



The changing economic regimes and expected time to recover of the peripheral countries under the euro: A nonparametric approach

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H I G H L I G H T S

- A nonparametric method for estimating the expected time to recover from a negative or positive shock or change is proposed.
- The proposed method relies on the basis of two assumptions: a Markovian property and stationarity.
- The method is applied to appreciate the impact of the monetary regime change on the dynamics of the peripheral countries in Europe.
- We show that the Euro generated a regime change in the macrodynamics of the economic space we consider.

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A nonparametric method is presented in order to estimate the expected time to cross a threshold on the basis of two assumptions, a Markovian property and stationarity. An empirical application is provided, using this method to investigate the dynamics of the GDP of 16 countries of the European Union for a long period, 1962–2016, and to detect the patterns of growth rates and expected mean reversion time after a negative, i.e. a recession, or a positive deviation from the trend. The conclusion supports the hypothesis of an economic regime change in the eurozone, affecting in particular the peripheral countries of southern Europe, ignited by the creation of the common currency.

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1. Introduction

The expected time to cross a given threshold is an important concept in stochastic analysis, although not commonly used in economic investigations. In the case of this paper, we develop a new method [1] to compute the expected time to recover or to adapt from a negative or positive shock or change. Independently of considerations on the endogenous or exogenous nature of perturbations in the dynamics of the aggregate measure of economic activity, the GDP, and accepting for the purpose of the computation the approximation provided by the required two assumptions (Markovian property and transformation for stationarization of data), we apply this method to appreciate the impact of the monetary regime change occurring from 1999 on the dynamics of the economies of the peripheral countries in Europe. Section 2 summarizes the methodology and Section 3 the empirical results, whereas Section 4 presents a conclusion.

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2. Methodology: a nonparametric method to estimate the expected time

The expected time for the economy to recover after a slump is an important indicator on how robust the economy is to shocks and how effective the policies and institutions are to regain the path of *normal growth*.

The econometric literature offers few alternative approaches to analyze this issue. A possible measure, commonly related to the level of persistence of a time series, is the half-life which is usually defined as the number of periods required for the impulse response to a unit shock of a time series to dissipate by half. However, empirical studies of half-lives have documented some issues related to the precision and unbiasedness of the estimates [2]. Most of the problems are related to incorrect model specification (apart from other sources such as temporal aggregation, structural breaks, etc.). Furthermore, half-life implies that a positive and negative shock of equal magnitude has the same impact on the impulse response function; however, the reversion to a fixed point (e.g. stationary mean) may display different behavior depending on whether the process is below or above that point.

Another way to discuss the time to recover can be based on the concept of expected time (ET) to cross some thresholds. For example, suppose that the GDP growth rate crosses some negative value say x_0 , indicating that the economy is in recession; then define a higher level or threshold that the process eventually reaches in the future, say x_1 . The expected time for the process to go from x_0 to x_1 is an indication of how resilient and robust the economy is to recover from recession. The ET concept has received little attention in economics. One of the reasons is probably the difficulty in obtaining a simple procedure to calculate, for example, the expected time (ET) to reach a threshold. In fact, analytical results on first hitting time problems (from which expected time may be calculated) are mostly based on stochastic processes of diffusion type or Markov chains where explicit analytical expressions are usually available. First hitting times are often used in mathematical finance, biology and other life sciences, where Markov chains and stochastic differential equations are more commonly used, for example, to study time to extinction or default (in finance). Nonetheless, ET may also be a very useful tool in economics to discuss topics such as the speed of mean-reversion, the time to equilibrium, and especially in the current case the time to recovery.

In this paper, we use a new estimator by Nicolau [1] to estimate the expected time to cross some thresholds. This estimator is formulated in a completely nonparametric framework and uses only two assumptions: Markovian property and stationarity. Standard errors can also be computed. We sketched the main ideas of the method here.

Let y be the GDP growth process with state space \mathbb{R} . We assume that: (A1) y is a Markov process of order r ($1 \leq r < \infty$) and (A2) y is a strictly stationary process. Under assumption A2, it can be proved that starting from a level a not belonging to the generic set A , the process y visits A an infinite number of times as $t \rightarrow \infty$, almost surely, see [3, chap. 9]. This property is of course crucial for (pointwise) identification.

We consider the hitting time $T := T_{x_1} = \min \{t > 0 : y_t \geq x_1\}$ and suppose that the process starts at value $x_0 < x_1$. The case $x_0 > x_1$ with $T_{x_1} = \min \{t > 0 : y_t \leq x_1\}$ is almost analogous. A brief remark on this case will be made later on. The distribution of T is usually difficult to deduce for general non-linear processes. However, there is a simple nonparametric method to estimate these quantities. Set $S_0 = 1$ if $y_0 = x_0$ (note that the process starts at $y_0 = x_0$). Now define the following transformation for $k \geq 0$

$$S_t = \begin{cases} 1 & \text{if } y_t < x_1, y_{t-1} < x_1, \dots, y_{t-k+1} < x_1, y_{t-k} \leq x_0 \\ 2 & \text{if } x_0 < y_t \leq x_1, x_0 < y_{t-1} \leq x_1, \dots, x_0 < y_{t-k+1} \leq x_1, y_{t-k} \geq x_1 \\ 3 & \text{otherwise.} \end{cases} \quad (2.1)$$

Fig. 1 illustrates the map (2.1) for a hypothetical trajectory of y .

The probabilities of T , which can be difficult or impossible to obtain from y , may be easily calculated from process S_t . It can be proved that

$$P(T = t) = (1 - p_t) \prod_{i=1}^{t-1} p_i = (1 - p_t) p_{t-1} p_{t-2} \dots p_1$$

where $p_t = P(S_t = 1 | S_{t-1} = 1, S_{t-2} = 1, \dots, S_0 = 1)$. Our strategy is to treat S_t as a Markov chain with state space $\{1, 2, 3\}$ from which we then estimate the relevant parameters. The following result supports our approach.

Proposition 2.1. Suppose that y is a r th order Markov process. Then S is a r th order Markov chain.

From the A1 assumption and previous proposition, one has $p_t = P(S_t = 1 | S_{t-1} = 1, S_{t-2} = 1, \dots, S_{t-r} = 1)$. The probabilities p_t can be estimated from standard Markov chain inference theory.

We first analyze the case $r = 1$. To emphasize the dependence of S_t on the thresholds x_0, x_1 , we write the transition probability matrix as $\mathbf{P}(x_0, x_1) = [P_{ij}(x_0, x_1)]_{3 \times 3}$ where $P_{ij} = P_{ij}(x_0, x_1) := P(S_t = j | S_{t-1} = i)$. The only parameter of interest is P_{11} . If S is a first order Markov chain, i.e. $r = 1$, then $p_t = P(S_t = 1 | S_{t-1} = 1) = P_{11}$ and

$$\mathbf{E}[T] = \sum_{t=1}^{\infty} t p_t = (1 - P_{11}) \sum_{t=1}^{\infty} t P_{11}^{t-1} = \frac{1}{1 - P_{11}}. \quad (2.2)$$

This quantity can be easily estimated from the maximum likelihood estimate $\hat{P}_{11} = n_{11}/n_1$ where n_{11} is the number of transitions of type $S_{t-1} = 1, S_t = 1$ and n_1 counts the number of ones (i.e. $S_t = 1$) in the sample.

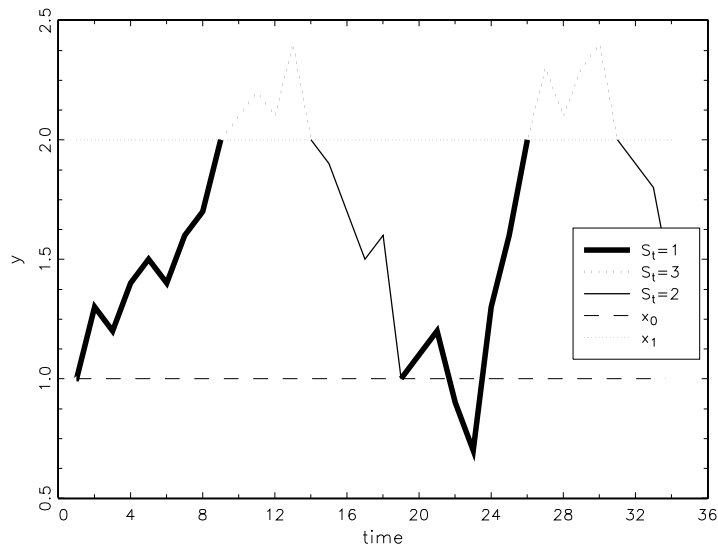


Fig. 1. Illustrating map (2.1), where $x_0 = 1, x_1 = 2$. Thick line: $S_t = 1$; thin line: $S_t = 2$; dot line: $S_t = 3$.

Proposition 2.2. We have $\hat{P}_{11} = n_{11}/n_1 \xrightarrow{p} P_{11}$ and $\sqrt{n}(\hat{P}_{11} - P_{11}) \xrightarrow{d} N(0, P_{11}(1 - P_{11})/\pi_1)$ where π_1 is such that $n_1/n \xrightarrow{p} \pi_1$.

It is interesting to observe that the process y has to visit (or cross) the threshold x_1 an infinite number of times over time, in order to achieve consistency, and this follows from A2, and in particular from positive Harris recurrence of y and also of S . This prevents, for example, having only ones in the sequence of S (which represents the case where y never visits x_1) and consequently $\mathbf{E}[T] = \infty$.

Proposition 2.3. Let $\widehat{\mathbf{E}}[T] = 1/(1 - \hat{P}_{11})$. We have in the case $r = 1$

$$\widehat{\mathbf{E}}[T] \xrightarrow{p} \mathbf{E}[T], \quad \sqrt{n}(\widehat{\mathbf{E}}[T] - \mathbf{E}[T]) \xrightarrow{d} N\left(0, \frac{P_{11}}{(1 - P_{11})^3 \pi_1}\right), \quad 0 < P_{11} < 1.$$

Proposition 2.4. Let us now focus on the case $r > 1$. We saw previously that $P(T = t) = (1 - p_t) \prod_{i=1}^{t-1} p_i$ where $p_t = P(S_t = 1 | S_{t-1} = 1, S_{t-2} = 1, \dots, S_0 = 1)$. Given that $p_t = p_r$ if $t > r$, in view of the Markovian property, we have

$$P(T = t) = \begin{cases} (1 - p_t) \prod_{i=1}^{t-1} p_i & t \leq r \\ \left((1 - p_r) \prod_{i=1}^{r-1} p_i \right) p_r^{t-r} & t > r. \end{cases}$$

Consequently, we have

$$\mathbf{E}[T] = \sum_{t=1}^r t (1 - p_t) \prod_{i=1}^{t-1} p_i + \left((1 - p_r) \prod_{i=1}^{r-1} p_i \right) \sum_{t=r+1}^{\infty} t p_r^{t-r} \quad (2.3)$$

$$= \sum_{t=1}^r t (1 - p_t) \prod_{i=1}^{t-1} p_i + \left((1 - p_r) \prod_{i=1}^{r-1} p_i \right) \frac{p_r (1 + r - r p_r)}{(1 - p_r)^2}. \quad (2.4)$$

This expression simplifies to the following formulas:

$$r = 1 \Rightarrow \mathbf{E}[T] = \frac{1}{1 - p_1} = \frac{1}{1 - P_{11}} \text{ (see Eq. (2.2)),}$$

$$r = 2 \Rightarrow \mathbf{E}[T] = \frac{1 + p_1 - p_2}{1 - p_2}, \text{ etc.}$$

Since the Markov chain is homogeneous, it follows that $p_k = P(S_k = 1 | S_{k-1} = 1, \dots, S_0 = 1) = P(S_t = 1 | S_{t-1} = 1, \dots, S_{t-k} = 1)$, $k < r$, and in particular, $p_1 := P(S_1 = 1 | S_0 = 1) = P_{11}$. To estimate p_k we use the maximum likelihood estimate $\hat{p}_k = A/B$, where A is the number of transitions from $S_{t-1} = 1, \dots, S_{t-k} = 1$ to $S_t = 1$ and B is the number of cases where $S_{t-1} = 1, \dots, S_{t-k} = 1$. However, modeling these probabilities may be problematic when k is relatively large and the sample size is small. Therefore k should be no higher than 4 or 5 (say), depending on the sample size, the level of persistence of y and the thresholds x_0 and x_1 . Nevertheless, the literature provides methods to deal with higher k , for example by using the Mixture Transition Distribution [4] or the probit-Mixture Transition Distribution [1,5].

We must also make a few observations on the statistical inference in the case $r > 1$. The estimate of $E[T]$ is straightforward: one needs only to replace the unknown parameters with the corresponding ML estimates. The estimator thus obtained is obviously consistent for $E[T]$. However, as it is evident from (2.4), an exact asymptotic expression for the distribution of $E[T]$ is difficult to obtain. To overcome this issue, we consider the regeneration-based bootstrap procedure of Athreya and Fuh [6] (see also [1] for more details).

3. Empirical illustration: The changing economic regimes of the peripheral countries under the euro

3.1. The economic problem

The investigation on economic fluctuations dominated macroeconomics through the first half of the twentieth century but was thereafter declared obsolete by an over-reaching confidence in stabilization policies. In this sense, Paul Samuelson joked at the fiftieth anniversary conference of the U.S. National Bureau of Economic Research, a major center for business cycle research, that its success was putting the organization out of a job. Nevertheless, the major recessions of the end of the century and that ignited by the subprime crash demonstrated major fragilities both in the economic structure of the developed countries and in their economic prescriptions and models.

The revival of business cycle analysis is built on different theoretical contributions, from the traditional approaches by Mitchell, Schumpeter [7,8] to the literature on long term processes of match and mismatch between the techno-economic paradigm and the institutional framework [9], to the historic analysis of different epochs [10,11], to the interpretation of the articulation among different institutional and economic factors [12–14], the convergence of general purpose technologies [15] and, finally, to the discussion on secular stagnation [13,16–18].

Although considering these contributions, we concentrate in this paper in an empirically oriented investigation in order to detect major structural changes in the schedule of quarterly GDP for some European countries (namely on Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and UK) through the long period of 1962–2016, suggesting that they indicate a regime change for the economies under scrutiny after the creation of the Monetary Union. In this case, therefore, the analysis of business cycles and long term dynamics is combined with the interpretation of the effect of a crucial change in the monetary regime of these economies.

Instead, the prediction suggesting that the Euro would imply the real convergence of the different economies has been canonical among the proponents of the single currency. Following the theory of an optimal currency zone, the deregulation procedures and the free movement of goods, capital and labor would allow for leveling the interest and the implicit exchange rates and to the convergence of factor prices in the different economies. As expressed by the then governor of the Bank of Portugal and current vice-president of the ECB, Vitor Constâncio, in a swearing-in 2000 speech, *without a currency of our own, we shall never again face the same balance of payments problems of the past. There is no macroeconomic monetary problem and no restrictive measures need to be taken for balance of payments reasons. No one analyzes the macro size of the external account of the Mississippi or of any other region belonging to a large monetary union.*¹ Recently, many authors challenged this view, considering the experience [16,19–21].

3.2. Empirical estimation

From a practical perspective, we estimate ET for the different starting points x_0 , but the same threshold x_1 . We call these estimates the ET curve or ETC. The value x_1 is defined as $x_1 = \bar{y}$ (empirical mean of y) which is the best estimate of the stationary mean. Therefore, the ETC measures the expected time for the process to revert to its stationary mean.

It should be point out the fact that, given the nonstationary nature of GDP process, we considered log-differenced series in order to achieve stationarity (A2) (both in mean and in variance) as it is confirmed by the augmented Dickey–Fuller tests.

To obtain the ETC we generate different values for x_0 equally spaced between $\bar{y} - \delta\hat{\sigma}_y$ and $\bar{y} + \delta\hat{\sigma}_y$, where $\hat{\sigma}_y$ is the sample standard deviation of y and δ is a parameter that controls the amplitude of the interval $(\bar{y} - \delta\hat{\sigma}_y, \bar{y} + \delta\hat{\sigma}_y)$. In our analysis we set $\delta = 1$. In order to compare the different ETC we standardize our data, so that all the standardized GDP will have zero mean and unit variance (hence, the point x_1 turns out to be zero). We have considered a second order Markov process (i.e. $r = 2$) based on the partial autocorrelation of y (we have analyzed seasonal adjusted series). However, it should be mentioned that other values of r lead to approximately the same results.

¹ Available at: <https://www.bportugal.pt/en-US/OBancoeoEurosistema/IntervencoesPublicas/Pages/intervpub20000223.aspx>.

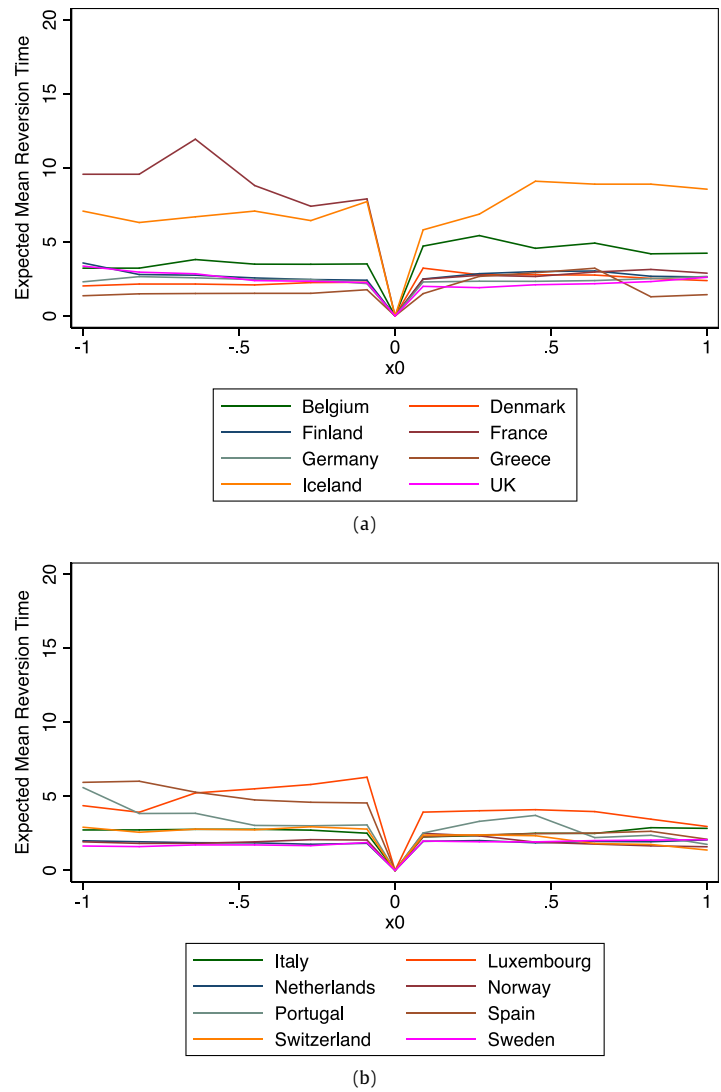


Fig. 2. ETC for the 1962–1998 period.

Table 1
Sample standard deviation of expected reversion time.

	1962–1998	1999–2016
$\sigma(\hat{y}_{ik} - \hat{\sigma}_{y_{ik}})$	2.27	4.00
$\sigma(\hat{y}_{ik} + \hat{\sigma}_{y_{ik}})$	1.70	4.23
$\sigma_{EM}(\hat{y}_{ik} - \sigma_{y_{ik}})$	2.49	4.68
$\sigma_{EM}(\hat{y}_{ik} + \sigma_{y_{ik}})$	1.96	4.96

Figs. 2(a) and 2(b) display the Expected Time Curves for the 1962–1998 period and Figs. 3(a) and 3(b) show the ETC for the 1999–2016 period on the GDP growth rates for 16 European countries. It is interesting to note that the dispersion of the mean expected reversion time among countries is much more higher in 1999–2016 than in the previous period (1962–1998), both for negative and positive deviations, as we shall see next (Figs. 8 and 9).

Fig. 4 displays the scatter plot of the average growth rates against the expected mean reversion time given a positive deviation of $(\hat{y}_{ik} - \sigma_{y_{ik}})$, where \bar{y}_{ik} is the average growth rate of the i th country at period k ($i = 1, 2, \dots, 16$ and $k = 1, 2$), for each subsample, and Fig. 5 is similar to Fig. 4 but represents the expected mean reversion time given a negative deviation of $(\hat{y}_{ik} - \sigma_{y_{ik}})$. Reference red lines denote the medians (considering the entire sample), therefore the Figure is divided into

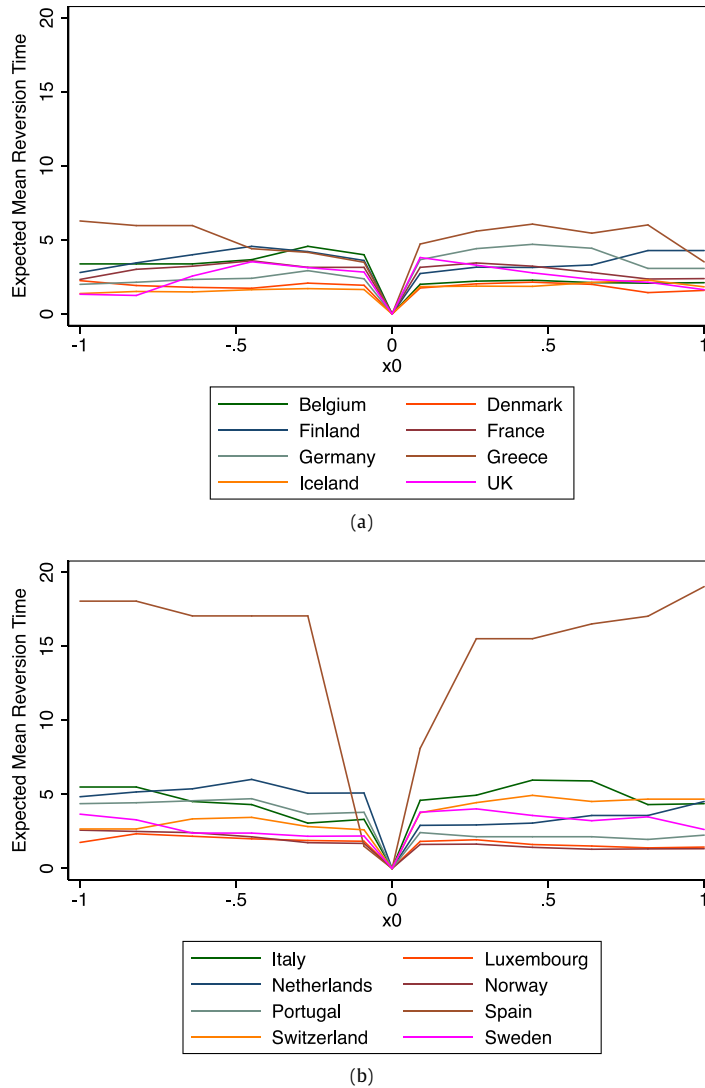


Fig. 3. ETC for the 1999–2016 period.

4 quadrants. Regarding Fig. 5, while the second quadrant (top left) represents the best possible situation (high growth rates and small mean reversion time given negative deviations) the fourth quadrant (bottom right) depicts the worst case scenario (small growth rates and high mean reversion time given negative deviations). On the one hand, after 1999, all the southern countries, notably, Portugal, Italy, Greece and Spain have moved from first or second quadrant to the fourth one. This circumstance is confirmed by the dendrograms (Figs. 7 and 11) where the southern European countries form a well defined cluster after 1999 onwards, whilst before 1999 (Figs. 6 and 10) the southern countries integrate different clusters among themselves. Nevertheless, one can observe a generalized mass migration of countries to the third and fourth quadrants of the scatter plots motivated by higher ET and lower growth rates.

However, the generality of the non Euro member states occupied the first quadrant until 1999 and moved to the third one quadrant after 1999 (there are no non Euro member states in the fourth quadrant) which means low recovery times after negative deviations in comparison with the Euro states. Moreover, the ET of the non Euro economies had not change a great deal from the 1962–1998 period to the 1999–2016

On the other hand, after 1999 the behavior of the countries is much more asymmetrical, both in terms of growth rates and in terms of (positive and negative) mean reversion time, with respect to the Euro member countries, and in particular regarding the Southern economies. In fact, unlike the 1962–1998 period, from 1999 countries exhibits a high degree of dispersion since the points are substantially diffuse over the clouds (Figs. 4 and 5 and Table 1).

The two extreme points of the ETC represent the expected reversion time when $x_0 = -1$ and $x_0 = 1$, that is to say, the mean ET to recovery given a deviation of $\bar{y}_{ik} - \hat{\sigma}_{y_{ik}}$. Table 1 displays the standard deviation of the ET for positive deviations

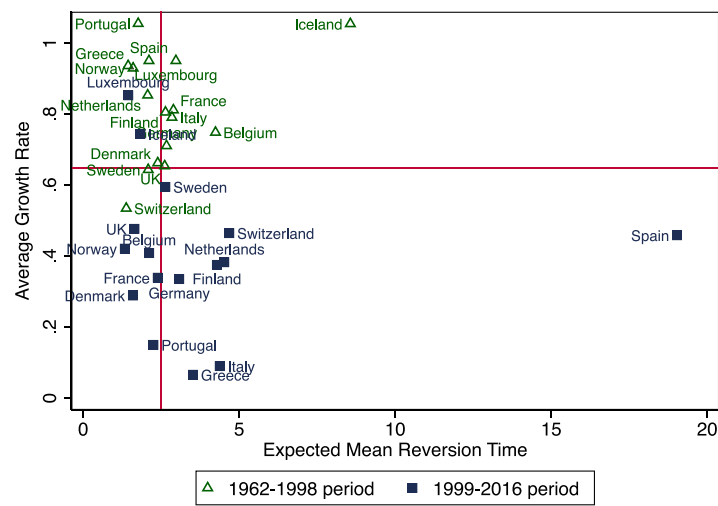


Fig. 4. Scatter plot for positive deviations from the mean.

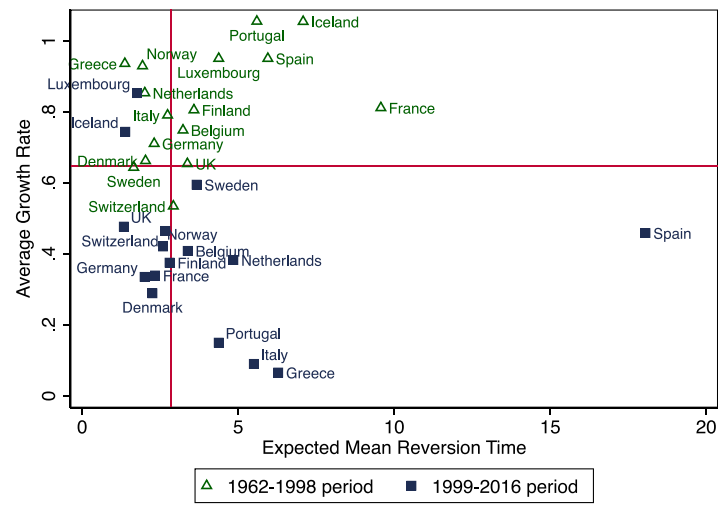


Fig. 5. Scatter plot for negative deviations from the mean.

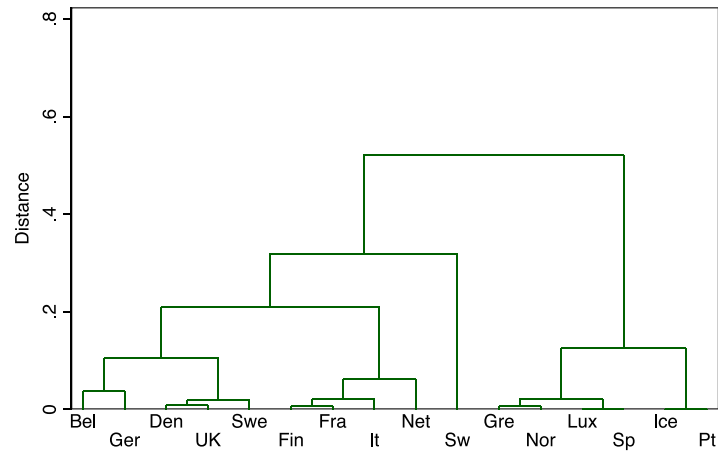


Fig. 6. Dendrogram: average growth rates for the 1962–1998 period.

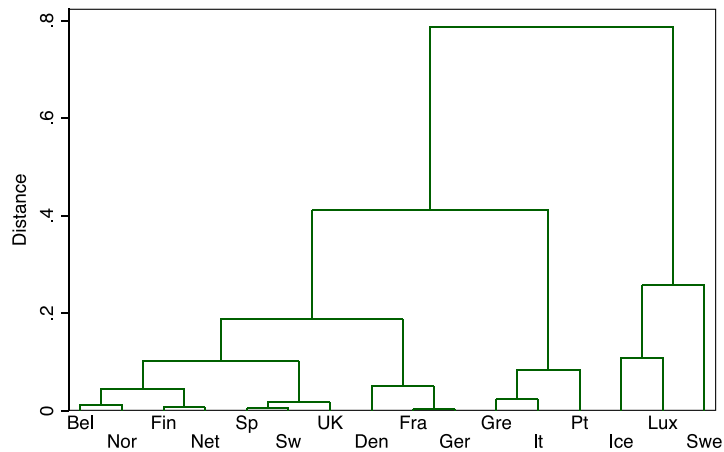


Fig. 7. Dendrogram: average growth rates for the 1999–2016 period.

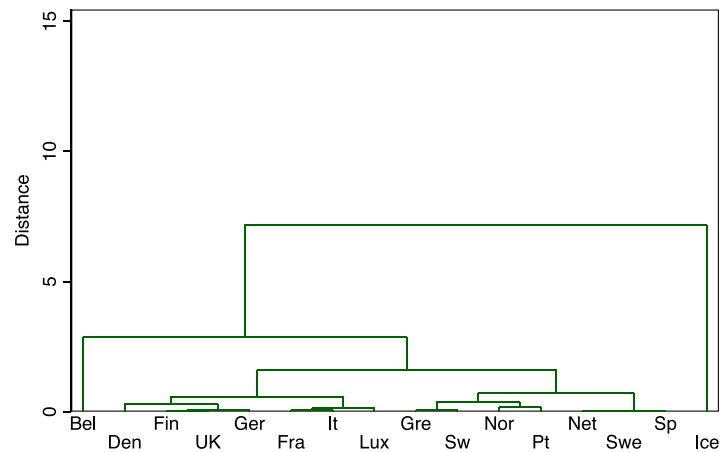


Fig. 8. Dendrogram: positive deviations from the mean 1962–1998 period.

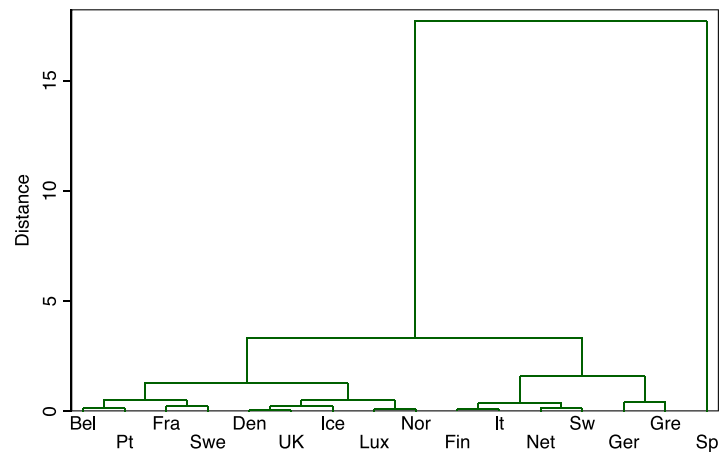


Fig. 9. Dendrogram: positive deviations from the mean 1999–2016 period.

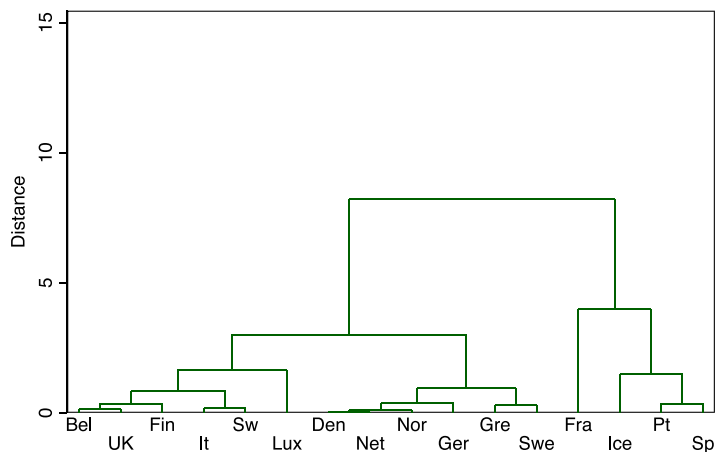


Fig. 10. Dendrogram: negative deviations from the mean 1962–1998 period.

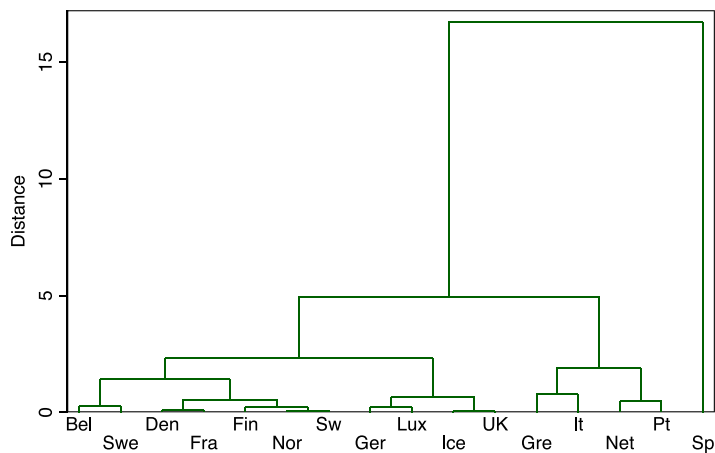


Fig. 11. Dendrogram: negative deviations from the mean 1999–2016 period.

($x_0 = 1$) and for negative deviations ($x_0 = -1$) between countries, for the whole set of countries - $\sigma_{(\tilde{y}_{ik} - \hat{\delta}_{y_{ik}})}$. In fact the standard deviation of expected reversion time given negative deviations raised more than 76% from 2.27 to 4.00 while the positive counterpart more than doubled (raised from 1.70 to 4.23) highlighting the overdispersion behavior of the recovery ET after 1999.

In order to analyze the *Euro effect*, let $\sigma_{(\tilde{y}_{ik} - \sigma_{y_{ik}})}^{EM}$ and $\sigma_{(\tilde{y}_{ik} + \sigma_{y_{ik}})}^{EM}$ denote, respectively, the mean reversion time given negative and positive deviations from the mean of one standard deviation for the Euro member countries only (excluding Denmark, Norway, Switzerland, UK and Sweden). This asymmetrical overdispersion pattern of the mean expected reversion time among countries is also much more higher from 1999–2016 than in 1962–1998 for the Euro member countries comparing with the whole set of countries. Considering only Euro member states, the relative dispersion (1999–2016 vs 1962–1998) of the expected reversion times over extreme negative deviations raised from 2.49 to 4.68 (88%) and given positive deviations from 1.96 to 4.96 (more than 154%).

This *Euro effect* related with recovery times can be isolated considering the ratios $\frac{(\tilde{y}_{ik} - \sigma_{y_{ik}})_{EM}}{(\tilde{y}_{ik} - \sigma_{y_{ik}})}$ and $\frac{(\tilde{y}_{ik} + \sigma_{y_{ik}})_{EM}}{(\tilde{y}_{ik} + \sigma_{y_{ik}})}$ for the two periods — before and after the introduction of the Euro. For negative deviations, the ratio raised from 1.10 in 1962–1998 to 1.17 in 1999–2016 suggesting an increase in the regional imbalances given recessions and, more precisely, that the gap between the European countries after the introduction of the euro is much more higher inside than outside the Eurozone

4. Conclusions

Our findings favor the hypothesis that the Euro generated a regime change in the macrodynamics of the economic space we consider and that this change impacted on the growth of the economies, imposing a process of divergence instead of

convergence. For 1999–2016 we detect higher dispersion of the performances of the different economies than in the previous period, both for positive and negative deviations from the mean but also, in particular, we find that low growth rates correlate with high mean reversion time given negative deviations. High persistence or low speed mean reversion indicates divergence either through successive shocks or through endogenous economic changes. This can signify the presence of self-reinforcing mechanisms or political choices consistent with the formation of this new regime for the Euro period. As expected, the results of clusterization analysis for the period after 1999 confirm these results and we find the Southern countries of Europe forming a well defined cluster for that period, unlike in the past.

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