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

Vítor Castro

No 860

# WARWICK ECONOMIC RESEARCH PAPERS

## DEPARTMENT OF ECONOMICS

THE UNIVERSITY OF WARWICK

# The duration of economic expansions and recessions: More than duration dependence

**Vítor Castro***

University of Warwick, University of Coimbra and NIPE

May 2008

**Abstract**

One widespread idea in the business cycles literature is that the older is an expansion or contraction, the more likely it is to end. This paper tries to provide further empirical support for this idea of positive duration dependence and, at the same time, control for the effects of other factors like leading indicators, the duration of the previous phase, investment, price of oil and external influences on the duration of expansions and contractions. This study employs for the first time a discrete-time duration model to analyse the impact of those variables on the likelihood of an expansion and contraction ending for a group of industrial countries over the last fifty years.

The evidence provided in this paper 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 variables in 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.

*Keywords*: Business cycles; Expansions; Contractions; Duration dependence; Duration models.

*JEL classification*: C41, E32.

* Department of Economics, University of Warwick, Coventry CV4 7AL, UK; Departamento de Economia, Universidade de Coimbra, Av. Dias da Silva, 165, 3004-512 Coimbra, Portugal; Núcleo de Investigação em Políticas Económicas (NIPE), Departamento de Economia, Universidade do Minho, Campus de Gualtar, 4710-057 Braga, Portugal. E-mail: v.m.a.castro@warwick.ac.uk, vcastro@fe.uc.pt.
The author acknowledges Jennifer Smith, Natalie Chen, Francisco Veiga, Elias Soukiazis, Paulo Santos Monteiro and the participants at the Macroeconomics Workshop, University of Warwick, for helpful comments and suggestions. The author also wishes to express his gratitude for the financial support from the Portuguese Foundation for Science and Technology under Scholarship SFRH/BD/21500/2005.

## 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 is an expansion or recession, 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.[1] Like most studies in this field, they have focused almost exclusively on the US business cycle. This paper 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 effect of some of its components and other potential explanatory

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

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 advanced 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 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 Europe because countries are not allowed to run sufficiently large deficits to stimulate the economy. This study will 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 paper 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 paper 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 paper 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.

Thus, 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, oil price 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 Europe. The political factors did not proved to be important to explain 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 for the US.

The remainder of this paper is organized as follows. Section 2 provides a review of the literature on business cycle duration dependence. A theoretical framework is derived in Section 3 to provide some intuition to the analysis. The data and main hypothesis to test are presented in Section 4, as well as the econometric model and the empirical results. Finally, Section 5 concludes emphasizing the main findings of this paper and offering some suggestions for future research.

## 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).[2] 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.[3] 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 may have higher power for detecting duration dependence than non-parametric methods. In fact, the small size of the samples for business cycles may impair the power of the non-parametric tests, making difficult to detect duration dependence when it really exists. Parametric techniques also make it possible to compute estimates of the magnitude of the duration dependence. Another advantage is the fact that they permit testing of additional hypothesis 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 attempted 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 upon Sichel's (1991) Weibull specification in any of the other cases.

[2] 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.
[3] See, for example, Diebold and Rudebusch (1990), Diebold *et al.* (1990), Mudambi and Taylor (1995), Mills (2001) and Ohn *et al.* (2004), among others.

Abderrezak (1998) also uses parametric hazard models to analyse the issue of duration dependence in eleven industrial countries. Instead of considering the classical business cycles, this author uses growth cycles.[4] Results from individual-country 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.[5] 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.[6]

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

[4] 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 of 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.

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

[6] 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.

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 reveal 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.[7] 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 paper is not analysing or predicting 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 and for the effect of some economic and political variables on the likelihood of an expansion or contraction ending.

As noticed 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 opt to use 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.

[7] 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.

## 3. Theoretical framework

This study relies on a basic AS-AD framework to analyse the duration of the fluctuations in economic activity and to illustrate how business fluctuations are affected by various potential sources of shocks (public and private spending, expectations, oil prices) that tend to shift the aggregate supply and demand curves. The AS-AD model pays special attention to the impact of sudden exogenous shocks on the position of the aggregate supply and aggregate demand curves. Moreover, it is also useful to explain the propagation mechanisms, i.e. the manner in which the economy reacts to shocks and how long it takes to adjust to a shock. Thus, it provides additional margin to consider the role of duration dependence in the economy.

A deeper and more complete explanation for business cycles is given by the Real-Business-Cycles (RBC) theory. It explains the cycles mainly as the result of technological shocks. Realising that explaining the business cycle considering just this kind of shocks is too restrictive, other RBC models have arisen and extended the basic model allowing for movements in oil prices, fiscal and monetary shocks (government expenditures/spending changes, interest rate changes), labour-supply shocks, investment-specific technical changes, exogenous shifts in beliefs.[8] Despite these efforts, the issue of duration dependence is always out of their scope. Hence, we cannot rely entirely in such models to provide the necessary intuition for our analysis. The AS-AD model has revealed more fruitful for that task. Nevertheless, when possible, we will also evaluate the consistence of our results with the RBC theory.

Following the AS-AD model described in Sorensen and Whitta-Jacobson (2005, Ch.19), we state our model of aggregate supply and aggregate demand as follows:

$$y_t - \bar{y} = \alpha_1(q_t - \bar{q}) + \alpha_2(g_t - \bar{g}) - \alpha_3(r_t - \bar{r}) + v_t, \quad \alpha_1, \alpha_2, \alpha_3 > 0 \qquad \textbf{(1)}$$

$$r_t = \bar{r} + \delta_1(\pi_t - \pi^*) + \delta_2(y_t - \bar{y}), \quad \delta_1 > 1, \delta_2 > 0 \qquad \textbf{(2)}$$

$$\pi_t = \pi_{t-1} + \gamma(y_t - \bar{y}) - s_t, \quad \gamma > 0 \qquad \textbf{(3)}$$

Equation **(1)** is the aggregate demand curve (AD) where the relative deviation of output ($y_t$) from its trend level ($\bar{y}$) depends on the deviation of private spending ($q_t$), public spending ($g_t$) and real interest rate ($r_t$) from the respective trends and on shifts in private sector confidence or expectations about the future behaviour of the economy ($v_t$). Equation **(2)** is the Taylor rule that describes how central bank reacts to deviations of inflation and output from their targets. Equation **(3)** is the short-run aggregate supply

[8] See, for example, King and Rebelo (2000) and Rebelo (2005) for further details and references.

curve (SRAS). For simplicity, this equation assumes static inflation expectations, i.e. the expected inflation rate for the current period is equal to the inflation rate in the last period. Therefore, the current inflation rate is dependent on the inflation rate in the last period, on the deviation of the output from the trend and on supply shocks ($s_t$), such as fluctuations in productivity caused by technological advances or changes in energy prices (a rise in the real price of oil, for example). $s_t$ takes a positive (negative) value in case of a positive (negative) supply shock.

Inserting equation **(2)** into **(1)** and rearranging gives the following simplified curve for the aggregate demand:

$$\pi_t = \pi^* - \theta(y_t - \bar{y}) + \theta d_t, \qquad \textbf{(4)}$$

where $\theta = (1+\alpha_3\delta_2)/\alpha_3\delta_1$ and $d_t = [\alpha_1(q_t - \bar{q}) + \alpha_2(g_t - \bar{g}) + v_t]/(1+\alpha_3\delta_2)$. Assuming first that there is no supply or demand shock following the initial shock that generated a recession or expansion ($s_t=d_t=0$, for $t\geq 0$), we can write the AS-AD model as follows:

$$AD: \quad \hat{\pi}_{t+1} = -\theta\hat{y}_{t+1} \qquad \textbf{(5)}$$

$$SRAS: \quad \hat{\pi}_{t+1} = \hat{\pi}_t + \gamma\hat{y}_{t+1}, \qquad \textbf{(6)}$$

where $\hat{\pi}$ and $\hat{y}$ represent, respectively, the deviation of the inflation rate from its target ($\pi^*$) and the relative deviation of the output from its trend. From **(5)** we also have $\hat{\pi}_t = -\theta\hat{y}_t$, which can be inserted into **(6)** along with **(5)** yielding, after some simplification, the following equation for output:

$$\hat{y}_{t+1} = \beta\hat{y}_t, \qquad \textbf{(7)}$$

where $\beta \equiv \theta/(\theta+\gamma)$. Solving this linear first-order difference equation, we get:

$$\hat{y}_t = \hat{y}_0\beta^t, \qquad \textbf{(8)}$$

where $\hat{y}_0$ is the initial value of $\hat{y}$. As, by definition, $0<\beta<1$ then $\beta^t \underset{t\to\infty}{\to} 0$, which means that $y_t$ will converge to $\bar{y}$ over time; the speed of convergence will depend on the fundamentals of the economy, i.e. on the magnitude of $\beta$.

This simple framework shows that after a country entering into recession (and considering no further shocks), the economic mechanisms will take the economy out of the recession by themselves. The same happens when a country is in an expansion (boom): over time the economy will adjust and the expansion will over. This analytical framework is therefore justifying the evolution of the economy through cycles and showing that there is a natural tendency for recessions and booms ending after a certain period of time, i.e. they are duration dependent.[9] However, as the economy is constantly affected by different shocks, the fluctuations in the business cycle and their durations may also depend on other factors. Relaxing the assumption of no further shocks, equations **(5)** and **(6)** can be rewritten as follows:

$$AD: \qquad \hat{\pi}_{t+1} = -\theta \hat{y}_{t+1} + \theta d_t \tag{9}$$

$$SRAS: \quad \hat{\pi}_{t+1} = \hat{\pi}_t + \gamma \hat{y}_{t+1} - s_t , \tag{10}$$

from where the following equation for the output can be derived as above:

$$\hat{y}_{t+1} = \beta \hat{y}_t + \beta \Delta d_{t+1} + \beta \theta^{-1} s_{t+1} . \tag{11}$$

We know that after the initial shock the economy evolved according to **(8)**. Considering that this will be its behaviour until period $t$ (i.e. before being hit by a demand or supply shock in period $t+1$), then we can rewrite equation **(11)** as follows:

$$\hat{y}_{t+1} = \hat{y}_0 \beta^{t+1} + \beta \Delta d_{t+1} + \beta \theta^{-1} s_{t+1} . \tag{12}$$

After $t+1$, the economy will evolve again according to an equation similar to **(8)**. Figure 1 presents a generic impulse response function that describes that evolution. In period 0, the economy is affected by an initial shock that puts it in expansion. However, as predicted by equation **(8)** the propensity for this expansion ending increases over time. In period $t+1$, the economy is affected by a positive supply/demand shock and the output is boosted again, which, as result, decreases the probability of the expansion ending. As after period $t+1$ the economy will evolve in a similar fashion as before, this shock will contribute to lengthen the expansion period. On the other hand, a negative shock would take the economy to a recession whose propensity to end also increases over time (see dashed line in Figure 1).

**[Insert Figure 1 around here]**

This shows that besides duration dependence, the propensity for the economy keeping in expansion (or leaving a recession) will depend positively on demand-side effects like increases in private and public spending and in private sector confidence, and on positive supply-side effects, such as technological progress or decreases in the price of

[9] These cyclical features could also be captured using a moving average of white noise or a spectral analysis. However, those procedures do not consider the issue of duration dependence.

important energy resources such as oil. Not surprisingly, these outcomes are also consistent with some of the conclusions provided by the RBC models.[10]

## 4. Empirical evidence

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 ends with the analysis of the results.

### *4.1. 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.[11] 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. This means that 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. Those chronologies represent a set of reference dates

---

[10] In particular, Rotemberg and Woodford (1996) and Finn (2000) show that energy price shocks have an important impact on economic activity. Christiano and Eichenbaum (1992) and Baxter and King (1993) notice the importance of government spending in the real business cycle fluctuations. Jaimovich (2007) uses multiple equilibrium models to show that self-fulfilling beliefs (or expectations) shocks can be another source of business cycles: pessimistic agents can "throw" the economy into recession.

[11] 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.

(peaks or end 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 personal income, employment, industrial production, sales and monthly estimates of real GDP.[12]

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."[13] 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 NBER chronology. Since they make such comparisons, they are giving 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 these 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.

---

[12] 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.1) as well as a complete description of the business cycle variables that can be extracted from those chronologies (see Table A.2).

[13] As already mentioned, besides Markov-switching models, other methodologies could be used to identify the business cycle chronology, like the rule that considers a recession when the growth of real GDP is negative for two consecutive quarters or more, or perhaps 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 the economic activity.

A complete description of the variables used in this study and respective sources is provided in Annex (see Table A.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 value 1 in the quarter that includes the month for which the ECRI has identified a turning point (peak or trough), and 0 otherwise.[14] 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 and our theoretical framework, 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 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 about 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 of 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.[15]

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

[15] 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

Regarding the good performance revealed by two of its components – interest rate spreads and stock prices – in predicting economic recessions,[16] this study will 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 they are positively (negatively) correlated to the duration of an expansion (contraction).

Other factors, not considered in the composite leading indicator, will be taken into account as well. 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 of this link. Given this mixed evidence, we hope to provide further evidence to clarify this issue.

According to our theoretical analysis, demand and supply shocks can affect the propensity for the economy leaving a recession or keeping in expansion. Private and government spending are two important variables in that dynamics. 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 and the intuition provided by our analytical framework, we expect that when private investment is boosted, expansions tend to last longer and recessions tend to be shorter. To collect this effect we use the growth rate of real private total fixed capital formation (*GPInv*).

---

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 contact OECD directly 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.

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

The theoretical framework presented in Section 3 predicts a similar outcome for government spending. Traditionally, Keynesians 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. Kneller *et al.* (1999) Bassanini and Scarpetta (2001) and Castro (2007) show that while public investment is able to stimulate economic activity, unproductive public expenditures like current government consumption are negatively related to output growth. Hence, we conjecture that the higher is public investment 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.[17]

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 and the conclusions of our theoretical framework, we expect that the likelihood of an expansion ending may increase as the price of oil increases. The oil import price deflated to real values by the GDP deflators of each country (*OilPr*) is used in this study to test for this conjecture.[18]

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 value 1 when the US economy reaches a peak (*PeakUS*) – in the case of expansions – or a trough (*TroughUS*) – in the case of contractions. This variable can be seen as representing an additional demand shock.

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

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

[18] 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.

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. With the intention of controlling 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 value 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.

To complete the group of hypotheses to test, this study will check whether the fiscal rules imposed by the Maastricht and Stability and Growth Pact (SGP) have affected the economic performance in the European Union (EU) countries. Buti *et al.* (1997) and Metz (2005) argue that there is a risk of those rules generating longer recessions in Europe because 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.

However, before presenting the empirical results, it is essential to describe the econometric model to be estimated. That is precisely the aim of the next section.

### *4.2. Duration models*

Duration analysis has been widely used in labour economics to study the duration of periods of unemployment.[19] Due to its properties, this kind of analysis is also suitable for studying the duration of expansions and contractions.[20]

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

[19] 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.
[20] For more details, see Section 2.

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: $f(t)=dF(t)/dt$. 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 $dh(t)/dt>0$ in the moment $t=t^*$, 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 is the expansion (contraction), 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 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 the previous studies on this issue.[21] The functional form that has been used to characterize and parameterize the hazard function is the so-called proportional hazards model:[22]

---

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

$$h(t,\mathbf{x}) = h_0(t)e^{\boldsymbol{\beta}'\mathbf{x}}, \tag{13}$$

where $h_0(t)$ is the baseline hazard function that captures the dependency of the data to duration, $\boldsymbol{\beta}$ is a $K\times1$ 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 are studying 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 has been the Weibull model, where $h_0(t)=\gamma p t^{p-1}$, with $\gamma>0$ and $p>0$. In this hazard function, $\gamma$ 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 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:[23]

$$\ln L = \sum_{i=1}^{n}\left[c_i \ln h(t_i,\mathbf{x}_i) + \ln S(t_i,\mathbf{x}_i)\right], \tag{14}$$

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 employ in that analysis. 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

[22] This means that the ratio of the hazard rates for any two observations is constant over time.
[23] See Allison (1982) and Kiefer (1988) for details.

problematic."[24] Therefore, discrete-time methods are more adequate for the analysis of the duration of expansions and contractions because the available data is always grouped in large discrete-time intervals.[25] 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, 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).[26] 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:

$$P_{it} = \Pr[T_i = t \mid T_i \geq t, \mathbf{x}_{it}], \qquad \textbf{(15)}$$

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 **(13)**, Prentice and Gloeckler (1978) show that the corresponding discrete-time proportional hazard function can be given by:

$$P_{it} = 1 - e^{-h_t e^{\boldsymbol{\beta}'\mathbf{x}_{it}}} = 1 - e^{-e^{\theta_t + \boldsymbol{\beta}'\mathbf{x}_{it}}} \Leftrightarrow \ln[-\ln(1 - P_{it})] = \theta_t + \boldsymbol{\beta}'\mathbf{x}_{it}, \qquad \textbf{(16)}$$

which is equivalent to the so-called complementary log-log (or cloglog) function, where $\theta_t$ (=ln$h_t$) represents an unspecified (baseline hazard) function of time and the coefficient vector ($\boldsymbol{\beta}$) is identical to the one in the continuous-time proportional hazards model **(13)**.

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

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

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

This means that the estimated discrete-time coefficients based on **(16)** 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 the baseline hazard function $\theta_t$. 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 $\theta_t = \ln h_t = \alpha + q \ln t$, where $q$, in this discrete-time case, corresponds (approximately) to $p$-1 in the continuous-time Weibull model.[27]

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:

$$\ln L = \sum_{i=1}^{n}\sum_{j=1}^{t_i} y_{it} \ln\left(\frac{P_{ij}}{1-P_{ij}}\right) + \sum_{i=1}^{n}\sum_{j=1}^{t_i} \ln\left(1-P_{ij}\right), \qquad \textbf{(17)}$$

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 nothing more than the log-likelihood for the regression analysis of binary dependent variables. Substituting $P_{ij}$ by **(16)** and using the adequate specification for the baseline hazard function, the model can be estimated.

### *4.3. 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 13 industrial countries over the period 1948-2006 are presented in Table 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

[27] Other specifications can be considered: (i) linear in time ($\theta_t=\alpha_0+ \alpha_1 t$); (ii) polynomial in time ($\theta_t=\alpha_0+ \alpha_1 t+\alpha_2^2 t+...$); (iii) piece-wise dummies – one for each particular sub-period of time – where the hazard the rate is assumed to be the same within each time-group but different between those groups ($\theta_t=\alpha_0+ \alpha_1 d_1+\alpha_2 d_2+...$); (iv) or, when possible, a fully non-parametric specification with one dummy for each value of $t$ for which an event is reported.

also evident in Figure 2, 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 1 also reveals that after 1992 and, more 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 Europe, because countries cannot run sufficiently large deficits to stimulate the economy, may not have empirical support.[28]

**[Insert Table 1 around here]**

**[Insert Figure 2 around here]**

Table 2 presents the results of 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 3 does the same for non-EU countries and includes an additional pooled regression with all EU and non-EU countries. Two kinds of duration models are used 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. No other study has provided yet an analysis of duration dependence for other industrial countries over the period after WWII using parametric duration models and classical business cycles. Moreover, to our knowledge, this is the first study that uses discrete-time duration methods to analyse the issue of duration dependence for expansions and contractions.[29]

**[Insert Table 2 around here]**

**[Insert Table 3 around here]**

As noticed in the previous section, in the discrete-time model we assume the following specification for 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-

[28] Further empirical evidence on this idea is given below in the parametric duration analysis.
[29] The reasons why this study uses discrete-time duration models are expressed in the previous section.

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. Robust and bootstrap standard errors are also reported for each individual estimate for that coefficient. Bootstrap standard errors are calculated to take into account the small sample size problem.[30] 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 can 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 pooling 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 EU countries, other for the non-EU countries and another for all countries.[31] 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

---

[30] 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).

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

the (baseline) hazard function 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.[32] 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 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 and the predictions of our theoretical framework, 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 opt to pool all the 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 and Table 5. Results are presented first for the panel of

[32] 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.

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 logarithm of the duration of an expansion or contraction (*LnDur*) corresponds to the parameter $q$ ($\approx p$-1) in the specification for 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 account of simultaneity problems, delays in reporting some economic data and to better identify their impact on the likelihood of a phase ending.[33]

**[Insert Table 4 around here]**

**[Insert Table 5 around here]**

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 presents 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 largely 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 and is consistent with the theoretical predictions of our model.[34]

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

[33] 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.

[34] 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).

by longer expansions in the period after WWII.[35] 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.[36] 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 reveals 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 expansion ending decreases. Government investment does not present any significant impact on the duration of expansions or contractions; only the duration of EU expansions seem 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.[37]

Results presented in Table 5 reveal 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,[38] this paper also estimates an instrumental variables probit model (ivprobit) where the lag of the oil price is instrumented with its second,

---

[35] 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*.
[36] This may mean 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.
[37] *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 also noticed that fiscal shocks have proved to be too small to be a significant source of fluctuations to the business cycle (see Rebelo, 2005).
[38] See, for example, Barsky and Kilian (2004) and Chen *et al.* (2007).

third and fourth lags.[39] Nevertheless, the Wald 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 in the results from the simple cloglog model, which is the best model to employ on a discrete-time duration analysis. Finally, it is worth mentioning that, despite several attempts, oil price 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.[40] 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 revealed in the sensitivity analysis provided below. Therefore, these results indicate that the political environment has not revealed very important to explain the duration of expansions or contractions in the 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 value 1 in the period after Maastricht, i.e. after 1992, for the sample of EU countries (*D_EU92*) and the other takes value 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 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 has to be really accomplished, otherwise

[39] 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 opt 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.
[40] 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.

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.[41] Given these results and the fact that no significant differences are found for the group of non-EU countries, this study concludes that Maastricht and SGP rules were not harmful for economic activity in Europe, contrary to the concerns raised by Buti *et al.* (1997) and Metz (2005).[42]

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 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 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*.[43]

Although these components of the *CLI* have revealed 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

[41] 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.
[42] This result is in accord with the findings of Castro (2007) in a study on the impact of the European Union fiscal rules on economic growth.
[43] Several ivprobit regressions 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 (results are not reported here).

producer confidence indicators, order books, stocks and labour market indicators. Thus, 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.

### *4.4. 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. The effects of the variables that have shown 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 until now to changes in some assumptions. The results of the robustness analysis are presented in Table 6.

**[Insert Table 6 around here]**

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 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). Consequently, 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 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. Our main results are not significantly or qualitatively affected. In practice, results in this kind of study have not shown sensitive to the choice of this minimum observable duration and the qualitative conclusions tend to be identical in any case.[44] Therefore, there is no practical advantage in complicating the analysis with such a small truncation, even more 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*.[45] 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 terms) decreases with the passage of time, which indicates 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 cannot ignore some evidence of positive duration dependence.[46]

The last estimations presented in Table 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:

$$\begin{aligned}\ln L = \sum_{t=1}^{T} \Big\{ & h_t^A \ln\left[\Lambda(\theta_1, Z_t)\right] + h_t^B \ln\left[1-\Lambda(\theta_1, Z_t)\right] \\ & + h_t^C \ln\left[1-\Lambda(\theta_2, Z_t)\right] + h_t^D \ln\left[\Lambda(\theta_2, Z_t)\right] \Big\}\end{aligned} \quad \textbf{(18)}$$

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

[45] Those dummies were created as follows: (i) For expansions, we have to create 4 two-year dummies (*D_Dur1*, *D_Dur2*, *D_Dur3*, and *D_Dur4*) and an additional fifth dummy (*D_Dur5*) that takes value 1 when the length of an expansion is higher than 8 years. The creation of year 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, 4 similar year dummies were created and the fifth dummy takes value 1 when the length of a contraction is higher than 4 years. As in the case of expansions, quarterly dummies are not appropriate. Note that even 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).

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

where $t$ is the time, $h_t^A$ is a dummy variable that takes value 1 when the economy is in 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 value 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 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,

$$\Lambda(\theta_i, Z_t) = \left(1 + e^{-\left(\alpha_i + \delta_i Dur_t + \boldsymbol{\beta}_i^{'} \mathbf{x}_{t-1}\right)}\right)^{-1}, \qquad \textbf{(19)}$$

where $i$=1 for expansions and $i$=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 now we are 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.

### *4.5. 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 of the 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 Summers (2005) to establish the periods of "Great Moderation" (GM) for each of the countries used in our sample.[47] A dummy variable is then built to separate

[47] We consider the same dates of GDP volatility reduction or switch to low volatility as Summers (2005) for: Australia (1984Q3), Canada (1988Q1), France (1973Q3), Germany (1971Q3), Italy (1980Q2), Japan(1975Q2), United Kingdom (1982Q2) and United States (1984Q4). As in Summers (2005), the dates

the pre-GM and GM periods for each country (*D_GM*): it takes value 1 for the GM period and 0 otherwise. To check whether there were 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 will correspond to a decrease (increase) in the likelihood of an expansion (contraction) ending as it gets older.

Descriptive statistics presented in Table 7 for the groups of EU, non-EU and all countries show that the mean duration of expansions has decreased slightly during the GM period, while the duration of contractions seems to have increased. Differences between the pre-GM and GM periods are not very large, but point out to the possibility of the presence 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 done 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.

**[Insert Table 7 around here]**

Estimation results for the panels of all countries, EU countries and non-EU countries are presented in Table 8. The first regressions report the results from a simple specification where we only compare whether the coefficient on duration dependence has significantly changed during the period of low volatility in economic activity. Results indicate no significant changes for expansions, for which positive duration dependence is found in both the pre-GM and GM periods. This evidence remains valid even when we add the variables that have revealed consistently significant and important in explaining the duration of expansions. A different result is found for contractions. Contrary to expectations, the evidence indicates that the likelihood of a contraction ending, as it becomes older, has decreased slightly in the group of all countries and in the group of non-EU countries – but not in the group of EU countries – during the GM period.[48] However, the coefficient on *LnDur∗GM* is no longer significant when we include the additional covariates that have proved to be important and relevant to explain the duration of contractions. The inclusion of the dummy *D_GM* in the model (see column 3

for the other countries were obtained considering the quarter in which the standard deviation of the real GDP growth (over the previous 20 quarters) has presented a substantial decrease: Austria (1984Q1), Spain (1978Q4), Sweden (1986Q1), New Zealand (1980Q2) and Switzerland (1980Q3). Figure A.1 in Annex presents the volatility of real GDP for these five countries. For the others see Summers (2005).

[48] Additional experiments, not reported here, have revealed that when New Zealand is excluded from the sample the coefficient on *LnDur∗GM* is no longer significant. In fact, New Zealand presents an abnormal long contractionary period between September 1986 and June 1991, which might be affecting the results.

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.[49]

**[Insert Table 8 around here]**

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 (and on average) the duration of their contractions and expansions or, more precisely, the duration dependence coefficient.[50] In general, expansions and contractions are still showing evidence of positive duration dependence, i.e. they remain more likely to end as they become older in the industrial countries during the GM period.

However, a particular country deserves a special attention: 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 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 9. The evidence confirms our expectations for this country: first, expansions are no longer duration dependent and the likelihood of they end has decreased significantly during the GM period; second, contractions present now a higher duration dependence coefficient, 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.[51] Thus, for the particular case of the US, we have evidence that the

---

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

[50] Additional regressions (not reported here) considering the pre-GM and GM periods separately have not presented 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.

[51] Note that these results should be analysed with a grain of salt due to the small number of business cycle turning points available. This is also a reason to estimate just a basic specification, i.e. a specification without additional regressors.

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, maybe because the "moderation" in their output volatility was not so "great", sharp and stable as in the US.

**[Insert Table 9 around here]**

## 5. 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 works has studied 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 paper 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 paper 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 paper 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 do not reveal 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 Europe. 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 procedure will 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.

## References

Abderrezak, Ali (1998). On the duration of growth cycles: An international study. *International Review of Economics and Finance*, 7(3), 343-355.

Alesina, A., N. Roubini, and G. Cohen (1997). *Political Cycles and the Macroeconomy*. The MIT Press. Cambridge, MA.

Allison, Paul (1982). Discrete-time methods for the analysis of event histories. *Sociological Methodology*, 13, 61-98.

Armingeon, K., P. Leimgruber, M. Beyeler and S. Menegale (2005). *Comparative Political Data Set 1960-2004*. Institute of Political Science, University of Berne.

Barsky, Robert and Lutz Kilian (2004). Oil and the Macroeconomy since the 1970s. *Journal of Economic Perspectives*, 18(4), 115-134.

Bassanini, Andrea and Stefano Scarpetta (2001). The driving forces of economic growth: panel data evidence for the OECD countries. *OECD Economic Studies*, 33(II), 9-56.

Baxter, Marianne and Robert King (1993). Fiscal policy in general equilibrium. *American Economic Review*, 83, 315-334.

Bry, G. and C. Boschan (1971). *Cyclical Analysis of Time Series: Selected Procedures and Computer Program*. New York: NBER.

Burns, A. F. and W. C. Mitchell (1946). *Measuring Business Cycles.* NBER studies in Business Cycles, No. 2. New York: National Bureau of Economic Research.

Buti, M., D. Franco and H. Ongena, 1997. Budgetary policies during recessions: Retrospective application of the Stability and Growth Pact to the post-war periods. *Mimeo*.

Castro, Vítor (2007). The impact of the European Union fiscal rules on economic growth. *The Warwick Economics Research Paper Series (TWERPS)*, WP 794.

Chauvet, Marcelle and Simon Potter (2005). Forecasting recessions using the yield curve. *Journal of Forecasting*, 24, 77-103.

Chen, N., L. Graham and A. Oswald (2007). Oil prices, profits, and recessions: An inquire using terrorisms as an instrumental variable. *The Warwick Economics Research Paper Series (TWERPS)*, WP 809.

Christiano, Laurence and Martin Eichenbaum (1992). Current real business cycles theories and aggregate labor market fluctuations. *American Economic Revew*, 82, 430-450.

Di Venuto, Nicholas and Allan Layton (2005). Do the phases of the business cycle die of old age? *Australian Economic Papers*, 44(3), 290-305.

Diebold, Francis and Glenn Rudebusch (1990). A nonparametric investigation of duration dependence in the American business cycle. *Journal of Political Economy*, 98(3), 596-616.

Diebold, F., G. Rudebusch and D. Sichel (1990). International evidence on business cycle duration dependence. *Institute for Empirical Macroeconomics*, DP 31.

Diebold, F., G. Rudebusch and D. Sichel (1993). Further evidence on business cycle duration dependence. In: J. H. Stock and M. W. Watson (Eds), *Business Cycles, Indicators, and Forecasting*, 87-116. Chicago: University of Chicago Press.

Dueker, Michael (1997). Strengthening the case for the yield curve as a predictor of U.S. recessions. *Federal Reserve Bank of St. Louis Review*, March/April, 41-51.

Durland, Michael and Thomas McCurdy (1994). Duration-dependent transitions in a Markov model of US GNP growth. *Journal of Business and Economic Statistics*, 12(3), 279-288.

Estrella, Arturo and Frederic Mishkin (1998). Predicting U.S. recessions: Financial variables as leading indicators. *Review of Economics and Statistics*, 80(1), 45-61.

Filardo, Andrew (1994). Business cycle phases and their transitional dynamics. *Journal of Business and Economic Statistics*, 12(3), 299-308.

Filardo, Andrew and Stephan Gordon (1998). Business cycle durations. *Journal of Econometrics*, 85, 99-123.

Finn, Mary (2000). Perfect Competition and the effects of energy price increases on economic activity. *Journal of Money, Credit and Banking*, 32, 400-416.

Fisher, Irving (1925). Our unstable dollar and the so-called business cycle. *Journal of American Statistical Association*, 20, 179-202.

Hamilton, James (1983). Oil and the Macroeconomy since World War II. *Journal of Political Economy*, 91(2), 228-248.

Hamilton, James (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica*, 57(2), 357-384.

Hamilton, James (2005). Oil and the Macroeconomy. In: S. Durland and L. Blume Eds. *The New Palgrave Dictionary of Economics*. Second Edition. Palgrave MacMillan.

Iiboshi, Hirokuni (2007). Duration dependence of the business cycle in Japan: A Bayesian analysis of extended Markov switching model. *Japan and the World Economy*, 19, 86-111.

Jaimovich, Nir (2007). Firm dynamics and markup variations: Implications for sunspot equilibria and endogenous economic fluctuations. Journal of Economic Theory, 137, 300-325.

Jenkins, Stephen (1995). Easy estimation methods for discrete-time duration models. *Oxford Bulletin of Economics and Statistics*, 57(1), 129-138.

Kiefer, Nicholas (1988). Economic duration data and hazard functions. *Journal of Economic Literature*, 26(2), 646-679.

Kim, Chang-Jin and Charles Nelson (1998). Business cycle turning points, a new coincident index, and tests of duration dependence based on a dynamic factor model with regime switching. *Review of Economics and Statistics*, 80(2), 188-201.

King, Robert and Sergio Rebelo (1999). Resuscitating Real Business Cycles. In *Handbook of Macroeconomics*. J. B. Taylor & M. Woodford (ed.), Ed. 1, Vol. 1, Ch. 14, 927-1007. Amsterdam: Elsevier.

Klein, Michael (1996). Timing is all: Elections and the duration of United States business cycles. *Journal of Money, Credit and Banking*, 28(1), 84-101.

Kneller, R., M. Bleaney and N. Gemmell (1999). Fiscal policy and growth: evidence from OECD countries. *Journal of Public Economics*, 74, 171-190.

Layton, Allan and Daniel Smith (2007). Business cycle dynamics with duration dependence and leading indicators. *Journal of Macroeconomics*, 29(4), 855-875.

Lam, Pok-Sang (2004). A Markov-switching model of GNP growth with duration dependence. *International Economic Review*, 45(1), 175-204.

Metz, Robert (2005). Does the Stability and Growth Pact lengthen recessions in the European Union countries? *Mimeo*. Washington University.

Mills, Terence (2001). Business cycle asymmetry and duration dependence: An international perspective. *Journal of Applied Statistics*, 28(6), 713-724.

Moneta, Fabio (2005). Does the yield spread predict recessions in the Euro Area. *International Finance*, 8(2), 263-301.

Mudambi, Ram and Larry Taylor (1995). Some non-parametric tests for duration dependence: An application to UK business cycle data. *Journal of Applied Statistics*, 22(1), 163-177.

OECD (2007). *OECD Economic Outlook*. Statistical Compendium, May 2007.

OECD (2007). *OECD Main Economic Indicators*. International Statistical Yearbook, May 2007.

Ohn, J., L. Taylor and A. Pagan (2004). Testing for duration dependence in economic cycles. *Econometrics Journal*, 7, 528-549.

Prentice, R. L. and L. A. Gloeckler (1978). Regression analysis of grouped survival data with application to the breast cancer data. *Biometrics*, 34(1), 57-67.

Rebelo, Sergio (2005). Real Business Cycle Models: Past, Present and Future. *Scandinavian Journal of Economics*, 107, 207-238.

Rotemberg, Julio and Michael Woodford (1996). Imperfect competition and the effect of energy price increases on economic activity. *Journal of Money, Credit and banking*, 28, 549-577.

Sensier, M., M.Artis, D. Osborn and C. Birchenhall (2004). Domestic and international influences on business cycle regimes in Europe. *International Journal of Forecasting*, 20, 343-357.

Sichel, Daniel (1991). Business cycle duration dependence: A parametric approach. *Review of Economics and Statistics*, 73(2), 254-260.

Sorensen, P. and H. Whitta-Jacobson (2005). *Introducing Advanced Macroeconomics: Growth and Business Cycles*. McGraw-Hill, New York.

Summers, Peter (2005). What caused the Great Moderation? Some cross-country evidence. *Federal Reserve Bank of Kansas City Economic Review*, 3rd Quarter, 5-32.

Wooldridge, Jeffrey (2002). *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, Massachusetts.

Zellner, A. (1990). Some properties of the durations of economic expansions and contractions. *American Economist*, 34, 20-27.

Zuehlke, Thomas (2003). Business cycle duration dependence reconsidered. *Journal of Business and Economic Statistics*, 21(4), 564-569.

## Tables

**Table 1. Descriptive statistics by country, 1948-2006**

| | Duration of Expansions | | | | | Duration of Contractions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Country** | **No. Exp.** | **Mean** | **Std. Dev.** | **Min.** | **Max.** | **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.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.

**Table 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 the 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 3. Basic parametric estimations for duration dependence by country: non-EU countries**

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

*Notes*: See Table 2.

**Table 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)[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 equal 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(-lnL+($k$/2)ln$N$), 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 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. 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.

**Table 6. Robustness analysis**

| ***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* | -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 | | -60.70 | -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. 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).

**Table 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) | 34 | 29.2 | 25.4 | 4 | 93 | 36 | 5.1 | 2.5 | 2 | 13 |
| All countries (GM period) | 45 | 27.9 | 16.5 | 2 | 69 | 32 | 7.8 | 4.3 | 2 | 19 |
| EU (before GM) | 13 | 32.8 | 26.7 | 8 | 88 | 14 | 6.1 | 3.3 | 3 | 13 |
| EU (GM period) | 24 | 29.8 | 14.6 | 8 | 59 | 17 | 8.1 | 4.2 | 3 | 17 |
| Non-EU (before GM) | 21 | 27.0 | 25.0 | 4 | 93 | 22 | 4.4 | 1.7 | 2 | 19 |
| Non-EU (GM period) | 21 | 25.8 | 18.6 | 2 | 69 | 15 | 7.3 | 4.6 | 2 | 13 |
| 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 1 and Table A.1 in Annex. The duration of expansions and contractions is measured in quarters.

**Table 8. Duration dependence and the "Great Moderation"**

| ***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* | | |
| | (3.53) | (2.41) | | (3.14) | (2.24) | | (1.80) | | |
| 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. Robust standard errors are in parenthesis. $q_1+q_2$ 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.

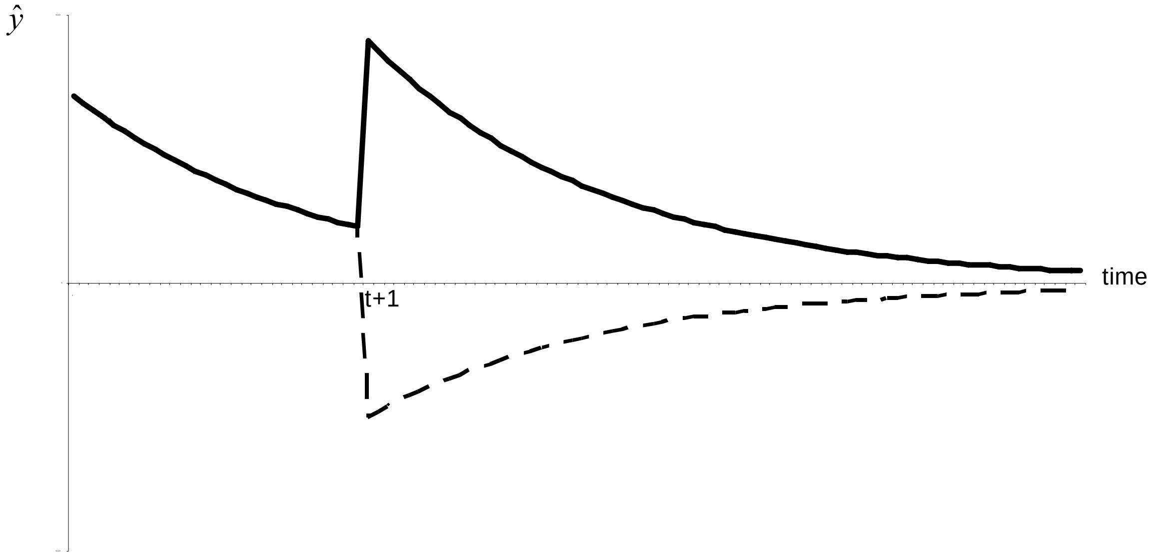
**Table 9. Duration dependence and the "Great Moderation" in the U.S.**

| | 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) | | (1.58) | |
| *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 and Table 8. Robust standard errors are presented in parentheses.

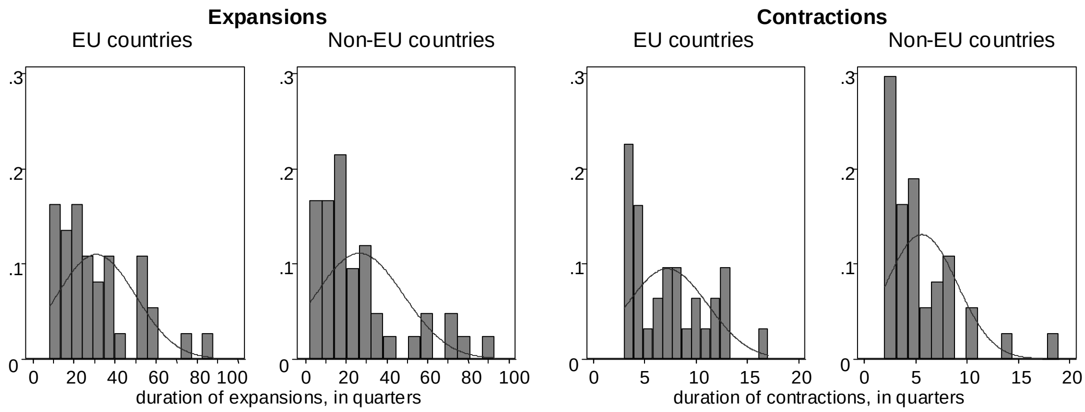
## Figures

**Figure 1. Impulse response functions to a positive and negative demand or supply shock**




*Notes*: The bold line indicates a positive demand or supply shock, while the dashed line corresponds to a negative demand or supply shock.

**Figure 2. Distribution of the duration of expansions and contractions: EU and non-EU countries**




*Sources*: See Table 1.

# Annex

**Table A.1. Business cycle chronologies, 1948-2006**

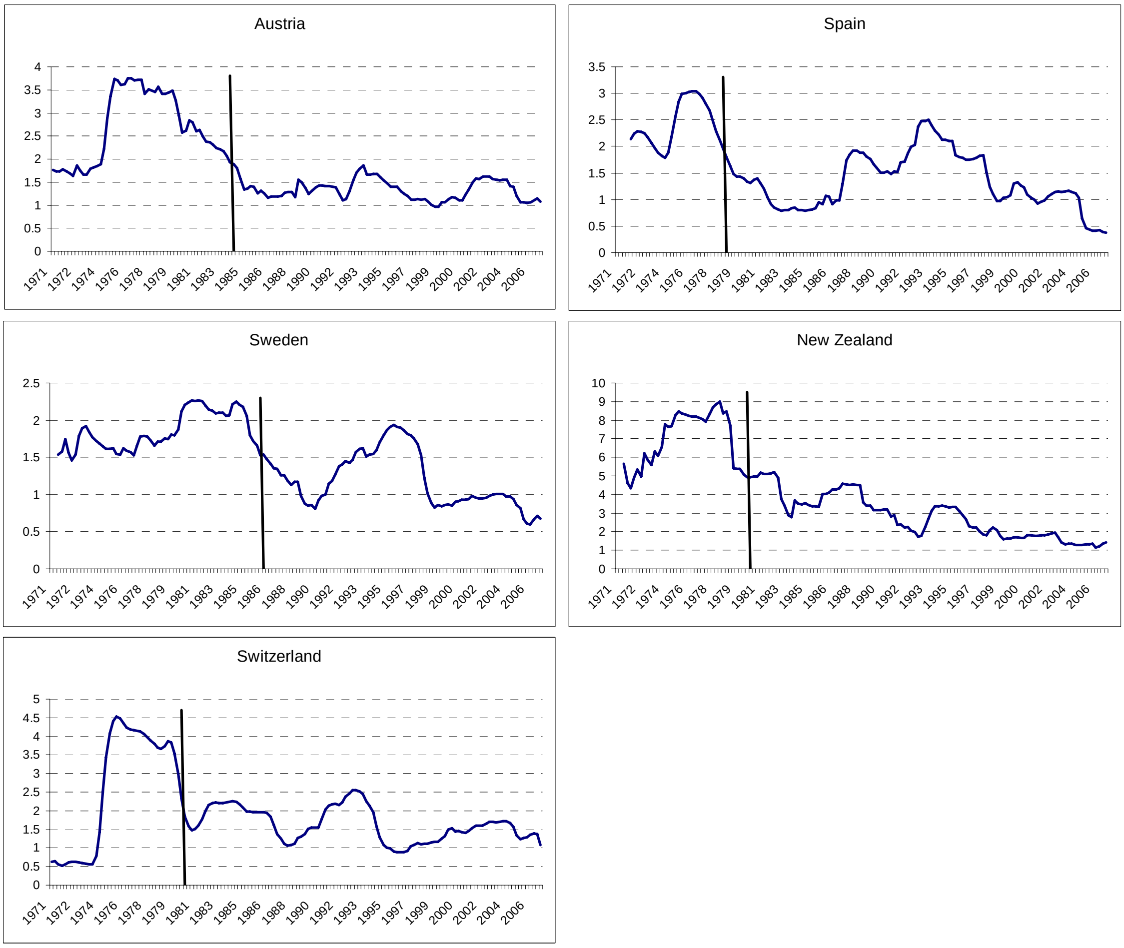
| | EU countries | | | Non-EU countries | |
|---|---|---|---|---|---|
| | **Peak** | **Trough** | | **Peak** | **Through** |
| **Austria** | August 1974 | June 1975 | **Australia** | June 1951 | September 1952 |
| | February 1980 | January 1983 | | December 1955 | August 1956 |
| | April 1992 | June 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.2. Description of the variables and respective sources**

| | |
|---|---|
| **Business cycle variables** | |
| *Peak* | Dummy variable that takes value 1 in the quarter in which a business cycle peak is reached, and 0 otherwise (*dependent variable*). |
| *Trough* | Dummy variable that takes value 1 in the quarter in which a business cycle trough is reached, and 0 otherwise (*dependent variable*). |
| *BCExpan* | Dummy variable that takes value 1 when a country is in expansion and 0 when the country is in contraction. |
| *BCContr* | Dummy variable that takes value 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 value 1 in the quarter in which a peak in the US business cycle is reached, and 0 otherwise. |
| *TroughUS* | Dummy variable that takes value 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 value 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. |

**Figure A.1. Volatility of real GDP growth**




*Notes*: Standard deviation of the real GDP growth over the previous 20 quarters. The vertical bar indicates the threshold between high-volatility and low-volatility in output.

*Sources*: OECD Economic Outlook.