons were selected using the SBIC and they seem to represent a sensible description of the actual way the ECB operates.[138]

[138] Results were not substantially different when other (shorter and longer) horizons were used.

Table 5.2. Results from the estimation of the linear monetary rule: Eurozone (January 1999-December 2007)

	Main estimation results							Robustness analysis				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Inflation	-0.045	2.774***	2.624***	2.322***	2.430***	1.179***	2.598***	1.337***	3.281***	1.651***		
	(-0.19)	(2.85)	(2.76)	(3.37)	(3.37)	(4.58)	(3.89)	(2.92)	(3.64)	(3.45)		
OutpGap	0.541***	1.991***	1.860***	1.717***	1.798***	1.153***	1.074***	1.099***		1.507***		
	(6.03)	(5.84)	(5.32)	(6.92)	(7.34)	(9.01)	(3.78)	(8.79)		(8.21)		
Eonia(-1)		0.948***	0.944***	0.947***	0.939***	0.953***	0.958***		0.953***	0.938***	0.950***	0.958***
		(101.3)	(87.7)	(125.0)	(101.6)	(175.5)	(141.6)		(93.2)	(108.7)	(84.3)	(127.1)
Euribor3m(-1)								0.947***				
								(116.5)				
M3			-0.083									
			(-0.93)									
FCI				0.534***								
				(3.73)								
EFCI					0.706**		1.561***	1.222***	0.911***	0.634***		1.758***
					(2.44)		(4.55)	(5.44)	(3.87)	(4.30)		(4.31)
REER_gap						0.122***						
						(3.37)						
RStock_gap						0.041***						
						(3.88)						
RHPI_gap						1.096***						
						(4.86)						
CredSprd						-0.271						
						(-1.27)						
Δ*FutSprd*						3.186***						
						(4.15)						
US_OutpGap							1.161***	0.648***				1.230***
							(4.59)	(3.67)				(4.14)
EcoSent_gap									0.347***	0.096***		
									(5.04)	(4.00)		
RT_Inflation											3.005***	2.018***
											(3.17)	(4.64)
RT_OutpGap											1.319***	0.632***
											(5.82)	(3.34)
π^*	2.05***	2.32***	2.22***	2.32***	2.42***	4.41	2.45***	2.68**	2.27***	2.65***	2.35***	2.62***
	(16.7)	(23.5)	(17.5)	(20.9)	(18.6)	(1.35)	(17.6)	(3.80)	(31.1)	(7.68)	(26.4)	(11.6)
Hansen *J*-stat.		17.5[0.953]	17.6[0.935]	16.5[0.985]	18.2[0.956]	22.1[0.999]	19.6[0.983]	19.8[0.987]	18.4[0.934]	19.1[0.981]	17.7[0.951]	20.3[0.978]
Adj. R^2	0.347	0.977	0.977	0.979	0.978	0.981	0.983	0.985	0.979	0.980	0.977	0.982
DW	0.37	2.21	2.20	2.34	2.32	2.51	2.57	1.50	1.96	2.40	2.10	2.51
SBIC	447.8	70.54	74.8	68.2	69.0	70.9	49.4	33.7	62.8	64.5	70.4	52.3

Notes: See Table A.5.2.1 in Annex for the sources. Column 1 presents the least square estimates of the following basic Taylor rule: $Eonia_t=\alpha+\beta^*Inflation_{t-1}+\gamma^*OutpGap_{t-1}+u_t$. A GMM estimator is used in the other regressions, where the horizons of the inflation and output gap forecasts are, respectively, 12 and 3 months (even when real time data is used); the other variables (except *US_OutpGap*) are all lagged one period to avoid simultaneity problems, i.e. $Eonia_t=(1-\rho)^*[\alpha+\beta^*Inflation_{t+12}+\gamma^*OutpGap_{t+3}+\boldsymbol{\theta}'\mathbf{x}_{t-1}]+\rho^*Eonia_{t-1}+\varepsilon_t$, where α, β, γ, and the vector $\boldsymbol{\theta}$ represent the estimated parameters; the respective standard errors are recovered from the estimated reduced form using the delta method. The set of instruments includes always a constant, 1-6, 9, 12 lagged values of the *Inflation*, *OutpGap*, *Yield10yr* and *M3*; identical lags of the other exogenous variables are also used when those variables are added to the equation. Robust standard errors (heteroscedasticity and autocorrelation-consistent) with Newey-West/Bartlett window and 3 lags were computed and the respective *t*-statistics are presented in parentheses; significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The estimate of π^* (=(r-α)/(β-1)) assumes that the long-run equilibrium real interest rate is equal to its sample average (here, r=1.02). The *p*-value of the Hansen's overidentification test is reported in square brackets. The Schwartz Bayesian Information Criterion is computed as follows: SBIC=N*ln(RSS)+k*ln(N), where k is the number of regressors, N is the number of observations and RSS is the residual sum of squares. DW is the Durbin-Watson statistic.

The set of instruments includes a constant and lags 1 to 6, 9 and 12 for *Inflation*, *OutpGap*, *Yield10yr* and *M3*.[139] To infer the validity of the instruments, we report the results from Hansen's (1982) overidentification test, i.e. the Hansen's *J*-statistic and the respective *p*-value. The validity of the instruments used is confirmed in any of the regressions presented in Table 5.2. Heteroscedasticity and autocorrelation-consistent standard errors are employed in all estimations.

Results for the baseline forward-looking estimation presented in column 2 show a significant reaction of the ECB to inflation: a one percentage point (p.p.) rise in expected annual inflation induces the ECB to raise the interest rate by substantially more than one p.p. Therefore, as the coefficient on inflation is greater than unity, the real interest rate increases as well in response to higher inflation and this will exert the desired stabilizing effect on inflation. Independently of its main concern about inflation, the ECB is also responding to the business cycle: a one p.p. increase in the output gap generates an interest rate increase of about two p.p.

We also obtain an interesting estimate of $\pi^*=2.32$, which indicates that the ECB's effective target for inflation is in practice only slightly higher than the 2% target announced in its definition of price stability. In fact, the data shown in Figure 5.1 for the evolution of inflation is consistent with this result: inflation is below (but close) to 2.3%-2.4% for most of the time, but generally above the 2% formal target. This means that the ECB was tough in setting the formal target for inflation to transmit the idea that it is highly concerned in controlling inflation (as the former

[139] We will see below that our results reject the hypothesis of *M3* being targeted by the ECB, but it has proved to be a good instrument for the forward-looking monetary rule for the ECB. In fact, movements in the monetary aggregates can be informative about future changes in prices, although their stabilization may not represent an independent policy goal. The 10-year government benchmark bond yield (*Yield10yr*) also contains good and useful past information about the future evolution of the interest rate to be included in the set of instruments.

German Bundesbank). But despite this toughness, its policy has allowed for some flexibility which permits to accommodate differences among the economies that constitute the Eurozone.[140]

Next we extend the baseline model by considering other factors that the central bank can take into account when setting the interest rate. According to the monetary pillar, the ECB should be considering the growth of M3 in its reaction function. However, no significant effect is detected from the inclusion of *M3* in the model (see column 3).[141] This result confirms the evidence provided by Fendel and Frankel (2006) and Surico (2007b) that the monetary aggregate is indeed not targeted by the ECB and should be excluded from the equation. But as this variable traditionally provides valuable information to forecast inflation, it constitutes an important variable to be considered in the set of instruments.

The inclusion of the financial conditions indices into the ECB's monetary rule provides a remarkable outcome: results indicate that the ECB is targeting not only inflation and the economic conditions but also financial conditions when defining the interest rate. The evidence provided in columns 4 and 5 of Table 5.2 shows that expansive financial conditions in the Eurozone are stabilized by an increase in the

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[140] Alternatively, if we assume that the target is really 2%, we can use it to estimate the equilibrium real rate (for different ways of estimating the natural equilibrium real interest rate see the discussion in Arestis and Chortareas, 2007). Our experiments provided estimates of around 0.5% for the regressions presented here, which can be considered a low value for the equilibrium real rate (see, for example, Fendel and Frenkel, 2006). This evidence reinforces the idea that the ECB may in fact be targeting a slightly higher value for inflation to accommodate asymmetric shocks that may affect the Eurozone countries differently. Another justification for this result can be the fact that the ECB may not be effective in communicating the idea to the economic agents that it is deeply interested in keeping inflation below 2%.

[141] In this case we are including in the estimation the variable *M3* minus the reference value of 4.5%, which is defined as the target for *M3* by the ECB. Results did not change even when we included in the regression the difference of (log) of M3 relative to its Hodrick-Prescott trend instead of *M3*-4.5%.

interest rate. For example, a unitary increase in the financial indicator developed in this study – *EFCI* – leads to an increase of about three quarters of a percentage point in the interest rate. As this index contains additional and valuable information concerning the evolution of future economic activity and about future inflationary pressures, targeting financial conditions is a way of the ECB also targeting inflation indirectly and avoiding financial imbalances that can be prejudicial for economic stability. This is a striking result and represents the first analysis providing evidence that the ECB is not only trying to promote monetary stability but, in doing so, it is also trying to promote the required financial stability. This means that the ECB's monetary policy can be explained by a Taylor rule augmented with information from financial conditions.

As mentioned in Section 5.2, there is a huge discussion in the literature about whether central banks should target financial variables and, in particular, asset prices. This chapter provides some evidence favouring the inclusion of the information contained in those variables in the monetary rule.[142] In general, existing studies deal with this issue by including each single asset price or financial variable independently in the model without taking into account the relative importance of each one at each particular moment in time. With the index used in this study, we overcome that problem and summarise all the information provided by those variables in a single indicator. This also avoids possible multicollinearity problems that may result from the inclusion of all those variables at the same time in a single regression. Nevertheless, to allow a direct comparison with other studies, column 6

[142] This evidence is in line with other works in the field, like Cecchetti *et al.* (2000), Borio and Lowe (2002), Goodhart and Hofmann (2002), Chadha *et al.* (2004), Rotondi and Vaciago (2005) and Driffill *et al.* (2006), for which asset prices and indicators of financial stress should be targeted by central banks.

provides the results of a regression that includes the components of *EFCI*. With the exception of the *CredSprd*, they all present a coefficient with the expected sign and are statistically significant.[143] However, the implicit target for inflation is very high and not significant, which can be a consequence of a multicollinearity problem.

Another interesting issue raised by this study is whether, besides the ECB is reacting to the Eurozone economic cycle, it is also responding to international economic conditions. To capture this effect, the US output gap is used as a proxy for the world economic cycle. The results indicate that the ECB takes into consideration the current state of the global economy when deciding on interest rates. In an open global economy, fears of imported inflation (or recession) resulting from a higher (lower) global economic growth above (below) the trend are counteracted by a higher (lower) interest rate in the Eurozone.

The next group of regressions was devised to analyse the robustness of the results presented so far. The first robustness test is related to the definition of the interest rate. We have been considering the *Eonia* interest rate as the policy instrument, but the main results are not substantially affected when we use the three months *Euribor* instead (see column 8). Only the implicit inflation target is higher than the expected, which confirms the use of *Eonia* as a sensible choice.

As industrial production is a variable that usually suffers from revisions, we include an alternative variable in the model to capture the reaction of the ECB to *expected* economic conditions (*EcoSent_gap*).[144] This variable is not affected by

[143] Note that a depreciation of the Euro above its trend, an increase in share and house prices above their trends and a higher departure of futures interest rate from the current interest rate all contribute to a significant reaction of the ECB to an increase in the interest rate.

[144] The variable *EcoSent_gap* is computed from the *EcoSent* variable in the same way as the output gap is computed from the industrial production. While *EcoSent* has a unit root, *EcoSent_gap* is stationary, as required.

revisions and provides good information regarding the expectations of economic agents about the state of economy at the time the central bank takes its decision on the interest rate. Results are presented in column 9 of Table 5.2 and show that the coefficient on the lag of this variable is positive and highly significant, as expected, and the other results are not substantially affected. Moreover, no major differences can be noticed even when we assume that the central bank is considering the economic information from both the *OutpGap* and *EcoSent_gap* simultaneously (see column 10). Results show that information from these two variables can be easily combined to take policy actions.

Finally, in columns 11 and 12 we use real-time data for inflation and output gap instead of ex-post revised data. However, as already shown by Sauer and Sturm (2007), the use of real-time data for the Eurozone, instead of ex-post data, does not lead to substantially different results.

In the next table, Table 5.3, we reproduce some of the main results obtained for the other two economies: US and UK. The sequence in which the results are presented is quite similar to the one used for the Eurozone. The estimates in columns US1 and UK1 were obtained from a basic Taylor rule. Such a rule produces quite good results for the US but not so impressive for the UK. While the coefficient on inflation is higher than 1 for the US, as expected, it is lower than 1 for the UK. In addition, note that both regressions suffer from a problem of autocorrelation (see DW). Moreover, it is expected that these central banks also tend to rely on all available information, which requires a GMM estimation of a forward-looking Taylor rule with interest rate smoothing.

Table 5.3. Results from the estimation of the linear monetary rule: US and UK

	United States (October 1982-December 2007)							United Kingdom (October 1992-December 2007)								
	US1	**US2**	**US3**	**US4**	**US5**	**US6**	**US7**	**UK1**	**UK2**	**UK3**	**UK4**	**UK5**	**UK6**	**UK7**	**UK8**	**UK9**
Inflation								0.532***	1.872***	1.971***	1.791***	1.377***	1.563***	1.809***	2.971***	0.610
								(3.27)	(4.89)	(4.59)	(4.02)	(3.60)	(6.62)	(5.81)	(2.73)	(1.43)
CoreInfl	1.632***	1.530***	1.462***	1.542***	1.556***	1.369**	2.759***									
	(11.5)	(5.18)	(4.71)	(5.53)	(5.80)	(2.12)	(3.00)									
OutpGap	0.356***	1.404***	1.314***	1.039***	1.203***		0.967**	0.264***	0.912***	0.839**	0.882**	0.865***	0.648***		1.727***	0.725***
	(2.59)	(2.77)	(2.61)	(2.71)	(2.96)		(2.15)	(2.85)	(2.80)	(2.43)	(2.10)	(2.94)	(3.01)		(2.97)	(3.02)
FedRate(-1)		1.430***	1.448***	1.471***	1.291***	1.739***	1.755***									
		(14.2)	(14.9)	(13.4)	(13.1)	(15.3)	(21.7)									
FedRate(-2)		-0.467***	-0.484***	-0.508***	-0.325***	-0.756***	-0.776***									
		(-4.73)	(-5.09)	(-4.73)	(-3.37)	(-6.85)	(-10.1)									
TreasRate(-1)									1.388***	1.396***	1.447***	1.456***	1.377***	1.318***	1.349***	1.577***
									(13.9)	(13.3)	(15.5)	(19.5)	(19.4)	(9.74)	(13.6)	(36.4)
TreasRate(-2)									-0.433***	-0.440***	-0.484***	-0.492***	-0.433***	-0.403***	-0.383***	-0.605***
									(-4.78)	(-4.69)	(-5.75)	(-6.96)	(-6.95)	(-3.29)	(-4.03)	(-15.3)
FCI			0.125							0.089						
			(0.56)							(0.63)						
EFCI				1.658							0.160					
				(1.29)							(0.39)					
CredSprd					1.242**							1.878***				
					(2.56)							(3.57)				
ΔFutSprd					4.734**											
					(2.14)											
US_OutpGap													0.135*			
													(1.82)			
EcoSent_gap						0.272								0.448***		
						(0.79)								(2.80)		
π^*	3.23***	3.52***	3.54***	3.56***	-1.36	3.54**	2.11***	1.80***	1.93***	1.93***	1.97***	-2.69	1.99***	1.74***	2.60***	2.05**
	(11.9)	(6.18)	(5.29)	(6.26)	(-0.44)	(2.27)	(10.5)	(6.48)	(7.80)	(8.17)	(6.31)	(-0.64)	(8.82)	(10.1)	(23.4)	(2.29)
Hansen *J*-stat.		20.3	21.6	21.9	24.9	16.2	13.2		22.2	21.6	22.4	26.5	32.2	17.8	21.1	18.6
		[0.441]	[0.485]	[0.407]	[0.635]	[0.299]	[0.868]		[0.771]	[0.710]	[0.664]	[0.739]	[0.951]	[0.852]	[0.822]	[0.910]
Adj. R^2	0.603	0.993	0.993	0.993	0.993	0.992	0.995	0.142	0.979	0.979	0.980	0.982	0.979	0.974	0.980	0.978
DW	0.06	2.18	2.22	2.29	2.18	2.57	2.48	0.10	1.73	1.73	1.91	2.11	1.68	1.17	1.87	2.31
SBIC	2010.5	754.0	759.2	745.9	753.7	808.3	66.6	927.4	234.7	238.9	228.2	213.0	241.4	275.4	226.6	28.8

Notes: See Table A.5.2.1 for sources. Columns US1 and UK1 present the least square estimates of a basic Taylor rule identical to the one estimated for the Eurozone. A GMM estimator is used in the other regressions; the horizons of the inflation and output gap forecasts for the US (UK) are, respectively, 12 (6) and 3 (0) months (these leads were chosen according to the SBIC); the other variables (except *US_OutpGap*) are all lagged one period to avoid simultaneously problems. The set of instruments for the US includes a constant, 1-6, 9, 12 lagged values of the *CoreInfl*, *OutpGap* and *Yield10yr*; the set of instruments for the UK includes a constant, 1-6, 9, 12 lagged values of the *RPI_Infl*, *OutpGap*, *Yield10yr* and *FCI*; identical lags of the other exogenous variables are also used when those variables are added to the equation. In these two cases, a second-order partial adjustment model fits the data better than the first-order model used for the Eurozone. Robust standard errors (heteroscedasticity and autocorrelation-consistent) with Newey-West/Bartlett window and 3 lags were computed and the respective *t*-statistics are presented in parentheses. The estimate of π^* assumes that the long-run equilibrium real interest rate is equal to its sample average (r=2.27 for the US and r=3.41 for the UK). The *p*-value of the Hansen's overidentification test is reported in square brackets. The variable for inflation used in regression UK8 is the RPIX inflation. Regressions in columns US7 and UK9 were estimated just over the period January 1999-December 2007 (for this period r=1.41 for US and r=3.13 for the UK). For further details see Table 5.2.

The results presented in Table 5.3 show that two lags of the interest rate are required to eliminate any serial correlation in the error term in the regressions for the US and UK (see DW). The horizons of the inflation and output gap forecasts for the US were chosen to be the same as the ones used for the Eurozone; for the UK, we have the contemporaneous value for the output gap and lead 6 for inflation. As in the estimations for the Eurozone, these horizons were selected using the SBIC. The set of instruments for the US includes a constant and lags 1 to 6, 9 and 12 of *CoreInfl*, *OutpGap* and *Yield10yr*; for the UK, it includes a constant and lags 1 to 6, 9 and 12 of *RPI_Infl*, *OutpGap*, *Yield10yr* and *FCI*. The validity of these instruments is confirmed by the Hansen's *J*-test in any of the GMM estimations.

The results are consistent with the Taylor rule for both countries: the coefficients on inflation are consistently higher than unity and statistically significant, as required; and the coefficients on the output gap are positive and statistically significant, as expected. The results also indicate that the Fed has been following an average target for inflation of about 3.5% from October 1982 to December 2007, while the BOE has been following an inflation target of about 2% in the period October 1992-December 2007, which is in line with the current inflation target pursued by this central bank.

Contrary to the ECB, these two central banks are not targeting financial conditions, as shown by the insignificant coefficients on *FCI* and *EFCI* in both cases. However, some components of the extended index seem to be considered by those central banks. As pointed out by Driffill *et al.* (2006), this work confirms that the Fed reacts to the expected future evolution of interest rates. Results show that it also reacts to the information provided by the credit spread variable. On the one hand, the Fed aims to reduce the volatility of the spread between the futures and current interest rates, which induces it to follow the pace of the futures market. On the other hand, when the long-term government bond yield rate is above the corporate bond yield rate – which means an expected improvement of the economic conditions and consequent inflationary pressures in the future – the Fed reacts by increasing the interest rate. The second effect is also found for the BOE, but not the first. Moreover, we found no evidence that these two central banks are targeting the evolution of the exchange rate or asset prices,[145] a result that is in line with the arguments advanced by Bernanke and Gertler (1999, 2001) and Bullard and Schaling (2002) on this matter.

These results bring about an important conclusion of this study: while the ECB is targeting financial conditions in general to avoid imbalances in the asset and financial markets and, in the limit, in the monetary market, the Fed and BOE are not so worried about the financial conditions and let the financial markets, in particular the asset markets, act free from any direct control. This different behaviour seems to be well evident in the recent credit crunch that arose in the US housing market and that quickly spread to the UK. Due to the integration of global markets, indirect repercussions are also felt in the Eurozone, but its asset markets (and the economy, in general) have shown more initial resistance to the credit crisis than their counterparts in the US and even in the UK. Thus, targeting financial conditions might be a solution to avoid imbalances in the financial and asset markets and, consequently, to avoid a sharp economic slowdown.

Results from column UK6 indicate that, as in the Eurozone, the international economic conditions (proxied by the US output gap) seem to be taken into account in the monetary rule for the BOE as well. However, in this case the statistical evidence

[145] As the coefficients on these variables have not proved to be statistically significant – either when included individually or in group – they were not included in the estimations reported here.

is much weaker. We also include the *EcoSent_gap* instead of *OutpGap* in the regressions US6 and UK7, to avoid the data revision problems that affect the output gap. The main results do not change, but the coefficient on the lag of *EcoSent_gap* for the US regression is not significant, which may mean that the Fed is not relying on consumers' and firms' economic sentiment as it relies on real output forecasts.

The results presented in column UK8 were obtained using a different variable for inflation, which is computed from the retail prices index excluding mortgage interest payments (RPIX). Results remain consistent relatively to the Taylor principle and the estimated target for (RPIX) inflation is now 2.6%, which is remarkably close to the official target of 2.5% that had been defined for RPIX inflation.[146]

Finally, to compare the monetary policy of the three central banks analysed here in the same time period, we estimate a regression for the US and UK using data for the period January 1999-December 2007 (see columns US7 and UK9).[147] The estimated target for the US inflation is now 2.1%, which indicates a stronger concern by the Fed in keeping inflation low during this period. In general, the results for the US are quite similar to the ones obtained for the Eurozone and respect the Taylor principle. However, the estimated model for the UK – despite presenting reasonable estimates for the implicit inflation target (2.05%) and for the coefficient on the output gap – does not show a stabilizing reaction of the BOE to the inflation rate. In reality, the coefficient on inflation does not respect the Taylor principle and it is not statistically significant. One reason might be the fact that inflation has remained

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[146] RPIX inflation was the measure of inflation targeted by the BOE before changing to the CPI inflation in 2003. But, as the time-span used in this study goes beyond 2003 and as results using CPI inflation have shown more robust to the inclusion of additional regressors, the current reference for the BOE's monetary policy – the CPI – is preferred to the former – the RPIX.

[147] Note that as operational independence was granted to the BOE in May 1997, this time-span also covers most of the period during which it has operated independently of the government control.

below the inflation target defined by the BOE for most of the time during the period 1999-2007 (see Figure 5.3), which makes it difficult to detect a significant reaction of the BOE to this variable.[148]

In sum, after analysing the results from the estimation of the linear Taylor rule for the ECB, Fed and BOE, we conclude that the monetary policy followed by these three central banks can be described by a forward-looking linear Taylor rule, which in the case of the Eurozone is clearly augmented by a composite indicator of financial variables. However, an important question remains: Is the monetary policy of these central banks indeed described by a linear Taylor rule or can their behaviour be instead characterized by a more complex nonlinear monetary rule? The next section is devoted to answering this question.

5.4. Specification and estimation of the nonlinear Taylor rule

A forward-looking nonlinear Taylor rule is specified and estimated in this section. We start by presenting the nonlinear model and a test to detect the presence of nonlinearities. For cases in which the nonlinearity is not rejected, we proceed with the estimation of the respective nonlinear specifications.

5.4.1. The nonlinear Taylor rule

The Taylor rule presented and estimated above is a simple linear interest rate rule that represents an optimal policy-rule under the condition that the central bank is minimising a symmetric quadratic loss function and that the aggregate supply

[148] Moreover, no further significant evidence was found from the inclusion of the *EFCI* or its components in some experimental regressions (not reported here) for the US and the UK for this shorter time period.

function is linear. However, in reality, this may not be the case and the central bank can be responding differently to deviations in aggregate variables from their targets. If the central bank is indeed assigning different weights to negative and positive inflation and output gaps in its loss function, then a nonlinear Taylor rule seems to be more adequate to explain the behaviour of monetary policy.[149] Moreover, inflation and the output gap tend to show an asymmetric adjustment to the business cycle. It is well known that output exhibits short and sharp recessions over the business cycle, but long and smooth recoveries (see Chapter 4). Inflation also increases more rapidly than it decreases over the business cycle.[150] Under those circumstances it is natural that the central bank has to respond differently to levels of inflation and output above, below or around the required targets. These arguments emphasize the importance of considering a nonlinear Taylor rule in the analysis of the central bank's behaviour.

To explain this non-linear behaviour, we have to consider non-linear time series models. The main options are the Markov-switching and the smooth transition regression (STR) models. Some studies in this field have employed the first model (see Section 5.2 for details), but as this assumes that the regime switches are exogenous and driven by an unobservable process, it is not able to account for the intuition behind the nonlinear central bank behaviour. On the other hand, as the STR model allows the regression coefficients to change smoothly from one regime to another, it provides a better structural framework to explain a nonlinear policy behaviour. Allowing for endogenous regime switches – in contrast to the Markov-switching models – it also provides economic intuition for the nonlinear policy

[149] See Nobay and Peel (2003), Ruge-Murcia (2003), Dolado *et al.* (2005) and Surico (2007a, 2007b).

[150] See, for example, Hamilton (1989) and Neftçi (2001).

behaviour of the central bank and it is able to explain why and when the central bank changes its policy rule.

Although three versions of this model have been applied to the study of the behaviour of some relevant central banks by Bec *et al.* (2000), Martin and Milas (2004) and Petersen (2007), no study has yet applied such a model to the analysis of the policy behaviour of the ECB.[151] This study intends to do so by providing, at the same time, a comparative analysis between the monetary policy followed by the ECB and the one followed by the Fed and the BOE. Additionally, this study extends the existing papers on nonlinear Taylor rules by controlling for financial conditions.

A standard STR model for a nonlinear Taylor rule can be defined as follows:[152]

$$i_t = \psi' z_t + \omega' z_t G(\eta, c, s_t) + \varepsilon_t, \qquad t = 1,...,T \qquad \textbf{(5.12)}$$

where $z_t = (1, i_{t-1},..., i_{t-n}; \pi_t, \tilde{y}_t; x_{1,t},..., x_{m,t})'$ is the vector of the explanatory variables, with h=n+2+m. The parameters $\psi = (\psi_0, \psi_1,..., \psi_h)'$ and $\omega = (\omega_0, \omega_1,..., \omega_h)'$ represent ((h+1)×1) parameter vectors in the linear and nonlinear parts of the model, respectively.[153] The disturbance term is assumed to be independent and identically distributed with zero mean and constant variance, $\varepsilon_t \sim iid(0, \sigma^2)$. The transition function $G(\eta,c,s_t)$ is assumed to be continuous and bounded between zero and one in the transition variable s_t. As $s_t \rightarrow -\infty$, $G(\eta,c,s_t) \rightarrow 0$ and as $s_t \rightarrow +\infty$, $G(\eta,c,s_t) \rightarrow 1$. The transition variable, s_t, can be an element or a linear combination of z_t or even a deterministic trend.

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[151] The presence of nonlinearities in the ECB monetary policy was studied by Surico (2007b), but without estimating a nonlinear model.

[152] For further details, see Granger and Teräsvirta (1993), Teräsvirta (1998) and van Dijk *et al.* (2002).

[153] Some of these parameters may be zero a priori.

A few definitions have been suggested for the transition function in the literature. We start by considering $G(\eta,c,s_t)$ as a logistic function of order one:

$$G(\eta,c,s_t)=[1+\exp\{-\eta(s_t-c)\}]^{-1}, \qquad \eta>0. \tag{5.13}$$

This kind of STR model is called a logistic STR model or an LSTR1 model. This transition function is a monotonically increasing function of s_t, where the slope parameter η indicates the smoothness of the transition from one regime to another, i.e. how rapid the transition from zero to unity is, as a function of s_t. Finally, the location parameter c determines where the transition occurs.

Considering this framework, the LSTR1 model can describe relationships that change according to the level of the threshold variable. Assuming that the transition variable is the level of inflation ($s_t=\pi_t$), then the LSTR1 model is able to describe an asymmetric reaction of the central bank to a high and to a low inflation regime. Given the important weight that the central banks analysed in this study put on inflation, we expect to find significant differences in the behaviour of these banks when (expected) inflation is deviating considerably from a certain threshold.

The STR model is equivalent to a linear model with stochastically time-varying coefficients and, as so, it can be rewritten as:

$$i_t=[\psi'+\omega'G(\eta,c,s_t)]z_t+\varepsilon_t \Leftrightarrow i_t=\zeta' z_t+\varepsilon_t, \qquad t=1,...,T. \tag{5.14}$$

Given that $G(\eta,c,s_t)$ is continuous and bounded between zero and one, the combined parameters, ζ, will fluctuate between ψ and $\psi+\omega$ and change monotonically as a function of s_t. The more the transition variable moves beyond the threshold, the closer $G(\eta,c,s_t)$ will be to one, and the closer the parameters ζ will be to $\psi+\omega$;

similarly, the further s_t approaches the threshold, c, the closer the transition function will be to zero and the closer the parameters ζ will be to ψ.[154]

As a monotonic transition may not be a satisfactory alternative, this study will also consider (and test for) the presence of a non-monotonic transition function, in line with the work of Martin and Milas (2004). In fact, central banks may not consider a simple point target for inflation but a band or an inner inflation regime, where inflation is considered under control and, consequently, the reaction of the monetary authorities will be different from a situation where inflation is outside that regime.

The non-monotonic alternative function to consider is the following logistic function of order two:

$$G(\eta, c, s_t) = [1 + \exp\{-\eta(s_t - c_1)(s_t - c_2)\}]^{-1}, \qquad \textbf{(5.15)}$$

where $\eta>0$, $c=\{c_1,c_2\}$ and $c_1 \geq c_2$. This transition function is symmetric around $(c_1+c_2)/2$ and asymmetric otherwise, and the model becomes linear when $\eta \to 0$. If $\eta \to \infty$ and $c_1 \neq c_2$, $G(\eta,c,s_t)$ becomes equal to zero for $c_1 \leq s_t \leq c_2$ and equal to 1 for other values; and when $s_t \to \pm\infty$, $G(\eta,c,s_t) \to 1$. To distinguish this STR model from the one specified above, we call this the quadratic logistic STR model or LSTR2 model.[155] Considering inflation as a transition variable, this model allows us to estimate separate lower and upper bands for the inflation instead of a simple target value (which in practice may not be easy to reach every time).

[154] Note that when $\eta \to 0$, the logistic transition function converges to 0.5 and the model is linear; when $\eta \to \infty$, the LSTR1 model becomes a two regime switching regression model.

[155] When $c_1=c_2$, the transition function is symmetric and the model is called exponential STR (ESTR).

5.4.2. Linearity versus nonlinearity

Before proceeding with the estimation of the nonlinear model, it is important to test whether the behaviour of monetary policy in a particular country can really be described by a nonlinear Taylor rule. This implies testing linearity against the STR model.[156] The null hypothesis of linearity is H_0: $\eta=0$ against H_1: $\eta>0$. However, neither the LSTR1 model nor the LSTR2 model are defined under this null hypothesis; they are only defined under the alternative. Teräsvirta (1998) and van Dijk *et al.* (2002) show that this identification problem can be solved by approximating the transition function with a third-order Taylor-series expansion around the null hypothesis. This approximation yields, after some simplifications and re-parameterisations, the following auxiliary regression:

$$i_t = \beta_0' z_t + \beta_1' \tilde{z}_t s_t + \beta_2' \tilde{z}_t s_t^2 + \beta_3' \tilde{z}_t s_t^3 + \varepsilon_t^*, \qquad t = 1,...,T, \tag{5.16}$$

where $\varepsilon_t^* = \varepsilon_t + \omega' z_t R_3(\eta, c, s_t)$, with the remainder $R_3(\eta,c,s_t)$, and $z_t = (1, \tilde{z}_t')'$ where $\tilde{z}_t$ is a $(h\times1)$ vector of explanatory variables. Moreover, $\beta_j = \gamma\tilde{\beta}_j$, where $\tilde{\beta}_j$ is a function of ω and c. The null hypothesis of linearity becomes: H_{01}: $\beta_1=\beta_2=\beta_3=0$, against the alternative H_{11}: "at least one $\beta_j\neq0$, j=1,2,3". A simple Lagrange-multiplier test can be used to investigate this hypothesis, because under the null: $u_t^* = u_t$. The resulting asymptotic distribution is χ^2 with $3h$ degrees of freedom under the null.[157] If linearity is rejected, we can proceed with the estimation of the nonlinear model. But, which transition function should be employed? The decision between an LSTR1 and an LSTR2 model can be made from the following sequence of null hypotheses based

[156] These tests require that the errors are uncorrelated with z_t and s_t, and that all the variables are stationary. Stationarity tests are provided in Table 5.1.

[157] See Teräsvirta (1998) for further details.

on the auxiliary regression **(5.16)**: H_{02}:β_3=0; H_{03}:β_2=0|β_3=0; and H_{04}:β_1=0|β_3=β_2=0. Granger and Teräsvirta (1993) show that the decision rule works as follows: if the *p*-value from the rejection of H_{03} is the lowest one, choose an LSTR2 model; otherwise, select an LSTR1.

5.4.3. Empirical results

The empirical work presented in this section provides clear evidence that the monetary policy followed by the ECB and by the BOE can be described by a nonlinear Taylor rule, but the evidence is not so clear regarding the behaviour of the Fed. The results of the linearity tests provided at the bottom of Table 5.4 (see line H_{01}) – where (expected) inflation is the threshold variable – show that we can reject the linearity hypothesis at a level of significance of 5% for the ECB and BOE, but only at 10% for the preferred model for the Fed.

Inflation is chosen to be the threshold variable because of the important weight central banks put on this variable and also because this variable has provided the lowest *p*-value for the rejection of the linear model.[158] The tests for the choice of the transition function are also presented in the bottom of Table 5.4 (see lines H_{02}, H_{03} and H_{04}) and indicate that an LSTR1 fits better to the Eurozone, while an LSTR2 model is more adequate for the UK (and the US). This means that the ECB is pursuing a point target, while the BOE (and perhaps the Fed) are attempting to keep inflation within a certain range.

[158] Teräsvirta (1998) argues that if there is no reason to choose one variable over any other to be the threshold variable, and if nonlinearity is rejected for more that one transition variable, the variable presenting the lowest *p*-value for the rejection of linearity should be chosen to be the transition variable. In this study, we also tried the output gap and the *EFCI* as transition variables but the *p*-value for the rejection of the linear model was higher than for inflation and, in most of those cases, the linearity hypothesis was not rejected.

The first results presented in Table 5.4 (EZ1, US1 and UK1) were obtained from the nonlinear least squares estimation of a simple nonlinear Taylor rule without allowing for a forward-looking behaviour or interest rate smoothing (see notes in Table 5.4). The best fitting model is found by sequentially eliminating insignificant regressors by using the SBIC measure of fit. The results indicate that the ECB is reacting to inflation – according to the Taylor principle, $\omega_{\pi}>1$ – only when it reaches values above 2%, which remarkably coincides with the ECB's target for inflation and with the implicit target for inflation estimated in the linear version.[159] When inflation is well below 2%, the ECB does not react to inflation directly, but reacts to the inflationary pressures that may arise through the economic cycle. In this case, the ECB's reaction to the output gap seems to become stronger when inflation grows above the 2% target.[160]

Instead of pursuing a point target (of 2%) for inflation like the ECB, the Fed and BOE try to keep inflation within, respectively, the 2.04%-3.67% and 1.61%-1.99% ranges, according to this basic nonlinear Taylor rule. Results show that when inflation is inside those ranges, these two central banks only react to output; and they only react to inflation when it is outside these ranges. However, the reaction of the BOE does not obey to the Taylor principle (note that $\omega_{\pi}<1$).

[159] Note that when inflation is above 2%, for each percentage point increase in inflation, the ECB will react by increasing the nominal interest rate by about 1.14 percentage points. As the coefficient on inflation is higher than one this implies that the real interest rate will increase as well, which means that the monetary behaviour of the ECB will exert the required and desired stabilizing effect over inflation.

[160] Note that one additional advantage of using this nonlinear model is that we do not need to make any assumption about the equilibrium real interest rate to estimate the (implicit) target for inflation.

Table 5.4. Results from the estimation of the nonlinear monetary rule

	Eurozone				United States		United Kingdom		
	EZ1	**EZ2**	**EZ3**	**EZ4**	**US1**	**US2**	**UK1**	**UK2**	**UK3**
ψ_0	3.156***	-0.397	2.636***	2.820***	4.806***	-1.712**	5.536***	2.063*	3.357***
	(19.9)	(-0.12)	(14.9)	(12.4)	(14.9)	(-2.03)	(11.0)	(1.71)	(2.92)
ψ_π		1.353							
		(0.87)							
ψ_y	0.347***	2.091***	1.979***	3.091***	0.303**	0.555*	0.257***	1.301**	1.136***
	(3.56)	(4.36)	(4.67)	(3.63)	(2.24)	(1.77)	(2.62)	(2.30)	(3.59)
ψ_{efci}		0.092**	0.537*						
		(2.34)	(1.71)						
ψ_{cs}									1.031*
									(1.72)
ρ		0.963***	0.960***	0.974***					
		(112.6)	(110.8)	(130.9)					
ρ_1						1.500***		1.258***	1.267***
						(11.6)		(11.6)	(14.4)
ρ_2						-0.561***		-0.295***	-0.289***
						(-4.37)		(-2.80)	(-3.54)
ω_0	-2.784***				-6.117***		-1.388**		
	(-3.08)				(-9.51)		(-2.28)		
ω_π	1.139***	1.164*	1.190**	1.169***	1.974***	2.537***	0.541**	2.356**	2.415***
	(2.88)	(1.83)	(2.38)	(2.59)	(13.5)	(7.52)	(3.28)	(2.52)	(2.82)
ω_y	0.321**	-2.483*	-1.639						
	(2.45)	(-1.82)	(-1.47)						
η	21.19	95.04	98.60	15.9	7.22	8.55	64.33	5.61	2.79
	{29.26}	{651.3}	{353.0}	{23.47}	{7.00}	{7.01}	{1490.1}	{6.64}	{3.13}
c	1.99***	2.47***	2.47***	2.41***					
	(45.0)	(190.3)	(197.7)	[72.4]					
c_1					2.04***	3.10***	1.61***	1.79***	1.75***
					(20.0)	(13.3)	(9.96)	(9.67)	(5.53)
c_2					3.67***	3.68***	1.99***	2.35***	2.37***
					(10.0)	(12.2)	(9.87)	(22.4)	(21.4)
$\psi_\pi+\omega_\pi$		2.517*							
		(1.78)							
$\psi_y+\omega_y$	0.668***	-0.392	0.340						
	(7.30)	(-0.31)	(0.33)						
Hansen		16.4	16.3	17.5		18.9		18.8	24.3
J-stat.		[0.927]	[0.947]	[0.983]		[0.331]		[0.804]	[0.912]
Adj. R^2	0.407	0.978	0.978	0.978	0.632	0.992	0.145	0.977	0.980
DW	0.54	2.27	2.36	2.30	0.09	1.98	0.15	1.50	1.60
SBIC	452.0	83.7	77.3	72.6	2006.2	817.0	942.5	262.0	247.0
H_{01}	0.000	0.037	0.037	0.000	0.000	0.092	0.001	0.075	0.023
H_{02}	0.053	0.004	0.004	0.003	0.274	0.646	0.187	0.224	0.016
H_{03}	0.045	0.300	0.300	0.121	0.061	0.054	0.055	0.095	0.005
H_{04}	0.014	0.180	0.180	0.019	0.117	0.042	0.562	0.424	0.017

Notes: See Table A.5.2.1 in Annex for the sources. Column EZ1, US1 and UK1 present the (Gauss-Newton) nonlinear Least Square (LS) estimates of the following basic nonlinear Taylor rule: $IR_t=\psi_0+\psi_\pi*Inflation_{t-1}+\psi_y*OutpGap_{t-1}+(\omega_0+\omega_\pi*Inflation_{t-1}+\omega_y*OutpGap_{t-1})*G(\eta,c,Inflation_{t-1})+u_t$, where *IR* is the respective interest rate considered for each country and $G(\eta,c,Inflation_{t-1})=[1+\exp(-\gamma(Inflation_{t-1}-c))]^{-1}$, when the LSTR1 is the chosen model, or $G(\eta,c,Inflation_{t-1})=[1+\exp(-\gamma(Inflation_{t-1}-c_1)*(Inflation_{t-1}-c_2))]^{-1}$, when an LSTR2 is preferred instead. H_{02} to H_{04} report the *p*-value of the tests used to choose the preferred model; H_{01} reports the *p*-value of the linearity test. A nonlinear Instrumental Variables (IV) estimator is used in the other regressions, where the horizons of the inflation and output gap forecasts are, respectively, 12 and 3 months for the Eurozone and the US, and 6 and 0 months for the UK. Considering the case of the Eurozone, the equation can be written generically as follows: $Eonia_t=(1-\rho)*(\psi_0+\psi_\pi*Inflation_{t+12}+\psi_y*OutpGap_{t+3}+\psi_{efci}*EFCI_{t-1})+\rho*Eonia_{t-1}+(1-\rho)*(\omega_0+\omega_\pi*Inflation_{t+12}+\omega_y*OutpGap_{t+3}+\omega_{efci}*EFCI_{t-1})*G(\eta,c,Inflation_{t+12})+\varepsilon_t$. A similar equation is considered for the US and UK, however, in these cases, a second-order partial adjustment model fits the data better than the first-order model used for the Eurozone; moreover, *EFCI* is replaced by *CredSprd* in regression 3 for the UK; both variables are lagged one period to avoid simultaneity problems. The best fitting model is found by sequentially eliminating insignificant regressors by using the SBIC measure of fit. The set of instruments includes: a constant, 1-6, 9, 12 lagged values of the *Inflation*, *OutpGap*, *Yield10yr* and *M3*, and the second and third lags of *EFCI* for the Eurozone; a constant, 1-6, 9, 12 lagged values of the *CoreInfl*, *OutpGap* and *Yield10yr* for the US; and a constant, 1-6, 9, 12 lagged values of the *RPI_Infl*, *OutpGap*, *Yield10yr* and *FCI* for the UK. Following Granger and Teräsvirta (1993) and Teräsvirta (1998), η is made dimension free by dividing it by the standard deviation (LSTR1) or variance (LSTR2) of the inflation variable; since η is not defined at zero, the respective standard error is reported (in brackets) instead of the *t*-statistic; η presents high standard deviations because relatively few observations are located around the threshold. Robust standard errors (heteroscedasticity and autocorrelation-consistent) with Newey-West/Bartlett window and 3 lags were computed and the respective *t*-statistics are presented in parentheses; significance level at which the null hypothesis is rejected: ***, 1%; **, 5%; and *, 10%. The delta method is used to compute the standard errors of $\psi_\pi+\omega_\pi$ and $\psi_y+\omega_y$. The *p*-value of the Hansen's overidentification test is reported in square brackets. The time periods considered for each country are the same as in the linear estimations. For further details see Table 5.2 and Table 5.3.

In general the results seem quite reasonable, but the autocorrelation problems presented by these estimations and the fact that central banks are taking into account not only present and past information but also future inflation expectations suggest we should proceed with the estimation of a forward-looking version of these nonlinear models, where the nonlinear Taylor rule allows for interest rate smoothing. A nonlinear instrumental variables (IV) estimator is used to estimate these models, where the horizons of the inflation and output gap forecasts and the set of instruments are the same as we considered in the estimation of the linear model. The validity of the instruments is confirmed by the Hansen's *J*-test in any of the IV estimations. Heteroscedasticity and autocorrelation-consistent standard errors are used in all estimations.

Considering the Eurozone first, we start by estimating a more general version of the model where inflation and the output gap are included in the linear and nonlinear parts of the model. Given the relevance demonstrated by the *EFCI* variable in the linear model, we extend the forward-looking nonlinear model with the lag of this variable. The results are presented in columns EZ2 and EZ3 and confirm the significant nonlinear reaction of the ECB to expected inflation: the ECB only starts to react actively to inflation when expected inflation is above 2.5%, a value that is very close to the implicit inflation target estimated in the linear model and only slightly higher than the official inflation target announced by the ECB; moreover, the ECB only reacts to the output gap when expected inflation is well below 2.5% ($\psi_y+\omega_y$ is not significant). These are very important results: first, they confirm the main aim of the ECB of keeping inflation low; second, once this objective is achieved, they also support the expressed ECB's intention of promoting a sustainable growth.[161] This means that the nonlinear Taylor rule estimated here presents a quite accurate description of the way the ECB conducts its monetary policy – even though its inflation target has proved to be slightly higher than the announced target of 2%.[162] Moreover, the nonlinear model also provides some evidence that the ECB is considering the information contained in some financial variables in its decisions on the interest rate.[163] Therefore, this study concludes that this augmented nonlinear Taylor rule is the policy rule that best describes the ECB's behaviour.[164]

The forward-looking Taylor rule with interest rate smoothing estimated for the US (see column US2) does not present any significant differences in comparison with the results presented in column US1. Nevertheless, it is important to emphasize that the forward-looking linear model for the US is only rejected at a level of significance of 10%, which means that the Fed's monetary behaviour can be well explained by a forward-looking linear Taylor rule. Therefore, this study shows that the evidence found by Petersen (2007) that the Fed follows a nonlinear Taylor rule is

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[161] Note that according to the ECB: "The contribution of monetary policy consists in maintaining price stability and establishing confidence in the continuation of its efforts, thereby creating the conditions necessary for the sustained, non-inflationary growth of output and employment." Cf. ECB (1999, p.10).

[162] Instead of estimating c, we also tried to set c=2% and then estimate the model, but it did not converge to reasonable values. Only for values of c around 2.5%, we were able to find robust results. This is the case because, as shown in Figure 5.1, inflation has remained well above 2% for most of the time period analysed here for the Eurozone. Nevertheless, we think it is preferable to estimate c than to impose a value that, in practice, may not fit well to the available data. When a larger time-period is available – and more time the ECB is in activity – maybe we can find a value closer to the official target of 2%. For now, our results show that the ECB is operating with a slightly higher target, which can be seen as a way of accommodating prevailing economic disparities between the countries that form the Eurozone and a way of accommodating asymmetric shocks that may affect them differently.

[163] Despite *US_OutpGap* proving significant in the linear model, it is not included in the nonlinear regressions because, due to the complexity of the model, it was not possible to achieve convergence after trying several combinations of initial values.

[164] The results of a nonlinear Taylor rule without *EFCI* are presented in column EZ4 to permit a direct comparison with the main results obtained for the other economies.

only valid when we consider a basic nonlinear Taylor rule. As soon as we depart from this assumption and consider a more complete framework – where the forward-looking behaviour of the Fed and interest rate smoothing are controlled for – the conclusion may not be the same.[165] In fact, additional linearity tests (not presented here) shown that linearity is not rejected when two relevant variables such as *CredSprd* and Δ*FutSprd* are included in the nonlinear model. The same result was obtained when we tried to include *EFCI*.

Finally, the results obtained for the UK are quite similar to the ones obtained for the Eurozone (see columns UK2 and UK3) and update the evidence provided by Martin and Milas (2004) that the BOE's monetary policy can be described by a nonlinear Taylor rule and that the BOE tries to keep inflation within a range – of 1.8%-2.4%, according to our evidence – rather than pursuing the current official point target of 2%. Results indicate a strong reaction of the BOE to inflation when expected inflation is outside the 1.8%-2.4% range. As soon as inflation is in this range, it only reacts to the business cycle and, to a lesser degree, to the additional economic information contained in the *CredSprd* variable.[166]

5.5. Conclusions

This chapter discusses two important issues. First, it asks whether central banks, besides targeting inflation and the output gap, are also targeting the information contained in the asset prices and financial variables. Second, it analyses whether central banks' monetary policy can be described by a linear Taylor rule or, instead, by a nonlinear rule. Related to this second point, this study also considers

[165] The recent evidence provided by Qin and Enders (2008) for the Fed also points in that direction.

[166] As in the linear model, no other significant results were obtained with the inclusion of other variables.

whether they are pursuing a point target or a target range for inflation. The central banks considered in this analysis are the ECB, Fed and BOE.

To answer the first question we built a financial conditions index from the weighted average of a group of asset prices and financial variables and included it, first, in the linear Taylor rule. The results indicate that while the ECB is targeting the information contained in this index in order to avoid inflationary pressures from imbalances in the asset and financial markets, the Fed and BOE do not respond to changes or developments in these markets. In our opinion, this different behaviour might be one of the causes for the recent credit crunch to have arisen in the US (and UK) housing and financial markets and not in the Eurozone – even though its repercussions have spread to all developed markets and to the real economy. Thus, the first main conclusion of this study is that targeting financial conditions might be a solution to avoid imbalances in the financial and asset markets and, consequently, it may help to avoid sharp economic slowdowns.

The results mentioned above were obtained using a linear Taylor rule but, considering that the central banks might be responding differently to deviations of inflation above or below from their targets, we decided to test for the presence of nonlinearities in the rule and estimate a nonlinear model in case they are present. The linearity tests indicate that the monetary policy followed by the ECB and by the BOE can be described by a nonlinear Taylor rule, but the evidence is not enough to clearly reject the linear Taylor rule for the Fed.

The estimation of the nonlinear Taylor rule using a smooth transition regression model provides interesting results. First, they show that the ECB pursuits a point target of about 2.5% for inflation. Second, the ECB only reacts actively to inflation when it is above that target and it only starts to react to the business cycle when inflation is stabilised well below 2.5%. Thus, another important conclusion of this study is that the nonlinear Taylor rule estimated in this chapter encompasses quite remarkably the principles of the ECB monetary policy: (i) promoting price stability above everything; (ii) when that is achieved, promote conditions for a sustainable growth. The fact that the estimated inflation threshold is slightly higher than the 2% reference value announced by the ECB may mean that the ECB is in reality allowing for some monetary flexibility to accommodate the economic differences among the countries that constitute the Eurozone and to accommodate asymmetric shocks that may affect them differently.

Even after the nonlinearities are controlled for, the ECB continues to consider the information contained in financial variables, which reinforces the first main conclusion of this study and allows us to say that the nonlinear Taylor rule, augmented with the financial conditions index developed in this study, is the policy rule that best describes the monetary behaviour of the ECB.

Finally, the nonlinear Taylor rule estimated for the BOE indicates that this central bank is pursuing a target range of 1.8%-2.4% for inflation rather than the official point target of 2%. The BOE reacts actively to inflation when it is outside that range, but, once inside, it only reacts to the business cycle and to the economic information provided by the credit spread variable.

Besides extending this study to other central banks, another important extension would be to understand whether and how financial sector regulation and commercial banks' off-balance sheet entities are taken into account in the central banks' reaction function. We believe that such an analysis could contribute a little more to the understanding of the reasons for the recent credit crunch. Our intention is to proceed with this analysis in future work, as soon as more data become available.

Annex 5.1. Derivation of the forward-looking linear Taylor rule

According to the New-Keynesian model,[167] the evolution of the economy can be described by the following system of equations:

$$\pi_{t+k} = a_1 \pi_{t+k-1} + a_2 (y_{t+p} - y^*_{t+p}) + \mu^s_{t+k}, \qquad \textbf{(A.5.1.1)}$$

$$(y_{t+p} - y^*_{t+p}) = b_1 (y_{t+p-1} - y^*_{t+p-1}) - b_2 (i_t - \pi_{t+k-1}) + \mu^d_{t+p}. \qquad \textbf{(A.5.1.2)}$$

Equation **(A.5.1.1)** can be interpreted in terms of a Phillips curve (or AS curve) where inflation is sluggish and depends on the cyclical component of output, whilst equation **(A.5.1.2)** can be considered as an aggregate demand curve where the output gap depends on its lagged value and on the real interest rate. Supply and demand disturbances are captured by μ^s and μ^d, respectively.

Assuming that the central bank uses a policy rule to control monetary policy, the problem faced by this authority is to choose the interest rate in period *t* conditional upon the information available at that time. Therefore, at time *t* the central bank commits to a state contingent sequence of short-term interest rates in order to minimize the following inter-temporal loss function:

$$E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \left[\lambda_1 (\pi_{t+\tau} - \pi^*)^2 + \lambda_2 (y_{t+\tau} - y^*_{t+\tau})^2 + \lambda_3 (i_{t+\tau} - \bar{i})^2 \right] \qquad \textbf{(A.5.1.3)}$$

subject to **(A.5.1.1)** and **(A.5.1.2)**. The parameter δ represents the inter-temporal discount factor (0< δ <1) and $\bar{i}$ is the long-run equilibrium nominal interest rate ($\bar{i} = \bar{r} + \pi^*$). Svensson (1997) shows that since i_t does not affect y_t and π_t contemporaneously, minimizing **(A.5.1.3)** is equivalent to the period-by-period static minimization of:

[167] For more details on the derivation of the forward-looking Taylor rule presented in this section, see Svensson (1997) and Clarida *et al.* (1999).

$$\min_{i_t} E_t\left[\lambda_1(\pi_{t+k}-\pi^*)^2+\lambda_2(y_{t+p}-y^*_{t+p})^2+\lambda_3(i_t-\bar{i})^2\right] \quad \textbf{(A.5.1.4)}$$

Therefore, after some calculations and simplifications, the first-order necessary conditions for policy reaction function are given as follows:

$$i^*_t=\bar{i}+\beta E_t(\pi_{t+k}-\pi^*)+\gamma E_t(y_{t+p}-y^*_{t+p}), \quad \textbf{(A.5.1.5)}$$

which can be rewritten as equation **(5.2)**, considering that the central bank relies on all available information in beginning period *t* to choose the interest rate for that period.

This model can easily be extended to include additional equations (and variables). In general, the vector $x_{t+q}=f(\pi_{t+k},y_{t+p}-y^*_{t+p},i_{t-j},x_{1,t+q-l},...,x_{m,t+q-l})$ of $j=1,\ldots,m$ linear equations (and variables) – where l=0,1,2,… and $x_1,\ldots,x_m$ are elements of the vector $\boldsymbol{x}$ – can be added to the system of equations presented above as a way of providing additional explanations for the evolution of the economy. Similarly, the central bank can also take those variables into account in its minimization problem, which means that the term $\sum_{j=1}^{m}\lambda_{j+3}x^2_{j,t+q}$ can be added to the loss function. In this case, the result of the minimization problem will resemble equation **(5.5)** after controlling for interest rate smoothing.

Annex 5.2. Description of the variables and descriptive statistics

A complete description of the variables used in this chapter is presented in this part of the Annex – for the Eurozone, United States and United Kingdom – as well as some descriptive statistics.

Table A.5.2.1. Description of the variables and respective sources

	Eurozone (January 1999-December 2007)	United States (October 1982-December 2007)	United Kingdom (October 1992-December 2007)
Eonia	Euro Overnight Index Average (Eonia) lending interest rate in the Eurozone money market (monthly average).		
Euribor3m	3-month (Euribor) Euro Interbank Offered Rate (monthly average).		
KeyIR	Key ECB interest rate of the main refinancing operations; minimun bid rate (end of the month).		
FedRate		Effective Federal Reserve funds interest rate (monthly average).	
Libor3m		3-month (Libor) Interbank US Dollar lending rate (monthly average).	3-month (Libor) Interbank Sterling lending rate (monthly average).
TreasRate			3-month Treasury bill discount rate (monthly average).
OfficRate			Official Central Bank interest rate (end of the month).
Inflation	Inflation rate computed as the annual rate of change of the harmonized index of consumer prices (HICP, base year: 2005=100), seasonally adjusted.	Inflation rate computed as the annual rate of change of the consumer price index (CPI, base year: 1982-84=100) for all urban consumers and all items, seasonally adjusted.	Inflation rate computed as the annual rate of change of the CPI (base year: 2005=100), seasonally adjusted. *Note*: The official CPI starts in 1996 but historical estimates back to 1988 were calculated by the UK Office for National Statistics based on archived RPI data.
CoreInfl		Core inflation rate computed as the annual rate of change of the consumer price index (CPI, base year 1982-84=100) for all urban consumers and all items less food and energy, seasonally adjusted.	
RPI_Infl			Retail price index (RPI) inflation rate computed as the annual change of the RPI all items (January 1987=100).
RPIX			RPI excluding mortgage interest payments (Jan.1987=100).
OutpGap	Output gap computed as the percentage deviation of the (log) industrial production index (total industry, seasonally adjusted) from its Hodrick-Prescott trend.	Output gap computed as the percentage deviation of the (log) industrial production index (total industry, seasonally adjusted) from its Hodrick-Prescott trend.	Output gap computed as the percentage deviation of the (log) industrial production index (total industry, seasonally adjusted) from its Hodrick-Prescott trend.
M3	Annual growth rate of the monetary aggregate M3 (seasonally adjusted, 3-month moving average).		
FCI	Financial conditions index computed as the weighted average of the real effective exchange rate, real share prices and real property prices.	Financial conditions index computed as the weighted average of the real effective exchange rate, real share prices and real property prices.	Financial conditions index computed as the weighted average of the real effective exchange rate, real share prices and real property prices.
EFCI	Extended financial conditions index computed from the weighted average of the real effective exchange rate, real share prices and real property prices plus credit spread and futures interest rate spread.	Extended financial conditions index computed from the weighted average of the real effective exchange rate, real share prices and real property prices plus credit spread and futures interest rate spread.	Extended financial conditions index computed from the weighted average of the real effective exchange rate, real share prices and real property prices plus credit spread and futures interest rate spread.

(To be continued in the next page…)

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REER	Real effective exchange rate of the Euro against a group of 24 currencies (CPI deflated); a depreciation of the Euro corresponds to an increase in *REER*.	Real effective exchange rate of the US Dollar against the currencies of a group of 26 major US trading partners (CPI deflated); a depreciation of the US Dollar corresponds to an increase in *REER*.	Real effective exchange rate of the UK Pound against the currencies of the major UK trading partners (CPI deflated); a depreciation of the UK Pound corresponds to and increase in *REER*.
RStock	Real share price index computed as the monthly average of the Dow Jones Euro STOXX price index (HICP deflated).	Real share price index computed as the monthly average of the Dow Jones Wilshire 5000 composite share price index (CPI deflated).	Real share price index computed as the monthly average of the FTSE 100 share price index (CPI deflated).
RHPI	Real house price index obtained by linear interpolation of half yearly data for the Eurozone residential property price index (period 1995-07; 2004=100; HICP deflated).	Real house price index obtained from the linear interpolation of the quarterly data for the US residential property price index (1980Q1=100; CPI deflated).	Real house price index obtained from the Nationwide monthly house price index (1993Q1=100; CPI deflated and seasonally adjusted).
Yield10yr	10-year Eurozone government benchmark bond yield (monthly average).	10-Year US Treasury benchmark bond yield (government constant maturity rate, monthly average).	10-year monthly average yield from British Government Securities.
CorpBond	Eurozone Corporate Bond Yield, i.e. interest rate returns on commercial corporate bonds (monthly average).		UK Corporate Bond Yield, i.e. interest rate returns on commercial corporate bonds (monthly average).
BAAYield		Moody's Seasoned BAA Corporate Bond Yield (monthly average).	
FutIR	3-month Euribor interest rate futures contracts (monthly average).	3-month Eurodollar interest rate futures contracts (monthly average).	3-month Sterling interest rate futures contracts (monthly average).
CredSprd	Difference between *Yield10yr* and *CorpBond*.	Difference between *Yield10yr* and *BAAYield*.	Difference between *Yield10yr* and *CorpBond*.
ΔFutSprd	Monthly change of the difference between *FutIR* in the previous quarter and the current *Euribor3m*.	Monthly change of the difference between *FutIR* in the previous quarter and the current *FedRate*.	Monthly change of the difference between *FutIR* in the previous quarter and the current *TreasRate*.
EcoSent	Economic sentiment indicator developed by the European Commission and based on surveys of firms and consumers at national level (seasonally adjusted).	Economic sentiment indicator computed as the simple average of the consumer sentiment and manufacturing industrial confidence indicators (seasonally adjusted).	Economic sentiment indicator computed as the simple average of the consumer and industrial confidence indicators (seasonally adjusted).
RT_Inflation	Real time inflation rate obtained from the inflation estimates reported in the Euro Area Statistics of the ECB Monthly Bulletins for each month.		
RT_OutpGap	Real time output gap computed as the ex-post *OutpGap*, but from the most recent values for the industrial production published in each ECB Monthly Bulletin.		
Sources:	European Central Bank Statistics and Monthly Bulletins (http://www.ecb.int/stats/html/index.en.html); Datastream for *CorpBond* and *FutIR*.	Federal Reserve Bank of St. Louis Economic Data – FredII (http://research.stlouisfed.org/fred2/); ECB Statistics for *Libor3m*; Datastream for *REER*, *RStock* and *FutIR*. Office of Federal Housing Enterprise Oversight (http://www.ofheo.gov/hpi_download.aspx) for *RHPI*.	Bank of England Statistics (http://www.bankofengland.co.uk/statistics/index.htm); UK Office for National Statistics (http://www.statistics.gov.uk/); OECD, Main Economic Indicators for *REER*, *RStock* and *EcoSent*; Nationwide Building Society for *RHPI* (http://www.nationwide.co.uk/hpi/historical.htm); Datastream for *CorpBond* and *FutIR*.

Table A.5.2.2. Descriptive Statistics: Eurozone (January 1999 – December 2007)

Variable	No. Obs.	Mean	Std. Dev.	Min.	Max.
Eonia	108	3.077	0.900	1.97	5.06
Euribor3m	108	3.213	0.939	2.03	5.09
KeyIR	108	3.014	0.891	2.00	4.75
Inflation	108	2.057	0.451	0.76	3.09
OutpGap	107	0.021	0.995	-2.33	3.30
M3	107	7.101	1.941	3.80	12.30
FCI	107	-0.161	1.347	-6.39	3.02
EFCI	107	0.007	0.502	-1.62	2.95
REER	108	102.605	8.895	89.38	121.18
RStock	108	334.188	78.552	191.24	506.99
RHPI	108	96.853	10.965	80.94	114.53
Yield10yr	108	4.442	0.653	3.16	5.70
CorpBond	108	4.706	0.847	3.35	6.18
FutIR	108	3.228	0.938	1.94	5.20
EcoSent	108	102.548	7.713	87.30	117.40
RT_Inflation	108	2.117	0.483	0.80	3.40
RT_OutpGap	107	-0.033	1.225	-2.58	4.05

Sources: See Table A.5.2.1.

Table A.5.2.3. Descriptive Statistics: United States (October 1982 – December 2007)

Variable	No. Obs.	Mean	Std. Dev.	Min.	Max.
FedRate	303	5.501	2.458	0.98	11.64
Libor3m	277	5.362	2.203	1.11	10.30
CoreInfl	303	3.227	1.114	1.09	5.86
Inflation	303	3.124	1.070	1.07	6.38
OutpGap	303	-0.035	1.469	-6.29	3.38
FCI	303	-0.035	1.543	-4.74	3.72
EFCI	303	0.004	0.317	-1.10	1.01
REER	303	105.350	11.081	78.59	123.50
RStock	303	4174.309	1998.298	1258.44	8233.81
RHPI	303	138.922	23.750	113.39	201.41
Yield10yr	303	6.913	2.284	3.33	13.56
BAAYield	303	8.999	2.256	5.82	15.15
FutIR	303	5.841	2.574	1.03	12.98
EcoSent	303	95.568	5.104	79.68	106.77

Sources: See Table A.5.2.1.

Table A.5.2.4. Descriptive Statistics: United Kingdom (October 1992 – December 2007)

Variable	No. Obs.	Mean	Std. Dev.	Min.	Max.
TreasRate	183	5.223	0.972	3.31	7.47
Libor3m	183	5.535	1.094	3.42	8.32
OfficRate	183	5.440	1.048	3.50	8.00
Inflation	183	1.817	0.621	0.50	3.10
RPI_Infl	183	2.709	0.855	0.70	4.80
RPIX_Infl	183	2.599	0.466	1.50	3.90
OutpGap	182	0.026	0.930	-3.85	2.43
FCI	182	0.208	1.505	-3.21	6.10
EFCI	182	0.129	0.569	-0.81	2.51
REER	183	108.309	8.648	97.35	127.21
RStock	183	80.367	17.296	50.32	113.43
RHPI	183	201.461	81.685	117.01	352.54
Yield10yr	183	5.895	1.461	4.08	8.90
CorpBond	183	6.817	1.486	5.10	10.49
FutIR	183	5.597	1.089	3.44	7.84
EcoSent	182	100.446	1.714	94.36	103.56

Sources: See Table A.5.2.1.

6. Overall conclusions

This dissertation comprises four essays on topics of particular interest for the EU economy and for other industrial countries: first, it considers the impact of EU's fiscal rules on economic growth; then, it studies the reasons for an EU country entering into excessive deficit and, therefore, breaking the 3% of GDP fiscal rule for the deficit; the effect of some economic and political variables on the duration of expansions and contractions in some EU and non-EU countries is analysed next; finally, this thesis analyses the policy behaviour of three influential central banks – ECB, Fed, BOE – and discusses whether their monetary policy can be described by a linear (augmented) Taylor rule or by a more complex nonlinear rule. Here we emphasize the behaviour of the recently created ECB and the role of the information contained in a financial conditions index.

The main conclusions of this dissertation are summarized next. The first essay shows that growth in the EU countries was not negatively affected in the period after Maastricht. This is true either comparing recent performance of the EU countries with their past performance or with the performance of other developed countries. Therefore, Chapter 2 concludes that Maastricht and SGP fiscal rules should not be blamed for harming growth of real GDP per capita in the EU area. On the contrary, evidence shows that, on average, growth is statistically higher in the period in which the fulfilment of the 3% criteria for the deficit started to be officially assessed. Furthermore, the essay presented in Chapter 2 provides some evidence favouring the EU fiscal rules for the public deficit and debt.

Chapter 3 studies the reasons for excessive deficits in the EU countries. It provides evidence that unfavourable economic conditions, parliamentary elections and political instability, and majority left-wing governments are the main causes of excessive deficits in the EU countries, where a deficit is considered excessive when it exceeds 3% of GDP. The results also indicate that the institutional constraints imposed after Maastricht over the EU countries' fiscal policy have been important in reducing the probability of excessive deficits in the EU, especially in small countries and in countries traditionally characterised by a higher propensity to excessive deficits. The empirical evidence does not indicate any significant erosion of the fiscal efforts made by the EU countries after they have been accepted in the EMU.

This chapter stresses the idea that the inclusion of political variables is important to fully explain excessive deficits in the EU. It provides a detailed analysis of the presence of political opportunism and partisan effects in that context. Elections and majority left-wing governments are two important causes of excessive deficits in the EU, a situation that remains well evident even after the implementation of the fiscal constraints over the EU countries. Nevertheless, the evidence provided by this analysis also emphasises that fiscal constraints are a necessary condition to avoid excessive deficits in a monetary union without a centralized budget.

This dissertation proceeds with the analysis of the factors that affect the duration of expansions and contractions. One interesting aspect of this analysis is that it allows to get additional insights about the impact of the EU fiscal constraints on the business cycle in some EU countries. However, this is not the major issue of the analysis provided in Chapter 4. The main focus of the essay presented in that chapter is to identify other factors that can affect the likelihood of an expansion or contraction ending, beyond its own length.

The study of the duration of business cycle phases shows that duration dependence is not the only factor that can explain the duration of a business cycle phase. Positive duration dependence is found for both expansions and contractions, but the duration of expansions is also significantly related to the performance of the variables in the OECD composite leading indicator. The duration of contractions is essentially explained by the duration of the previous expansion. The likelihood of an expansion ending is also affected by the behaviour of private investment, the price of oil and by external influences. The evidence provided by this study shows that the duration of expansions tends to increase when private investment accelerates and the price of oil decreases. There is also some evidence that when the US economy reaches a peak (and enters into recession), the likelihood of an expansion ending increases substantially in the other industrial countries. Political conditionings do not seem to be as important as economic factors to explain the duration of the business cycle phases and no support was found for the idea that fiscal rules have lengthened recessions in the EU. Finally, the "Great Moderation" in output volatility is a period in which evidence of positive duration dependence disappears for expansions and increases for contractions in the US economy. However, our evidence also shows that this result cannot be generalized to the panel of countries analysed in this study.

Therefore, Chapter 4 concludes that the duration of expansions and contractions is not only affected by their current age, but also by the behaviour of other economic factors, some of which encompass the expectations of the economic agents about the future trend of the economy. Moreover, contractions tend to present evidence of increasing positive duration dependence, whilst constant positive duration dependence is found for expansions, which means that the probability of a contraction ending increases more rapidly with its age than an expansion.

Finally, Chapter 5 discusses two important issues concerning the behaviour of modern central banks. First, it asks whether central banks, besides targeting inflation and the output gap, are also targeting the information contained in asset prices and financial variables. Second, it analyses whether central banks' monetary policy can be described by a linear Taylor rule or, instead, by a more complex nonlinear rule. Related to this second point, this dissertation also considers whether they are pursuing a point target or a target range for inflation.

Regarding the first question, the results indicate that while the ECB is targeting the information contained in this index in order to avoid inflationary pressures from imbalances in the asset and financial markets, the Fed and BOE do not respond to changes or developments in these markets. In our opinion, this different behaviour might be one of the causes for the recent credit crunch to have arisen in the US (and UK) housing and financial markets and not in the Eurozone – even though its repercussions have spread to all developed markets and to the real economy. Thus, the first main conclusion of this analysis is that targeting financial conditions might be a solution to avoid imbalances in the financial and asset markets and, consequently, it may help to avoid sharp economic slowdowns.

Concerning the second question, results do not provide any clear evidence to reject the linear Taylor rule for the Fed, but provide significant evidence that the monetary policy followed by the ECB and by the BOE can be described by a nonlinear Taylor rule. In particular, results show that the ECB pursues a point target of about 2.5% for inflation – whilst the BOE follows a target range of 1.8%-2.4% for inflation rather than the official point target of 2% – and that the ECB only reacts actively to inflation when it is above that target. This means that it only starts to react to the business cycle when inflation is stabilised well below 2.5%. Thus, another important conclusion of this essay is that the nonlinear Taylor rule estimated in this chapter encompasses quite remarkably the principles of the ECB monetary policy: (i) promoting price stability above everything; (ii) when that is achieved, promote conditions for a sustainable growth. The fact that the estimated inflation threshold is slightly higher than the 2% reference value announced by the ECB may mean that the ECB is in reality allowing for some monetary flexibility to accommodate the economic differences among the countries that constitute the Eurozone and to accommodate asymmetric shocks that may affect them differently.

Even after the nonlinearities are controlled for, the ECB continues to consider the information contained in financial variables, which reinforces the first main conclusion of this study and allows us to say that the nonlinear Taylor rule augmented with the information contained in the financial conditions index is the policy rule that best describes the ECB's policy behaviour during its (yet) short life.

To sum up, this dissertation provides evidence that the institutional changes in which several European countries were involved during the last decade, and that culminated with the creation of the EMU in Europe, do not undermine the economic performance of those countries. Moreover, those institutional changes, in particular at the fiscal level, were important to discipline fiscal policy in a monetary union without a centralised budget and to consolidate public accounts in some EU countries. Our evidence also indicates that the creation of the ECB has contributed greatly to reinforce the monetary and financial stability in the Eurozone. In addition, it shows that the ECB's monetary policy is well described by a nonlinear Taylor rule augmented with information from the asset and financial markets. Results indicate that the ECB tends to react more to inflation when it is above its target. Finally, this dissertation provides further evidence that the likelihood of expansions and contractions ending is dependent on other factors, in addition to the age of each of these business cycle phases, and that this likelihood increases more rapidly for contractions than for expansions.

Some lines for future research were already mentioned at the end of each essay included in this dissertation, but it is important to mention a final and broader extension. Considering that this study analyses economic growth, fiscal policy and monetary policy issues separately, the next thing to do might be to provide an analysis where the relations between them are taken into account in a single model/framework. The idea is to implement a more rigorous analysis of the reciprocal relationship between fiscal policy, monetary policy and economic growth in Europe. For example, the link between economic growth and public finances has been shown to be the most important issue for the operation of Maastricht and SGP fiscal rules: on the one hand, economic growth determines the budgetary performance and the sustainability of public finances; on the other hand, fiscal policies also affect growth. Unfortunately, in the literature those links have been analysed independently in the European Union’s context. The work of Artis and Onorante (2006) is an exception: they estimate a set of structural vector autoregressive models, one for each EU country, to assess the possible effects of alternative sets of fiscal rules. Considering the role of monetary policy in such an analysis will certainly contribute further for a deeper understanding of the working of the EU economy under the institutional changes that took place in Europe during the 1990s. Simultaneous equations and/or structural vector autoregressive models are potential tools to be used in such a challenging task, which the author will try to embrace in his next endeavour.

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