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UNITY AND PLURALITY OF THE EUROPEAN CYCLE

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Abstract

This paper aims to apply the methodology of uni- and multivariate Structural Unobserved Components Time Series Models developed by Andrew Harvey to the study of European growth trends and cycles. The multivariate dimension enables to search similar or, more strongly, common components among national series. Common factors models are an interesting way to study the relations between trends and cycles of several series.

The first section presents the general methodology of the paper. The second section presents uni- and multivariate structural time series models more accurately. It presents explicitly the multivariate form of the models in the trivariate case. The trivariate dimension is convenient to understand the logic of these models. The trivariate case remains simple enough to be written explicitly without using systematically matrix presentation and it is more general than the bivariate case, which is too particular to illustrate the general features of multivariate models.

Sections 3 to 5 present and comment the application of this methodology to the study of European growth trends and cycles. Data covering all the decades 1960 to 1990 are extracted from the quarterly national accounts collected in the BSDB database of OECD (*Business Sector Data Base*). The application uses the software STAMP (Koopman, Harvey, Doornik and Shephard, 2000), which was specially built to implement the multivariate structural time series models. Three successive ways to exhibit the European cycle are used: the direct split of the European aggregate GDP, compared to the US split in a bivariate model; the aggregation of the national cycles of the member countries; the search for common components between these national cycles. The results of these ways are compared. Convergence between the results of these approaches is satisfactory.

The European aggregate fluctuations reveal two distinct cyclical components, which can be assimilated to the classical Juglar (or decennial) and Kitchin (or triennial) cycles. The European Juglar or decennial cycle exists clearly but it cannot be reduced to a single common component of the national cycles, which would be generated by a single series of shocks. The European Juglar cycle has at least the dimension “three”, i.e. it can be understood as the result of the interference of three elementary and independent sequences of stochastic shocks. These elementary components correspond to current geographical division of Europe. From this point of view, the euro-zone is not yet an optimal currency area, as the shocks generating the European cycles are not completely symmetrical. The national cycles are not yet reducible to the common symmetrical component which shows through the aggregate cycle of the European GDP. This common and symmetrical component contributes approximately only for one third to the whole national cycles.

The sixth section uses the sequences of shocks (or innovations) extracted from the uni– and multivariate models to build indicators giving information about the evolution of the symmetrical character of shocks hitting euro-zone countries. The vulnerability of the euro-zone to strong shocks and the asymmetry of these shocks show some decreasing trend during the last ten decades but this trend is neither regular, nor irreversible.

The conclusion sums up the main ideas coming from this set of applications. It confirms the practical interest of the specific stochastic models used by this paper and the complexity of the European cycle. The definition of a balanced policy mix should take into account the persistent plurality of the European cycles.

Key words: (A)symmetrical shocks, Common factors, European integration, Growth cycles, Stochastic trends, Structural time series model.

JEL codes: C 32 , E 32 , F 42

UNITY AND PLURALITY OF THE EUROPEAN CYCLE[1]

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Studying the trends and cycles of the European economy is not only a technical issue for curious experts. It underlies the need for an educated cooperation among institutions in charge of the economic policy. It plays a part in the consensual and objective valuation of the economic situation and its tensions, which is necessary for an informed practice of that policy. It focuses on a definition of the European economic situation that is deeper and more synthetic than the plain use of a large range of indicators, as relevant as they can be. In the now canonical – although multiple – models of monetary policy, the split into trend and cycles is used for at least two different issues:

– The trend of GDP (or potential GDP) appears in the loss functions of the political and monetary authorities if they are concerned by the gaps between the actual GDP and its trend (or potential level); as a result, the final monetary target which comes from the minimisation of that loss function is not independent from the measurement of that trend.

– Even if the gap between actual and potential GDP does not appear in the loss function, it may be an explicative variable of inflation and therefore its measurement is a key-indicator of the inflationary tensions. That is why it is used in the model constraining the minimisation of the loss function.

One is confronted with two types of problems when identifying the cyclical component of the European activity (Europe being hereafter considered as the euro-zone). The first problem concerns the choice of the method and is not specific to the European case, while the second one concerns expressly the European case. If the euro-zone could be considered as an optimal currency area[2], its cyclical manifestation would be perfectly common among the various countries which constitutes the euro-zone. In other words, it would be generated by shocks which affect simultaneously and identically all the countries. So as to justify the order that will be used to present the results, we first introduce the nature of our approach, from the double point of view of the method and the application to the European case, and we then describe precisely its contents.

[1] This study has benefited from support by Eurostat.

[2] An optimal currency area is a set of countries whose structural and institutional characteristics are similar enough so that they are not much concerned by asymmetrical or opposite shocks. The reference paper is Mundell (1961). De Grauwe (1999) proposes a review of the literature concerning the European case.

The first section presents the methodology using Unobserved Components Structural Time Series Models. The second section presents uni- and multivariate structural time series models more accurately. Sections 3 to 5 present and comment the application of this methodology to the study of European growth trends and cycles. Three successive ways to exhibit the European cycle are used: the direct split of the European aggregate GDP, compared to the US one in a bivariate model; the aggregation of the national cycles of the member countries; the search for common components between these national cycles. The results of these ways are compared, in order to evaluate their convergence. Section 6 uses the sequences of shocks extracted from the models to build indicators giving information about the evolution of the symmetrical character of shocks hitting euro-zone countries. The conclusion sums up the main ideas coming from this set of applications. It confirms the practical interest of the specific stochastic models used in this paper and the complexity of the European cycle.

1. The methodology

1.1. Choice of the method

Several statistical and econometric methods are in competition to identify the European cycle. This paper stands on results given by univariate and multivariate Unobserved Components Structural Time Series Models, proposed by the statistician Andrew Harvey (Harvey, 1989; Koopman and Harvey, 1997). They are named more briefly and usually Structural Time Series Models.

This method is still a statistical one. Nonetheless, it has an advantage on more descriptive methods: it can be tested by estimation and diagnoses. It allows an interpretative economic diagnostic provided that one accepts the strict distinction between long-term trend and growth cycles which fluctuate around this trend. Such a distinction is not to be interpreted as an absolute and definitive independence between these two components of the economic development. Rather, it means modestly that, concerning the estimation period, this development is characterised by a sufficiently strong structural stability. Thus, the short-run fluctuations reflect the apparition of disequilibriums and tensions that shift economic activity from its trend, but also factors of correction that take it back there. Fluctuations can be ***persistent*** – expansion or recession last a long time because the inertia of a short-term movement is strong when initiated – but they still are ***stationary***: the situation will always come back to the trend. This combination of persistence and stationarity defines statistically the cycle although it is difficult to exhibit it econometrically.

Within this framework, trend and cycles are stochastic components generated by independent series of shocks. The trend may be chosen within a rather large range of formulations, according to *a priori* assumptions about its smoothing degree and to their possible corroboration by tests. The method is sufficiently flexible to take into account more or less progressive breaks in the fundamental pattern of the trend. A deterministic trend which is only function of time would be a borderline case.

The formulation of cycles gives a formal representation of the impulse-propagation dynamics first proposed by Frisch (1933). The cyclical component(s) extracted from a series is the result of a time series of random impulses (called innovations by a statistician and shocks by an economist), characterised by a given variance, that is applied to a mechanism of cyclical propagation, characterised by a "virtual" periodicity and a damping factor. As a result, the cyclical component, though it is basically a succession of expansions and recessions, may have a much more complex pattern than a totally regular theoretical cycle. It can incorporate actual variations in the length, magnitude and profile of the successive cycles. The global pattern is then function of the series of shocks revealed by the actual history.

When the estimated model is multivariate (several national GDPs for instance), it is a means to look for common factors that may be at the origin of the stochastic components of every dependent variable; this may be used for trends or cycles. Trends can be co-integrated, that is generated by common factors less numerous than the initial trends. It does not mean that the trends will be identical but that they are linked by linear relations. The latter may be for instance the sign of a long-term catching-up between countries.

Concerning the cycle, it is crucial to make a distinction between similar cycle and common cycles. Several series have a similar cycle when the cyclical components of each of them come from the same mechanism of propagation (same "virtual" period and damping factor) but are generated by specific series of impulses. The result is that the cyclical components may be clearly different and in particular strongly desynchronised. A similar cycle becomes common when the series of impulses are perfectly correlated. Their only difference is their variance, and so the cyclical components are exactly synchronised and differ only in their magnitude.

Shifting from similar to common cycles means shifting from asymmetrical to symmetrical shocks (even of various intensity, like an oil shock striking simultaneously several countries that are differently dependent on oil imports)[3]. The concept of cyclical convergence could be defined as the realisation of such a shift, within a set of structurally similar enough economies so as their mechanisms of cyclical propagation could be defined as similar.

[3] However, talking about symmetrical shocks supposes that the common cycle affects the various countries with the same sign. If the common impulses were perfectly but negatively correlated between two countries, the common cycle would not affect them with the same sign: it would be better then to talk about "opposite shocks". In order to be accurate, it seems normal to use the term "asymmetrical shocks" when independent shocks (*a priori* non synchronised) affect the similar cycles of various countries; and to use the term "opposite shocks", when the shocks – simultaneous and perfectly correlated but with opposite signs – pass through the same common component to influence the national cycles.

1.2. Application to the European Monetary Union

The method has already been applied to the OECD countries in its univariate approach (Fayolle and Mathis, 1993 and 1994). Its analytical usefulness makes its application to European cycles particularly motivating: will it show the existence or the emergence of a really unified short-term dynamics among euro-zone countries? However, such an application raises particular difficulties. Long series are needed to use the selected method, which imply to measure the European GDP on a quarterly basis for the last decades. Such a measurement is a fragile statistical reconstruction and reflects also a bet on the minimal consistency of the European dynamics. If there were during those decades only idiosyncratic or even contradictory economic dynamics among European countries, one could be doubtful about the possibility to infer cyclical regularities concerning the European growth. Indeed, it appears less easy to summarise the features of the European fluctuations than the American ones. The heterogeneity of the European area makes more difficult to characterise its cyclical properties, when compared with the US which has been an unified monetary zone since much longer and whose cyclical movements were early studied by analysts and policy makers. Our paper aims to identify the economic cycles of the euro-zone on the whole four decades from 1960 to 1999, while this zone has only been really constituted at the end of the nineties !

Therefore, we used three distinct approaches in order to identify the European cycles with the chosen methodology, considering that the convergence of the results could enable us to identify more strongly the European cycles:

– The first approach characterises the European cycles "from above", i.e. using a bivariate model which explains the joint movements of the United States GDP and the European aggregate GDP. Because the dynamics of the latter are characterised by instability, it is more easily identified by a model that takes advantage of the American cyclical regularity in order to detect the European cycles.

– The second approach aggregates the national cycles of the euro-zone countries that are estimated by univariate models, in order to get back to the European aggregate cycle "from below". This approach gives results that meet remarkably the ones given by the first approach. It backs the idea of a sufficient regularity of the European cycles so that stylised features can be produced. The approach confirms as well a remarkable peculiarity of the European cyclical movements that was already noticed with the first approach, but not so clearly in the US: the global European cycle is the conjunction of "short" and "long" cyclical components. The period of the short one is around three years and can be related to inventory variations; the period of the long one, of about ten years, is related to investment fluctuations. This duality of the European cycle makes more difficult its grasp by the economic policy makers, but it is even more needful to take it into account.

– The third approach seeks to identify how much the European cycles can be considered as cycles that are common to the different European countries, using a multivariate model including the whole set of national GDPs from the euro-zone. If the euro-zone was an optimal currency area, there would be, for a given cyclical frequency, a single common cycle, which would be the mark of the perfect symmetry of the shocks generating the national and European fluctuations. Our result is not so radical and shows that, over the four considered decades, it is possible to reduce to a small number of common factors, but not to only one, the national sequences of innovations that drive the "long" cyclical movements (of around ten years). A cautious interpretation of those common factors would be that some geographical discrepancies remain among the euro-zone at the end of the nineties, which could explain a persistent plurality of the cyclical economic fluctuations. Nonetheless, the nature of the discrepancies let assume that they could be dampened with the maturing of the euro-zone, where the cyclical movements would become more homogeneous.

Beyond the statistical quality, often imperfect, of each estimated model considered alone, it is the convergence of the three approaches which is sought as a proof of robustness when identifying the European cycles and their characteristics.

We first present the specifications of the selected models and their estimation method, in order to permit the comprehension of the results. Then we successively comment and confront the results of the three approaches. We finally intent to give a synthesis on the measure of the symmetry of impulses which govern the European cycles.

The data are taken from the BSDB quarterly database of the OECD *(Business Sector Data Base*, June 2000), which gives series from the first quarter of 1960 to the fourth quarter of 1999, i.e. exactly four complete decades. All the estimations have been systematically done for this period of time. A few series with missing values have been completed using national sources or other OECD databases. Some peculiarities concerning the data or its treatment will be indicated below, when necessary. In order to carry out our estimations, we used the application STAMP (*Structural Time Series Analyser, Modeller and Predictor*) that has been designed especially to deal with unobserved components models (Koopman, Harvey, Doornik and Shephard, 2000).

2. The trend-cycle split of series

2.1. Univariate Models: Stochastic Trends and Cycles

The structural time series model splits every series into trend, cycles, and irregular components. More precisely, we have the following split (for a non-seasonal series, which will be the standard case in this paper):

$$y_t = T_t + \sum_{j=1}^{m} C_{jt} + \varepsilon_t \qquad t = 1,...,T \qquad [1]$$

where y_t is the logarithm of a series Y_t presenting long- and short-run movements. T_t , C_{jt} and ε_t are respectively the trend, cyclical and irregular components. The model can include several cyclical components associated to different frequencies. STAMP allows the inclusion of up to three cycles in the model ($m=3$).

2.1.1. *Trends*

The trend is a local linear one for which both the level and the slope are random walks specified as follows:

$$T_t = T_{t-1} + \beta_{t-1} + \eta_t \qquad [2]$$
$$\beta_t = \beta_{t-1} + \zeta_t \qquad [3]$$

where η_t and ζ_t are orthogonal white noises with variances σ_η^2 and σ_ζ^2 respectively. The noise η_t allows the level of the trend to fluctuate while ζ_t tilts the slope.

In the general case, it is clear that the trend defined by the equations [2] and [3] is an ARIMA(0, 2, 1). But particular cases are interesting:

– In the extreme case where $\sigma_\eta^2 = \sigma_\zeta^2 = 0$, the trend is simply a deterministic one; i.e. $T_t = T_{t-1} + \beta$, or equivalently $T_t = T_0 + \beta t$.

– If only $\sigma_\zeta^2 = 0$, equation [3] reduces to $\beta_t = \beta_{t-1}$. The slope is constant in time and the trend becomes a random walk with drift. We find the standard stochastic trend, stationary in first difference, as used by Nelson and Plosser (1982).

– If only $\sigma_\eta^2 = 0$, the trend is still integrated of order two as in the general case but without white noise affecting its level. $\Delta^2 T_t$ is a white noise. Clark (1987) calls this trend *Slowly Moving Smooth Trend* (we will say *smooth trend*). Such a trend gives, as indicated by its name, a smooth curve which looks like the ones obtained with the practical methods used by business cycles analysts.

2.1.2. *Stochastic growth cycles*

A cycle is a stationary process, which explicitly takes the cyclical pattern of this component into account. In recursive form the cycle component can be expressed as:

$$\begin{bmatrix} C_t \\ C_t^* \end{bmatrix} = \rho \begin{bmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{bmatrix} \begin{bmatrix} C_{t-1} \\ C_{t-1}^* \end{bmatrix} + \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix} \qquad [4]$$

The disturbances κ_t and κ_t^* are two orthogonal white noises with identical variance σ_κ^2. The damping factor of the cycle is given by $\rho \in [0,1]$ and its frequency is $\lambda \in [0,\pi]$, which corresponds to a period equal to $\frac{2\pi}{\lambda}$. C_t^* is a technical variable needed to write the cycle in recursive form. The disturbances make the cycle stochastic and able to take into account the complexity of the apparent cyclical movement, which usually presents asymmetry and angular turning points. If we cancel the disturbances in equation [4], the cycle becomes deterministic, $C_t = \rho^t(\alpha\cos\lambda t + \beta\sin\lambda t)$ with $C_0 = \alpha$ and $C_0^* = \beta$.

One can verify that the cycle is a stationary ARMA(2, 1) process when the coefficient ρ is strictly inferior to one. There is equivalence between the statistic property of stationarity and the damping of the cycle.

2.1.3. *Intervention variables*

In this unobserved components model, the dependent variable y is explained in terms of stochastic trends and cycles. In order to expand the information set of the structural model, we can add intervention variables, which are used to take account of outlying observations and structural breaks. Three kinds of intervention variables are possible. They can be thought as dummies taking the value one at the time of the event and zero elsewhere. They concern respectively the irregular component, the level and the slope of the trend component: an *impulse* intervention variable that corresponds to a particular outlier in the irregular disturbance ε ; a *step* intervention variable that can be modelled by adding a dummy to the level equation [2] and that represents a permanent change of the series level; a *staircase* intervention variable, modelled by adding a dummy in the slope equation [3] and representing a permanent change of the trend slope, i.e. of the long run path of the series. If the step and staircase interventions are represented directly in the equation [1], the step variable is zero before the break and one after, while the staircase variable takes the value 1, 2, 3, … , starting at the first period after the break.

The equation [1] is now written in the more general form:

$$y_t = T_t + \sum_{j=1}^{m} C_{jt} + \sum_{k=1}^{p} \delta_k w_{kt} + \varepsilon_t \qquad t=1,\ldots, T \qquad [5]$$

where the w_h are p intervention variables. The coefficients δ are unknown.

2.2. The multivariate dimension: presentation in the trivariate case

We are going to use the trivariate case for the presentation of the Multivariate Structural Time Series Models. The trivariate case remains simple enough to be presented explicitly without using systematically synthetic matrix presentation and it is more general than the bivariate case, which is too particular to illustrate the general characteristics of multivariate models. "Three" is a convenient dimension to understand the logic of these models.

2.2.1. ***General form of multivariate models***

The multivariate models have a form similar to univariate models. y_t is now an $(n\times 1)$ vector of observations that depends on unobserved components which are also $(n\times 1)$ vectors (we will emphasise the case $n=3$). As in the univariate case, STAMP allows to include up to three cycles in each series, but it imposes the restriction that, for a given cycle C, the damping factor ρ and the frequency λ are the same for all series. Cycles with the same coefficients ρ and λ are called similar cycles. The strength of such a similar cycle can be different between series, because it depends on the variance of its disturbance, which is specific to each series. The similar cycle is not necessarily synchronised among series, because the sequence of its disturbances is also peculiar to each series. In order to simplify the presentation, in accordance with the following applications, we consider the case of two possible cycles:

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$$\left.\begin{aligned} y_{it} &= T_{it} + \sum_{j=1}^{2} C_{ijt} + \varepsilon_{it} \\ T_{it} &= T_{i,t-1} + \beta_{i,t-1} + \eta_{it} \\ \beta_{it} &= \beta_{i,t-1} + \zeta_{it} \end{aligned}\right\} \quad i=1,2,3 \qquad [6]$$

where i and j are respectively the indices of the three variables and of the two cycles.
The equation of the cycle j for the variable i is the following, with the coefficients ρ_j and λ_j, but not the disturbances κ_{ij} and κ^*_{ij}, independent of the variable :

$$\begin{bmatrix} C_{ijt} \\ C^*_{ijt} \end{bmatrix} = \rho_j \begin{bmatrix} \cos\lambda_j & \sin\lambda_j \\ -\sin\lambda_j & \cos\lambda_j \end{bmatrix} \begin{bmatrix} C_{ij,t-1} \\ C^*_{ij,t-1} \end{bmatrix} + \begin{bmatrix} \kappa_{ijt} \\ \kappa^*_{ijt} \end{bmatrix} \qquad i=1,2,3\ ,\ j=1,2 \qquad [7]$$

The (3×1) disturbances vectors ε_t , η_t , ζ_t , κ_{jt} and κ^*_{jt} are trivariate normal disturbances $N(0,\Sigma)$, which are mutually uncorrelated in all time periods and have (3×3) covariance matrices Σ_ε , Σ_η , Σ_ζ and Σ_{κ_j} (the same matrix for κ_j and κ^*_j). Models of this kind are called *Seemingly Unrelated Time Series Equations*. Explanatory and intervention variables may be included in multivariate models.

2.2.2. ***Common cycles***

In a common factors model, some or all of the components are driven by disturbances vectors with less than n elements (n is the size of the variables vector). The covariance matrices of the relevant disturbances are less than full rank. The interest of common factors is the possible interesting interpretation but also more efficient inference. STAMP allows for common trends or cycles. We only focus here on common cycles, i.e. on the case in which n similar cycles C_{it} ($i=1...n$) are generated by less than n (let say k) different disturbances κ_t .

Common cycles may be introduced by using a $(n\times k)$ loadings matrix Θ . The rank of the cycle disturbances matrix Σ_κ is k , with $\Sigma_\kappa=\Theta' D\Theta$, where D is a $(k\times k)$ diagonal matrix. If we consider a model with one similar cycle C_t , the supplementary constraint of a $(k\times 1)$ common cycle vector C^ω_t induces the following form:

$$y_t = T_t + \Theta C^\omega_t + \varepsilon_t \qquad [8]$$
$$\text{i.e. } C_t = \Theta C^\omega_t$$

The identification of the number k of common cycles is an important step in the process of specification and estimation of a convenient model. For example if we consider a trivariate model with the constraint $k=1$ the cycle of each variable will be a multiple of the elementary cycle C^ω_t:

$$\begin{aligned} y_{1t} &= T_{1t} + C^\omega_t + \varepsilon_{1t} \\ y_{2t} &= T_{2t} + \theta_2 C^\omega_t + \varepsilon_{2t} \\ y_{3t} &= T_{3t} + \theta_3 C^\omega_t + \varepsilon_{3t} \end{aligned} \qquad [9]$$

Not only the single common cycle has similar characteristics but the innovations of the cycle are the same for all the variables. Their cycles are perfectly synchronised. The only difference is the strength of the cycles: each cycle is proportional to the others. Common cycles embody much stronger restrictions than similar cycles.

If $k=2$, there will be two elementary cycles C^{ω}_{1t} and C^{ω}_{2t}, which are similar but do not result from the same chronic of innovations:

$$y_{1t} = T_{1t} + C^{\omega}_{1t} + \varepsilon_{1t}$$
$$y_{2t} = T_{2t} + \theta_{21}C^{\omega}_{1t} + C^{\omega}_{2t} + \varepsilon_{2t} \qquad [10]$$
$$y_{3t} = T_{3t} + \theta_{31}C^{\omega}_{1t} + \theta_{32}C^{\omega}_{2t} + \varepsilon_{3t}$$

The synchronisation between the cycles of the different variables will be only partial and depends on the elements of matrix Θ.

This formulation of the common factors model makes easy its understanding and its estimation, but it is conventional because it depends on the order of the n series y_i . When k common factors drive the national movements of a similar cycle shared by n countries, other equivalent formulations are conceivable. It is possible and interesting to search formulations more adapted to a clear economic interpretation of the k common factors. It is a simple problem of change of base in a k-vectorial space.

When we consider a set of national series (national GDP for example), the plurality of the cyclical phenomenon presents two aspects:
– For a given country, several cycles, with specific characteristics, can contribute to its own fluctuations.
– A specific cycle, identified by its structural parameters (period and damping factor) can be shared by different countries. If the innovations which generate this cycle are not identical among countries, it is only a similar cycle: propagation mechanisms are similar among these countries but they are affected by asymmetrical shocks. If it is possible to reveal some factors common to the idiosyncratic innovations, the cycle is not only similar but also – partially or totally – common.

2.3. Estimation and diagnoses

The method of estimation used by STAMP is maximum likelihood applied to the state-space form of the model, which is decomposed into observation and state equations. In the case of a simple univariate trend-cycle model, the observation equation is the following:

$$y_t = \begin{bmatrix} 1 & 0 & 1 & 0 \end{bmatrix} x_t + \varepsilon_t \qquad [11]$$

where the state vector x_t is defined by $x_t = \left[T_t, \beta_t, C_t, C_t^* \right]'$

The state equation is:

$$x_t = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \rho\cos\lambda & \rho\sin\lambda \\ 0 & 0 & -\rho\sin\lambda & \rho\cos\lambda \end{pmatrix} x_{t-1} + \begin{pmatrix} \eta_t \\ \zeta_t \\ \kappa_t \\ \kappa_t^* \end{pmatrix} \qquad [12]$$

The extraction of the unobserved components uses the Kalman filter. This filter produces a recursive estimation of the state vector for the date *t*, conditioned by the information available until *t-1* : it is the filtering step. Then the smoothing step permits to obtain the expected value of the state vector for the date *t*, conditioned by all the information covering the whole sample period, between *1* and *T*.

A set of diagnoses is available in STAMP in order to assess the empirical fitness of the model. The basic goodness indicator is the Prediction Error Variance (*PEV*), which is the variance of the one-step-ahead prediction errors (or innovations). Its square root is considered as the equation standard error. The residuals of the model are the standardised one-step-ahead errors, i.e. the errors divided by *PEV* square root.

Three other specific diagnoses will be always considered in this paper:

– Normality Bowman-Shenton statistic N_{BS} or Doornik-Hansen N_{DH} (more adapted to small samples) based on third and fourth moments of the residuals and having a χ^2 distribution with 2 degrees of freedom if the model is correctly specified. The normality test permits the detection of particular observations badly explained by the model.

– Serial correlation Box-Ljung statistic *Q(p,q)* based on the first *p* residual autocorrelations, tested against a χ^2 with *q* degrees of freedom, where *q* is equal to *p-n+1* and *n* is the number of hyperparameters, i.e. the parameters governing the stochastic components (variance matrices of the disturbances, damping factors and frequencies of the cycles).

– Relative determination coefficient R_D^2 which compares the PEV with the variance of the one-step-ahead prediction errors obtained by a random walk plus drift model

($y_t = y_{t-1} + \beta + \eta_t$). A very simple forecast function corresponds to this naïve model: the best forecast for the next date is the current observation plus the mean variation $\overline{\Delta y}$ calculated over the sample period. If the R_D^2 is positive, the historical forecast performance of the estimated model is better than the one of the naïve model. The R_D^2 indicates the percent of *PEV* reduction (if R_D^2=0.2, the reduction is 20%). A negative R_D^2 constitutes a criterion for rejecting the estimated model.

Other specific diagnoses can also be considered, as they give further interesting indications about the flaws of the estimated model:

– Periodogramm and spectrum of residuals, which indicate the frequencies badly identified by the model.

– Residual Cusum graph, which exhibits the evolution of the mean of first *t* residuals, until *t*=*T*. If the mean changes through time, the Cusum will drift up or down, before going back to zero at Cusum(*T*). A formal check of the mean stability is based on two boundary lines for Cusum(*t*) given by $\pm\left[0.85\sqrt{T} + 1.7t/\sqrt{T}\right]$ and based on a significance level of 10%.

– Residual Cusum of squares, which permits to detect a change in the variance of the residuals by comparing the sum of squares of the first *t* residuals to the complete sum. If the model is homoskedastic, the increase of residuals should be linear regarding *t*. Departures from the 45° line in the graph suggest that this assumption is false.

Finally, a last set of diagnoses can be used, if necessary. It concerns the sequence of auxiliary residuals. For a particular stochastic component (irregular, level, slope or cycle) the auxiliary residuals are standardised smoothed estimates of the corresponding disturbances. Normality tests can be calculated for the auxiliary residuals and the graph of these residuals is very useful for detecting outliers and breaks in components.

These diagnoses have been complementarily used to select the models, without being always completely satisfactory. For a globally convenient model, the normality tests are frequently sensitive to badly explained particular observations. We did not try to resorb systematically these outliers, which can result from statistical irregularities or peculiar events. The tests are also frequently less satisfactory for small European countries, affected by idiosyncratic events not embodied in the basic specification of the model. This paper is limited to the application of this basic model to the set of euro-zone countries.

3. The European cycle as aggregate cycle, compared to the US cycle

3.1. Simplicity of the US cycle, duality of the European one

Table 1 gives the results of the univariate split of the American quarterly GDP for the period 1960-1999. In order to appraise easily scales of sizes, the standard errors of the innovations that generate trends and cycles, as well as the prediction error, are expressed in percentage of the trend level[4] (the logarithmic transformation allows to use the additive version of the model). The adequate model is spontaneously a smooth trend one with one stochastic cycle and without irregular component. The American case fits well with the simplicity of this split[5].

The estimated period of the American cycle is reasonable (eight years) but appears longer than the five years usually attributed to it. It is not surprising: when the estimation starts in 1960, the three long expansion periods of the 1960s, 1980s and 1990s (the end of the last was not yet observed in 1999) are relatively stronger, whereas the expansions periods were shorter in the 1950s. We remind the reader that in such a kind of models, the cycle period corresponds to a virtual length. Its realisation is determined by the effective innovations sequence that generates the cycle.

It is less easy to obtain a robust and stable split of the euro-zone GDP. First, it is a fragile and conventional statistical reconstruction. It has been retrospectively calculated from 1960 as a simple additive aggregation of the national GDPs in 1995 prices, converted into dollars using the exchange rates in purchasing power parity of 1995. Ireland and Luxembourg have been excluded from this aggregation, that only incorporates ten countries (including Greece, a member of the euro-zone since the beginning of 2001), among the twelve members. The exclusion of Ireland and Luxembourg, two countries whose weight in the union is low, has only limited consequences on the results concerning the aggregate European GDP. It is justified by the need of comparing the cyclical analysis of the aggregate GDP and the aggregation of the national cycles. The trend-cycle split obtained for Ireland and Luxembourg appears clearly different from the other countries (cf. infra). It was thus difficult to integrate them to the aggregation of national cycles that must involve commensurable elementary cycles. It is a confirmation, if needed, of the tangible singularities of those two countries.

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[4] A standard error of 1% is attached to a random shock whose average variability is equal to 1% of the trend; it is often less in the estimations. In particular, the scales of sizes of the innovations generating the slope of the trend are far inferior, which shows the progressivity of the inflexions of the trend.

[5] Diebold and Rudebusch (1999, p.20) also emphasise that simplicity: "For U.S. real output, it appears that a trend representation that is very smooth, even if not exactly linear, is a viable candidate". See also Clark (1987).

Table 1.***Trend-cycle split of US and European GDP (60Q1-99Q4)***

	Univariate Model	Bivariate Model	
	USA	*USA*	*Europe*
Diagnoses			
$\sqrt{PEV}$ (Standard error of prediction error)	0.85	0.81	0.43
R^2_d (Relative Coefficient of determination)	0.10	0.17	0.59
N_{DH} (Statistic of normality)	5.20	5.99	15.27 **
Q(p,q) (Box-Ljung Statistic of correlation)	14.0 (*p=13, q=10*)	8.4 (*p=13, q=6*)	11.7 (*p=13, q=6*)
Parameters			
σ_ε (Standard error of irregular component)		0.18	0.08
$Corr_\varepsilon$(Coefficient of correlation of contemporaneous irregular components)		-1	
σ_η (Standard error of innovations shocking the level of trend)	-	-	-
σ_ζ (Standard error of innovations shocking the slope of trend)	0.04	0.03	0.08
$Corr_\zeta$(Coefficient of correlation of contemporaneous innovations shocking the slopes of trends)		0.96	
Long Cycle			
σ_κ (Standard error of innovations shocking the cycle)	0.75	0.60	0.19
$Corr_\kappa$ (Coefficient of correlation of contemporaneous innovations shocking the long cycles)		0.26	
ρ (Damping factor of the cycle)	0.95	0.98	
Period of the cycle in quarters	32.0	38.6	
Short Cycle			
σ_κ (Standard error of innovations shocking the cycle)		0.27	0.21
$Corr_\kappa$ (Coefficient of correlation of contemporaneous innovations shocking the long cycles)		0.62	
ρ (Damping factor of the cycle)		0.94	
Period of the cycle in quarters		13.1	
Observations		A dummy on the irregular component of European GDP in 68Q2 A dummy on the level of the trend of European GDP in 91Q1	

Key **:**
The quarter k of the year 19ij is written ijQk. The standard errors have been multiplied by 100 and express the mean volatility of error prediction and innovations in % of the series. The unsatisfactory tests of null hypothesis are indicated by * at the threshold of 5% (less than 5% for the probability that the null hypothesis is rejected by error) and by ** at the threshold of 1%.

The aggregate European GDP incorporates a break in its level at the first quarter 1991, when the east-German Länder joined back Federal Germany and thus the European Union. Rather than trying a difficult and arbitrary statistical reconstruction of the series for a "unified Germany" on the whole period, we preferred to keep the break, that respects history, because such a break can be easily dealt by using an appropriate dummy in the model. It is not this issue which makes the European split difficult, but rather the whole set of statistical or actual irregularities that disrupted in the past the short-term dynamics of the somehow virtual entity composed by the reconstituted euro-zone. The obtained univariate split can vary with the boundary of the selected estimation period. It varies also with the use of *ad hoc* dummies to deal with singular shocks that strongly influence a member state and are visible on the European GDP, such as French strikes (second quarter 1968) or Italian ones (last quarter 1969).

More important, the analysis of the European GDP reveals a duality of its cyclical movements. A "smooth trend" model proves to be appropriate but with a particularity: its cyclical part can be decomposed into two distinct cyclical components, the first being of short period, around three years, and the second of long period, almost ten years. The hypothesis of unicity of the cycle disturbs the trend-cycle split of the European GDP, by producing too volatile a trend that integrates a non specified part of the cyclicity. Obviously the split into "long cycle" and "short cycle"[6], that is not really convincing in the American case, might be a statistical artefact permitting to encapsulate the misguided European short-term fluctuations. However, we will see below that such a duality reflects distinct and identifiable economic forces that generate the global cycle of the euro-zone (in our bi-cyclical model, the global cycle is defined as the sum of the two elementary cycles).

In order to strengthen the estimation of the trend-cycle split of the European GDP, it has been carried out in a bivariate model that incorporates also the American GDP. Since the American split is robust, it is only slightly modified by the bivariate estimation, if we compare both trends and both global cycles (Table 1, Graphs 1 and 2). On the other hand, the European split is easier: the stability of the American split serves as a standard for the European one[7]. Each of the two cycles from the bivariate split is similar in the US and in Europe (same period and damping factor in both zones). The short cycle plays a minor role in the US, as it can be noticed in its innovations standard error, which is far lower than the long cycle one. In the European case however, those two standard errors have a similar size and the corresponding cyclical components show not equal but at least analogous amplitude: in Europe, even if the

[6] For convenience, we keep below those *ad hoc* terms the use of which is explicitly restricted to this paper.
[7] This is the "group of control" technique: the two dependent variables are highly correlated, but if one of them is less affected by singular shocks, its presence improves the estimation of the other trend-cycle decomposition (cf. Koopman, Harvey, Dornik and Shephard, 2000).

short cycle does not reach the long cycle amplitude, it is ample and volatile enough to bend the global movement of the cycle (Graph 3).

The bivariate estimation of the American and European splits gives some information about the comparative behaviour of the two economies.

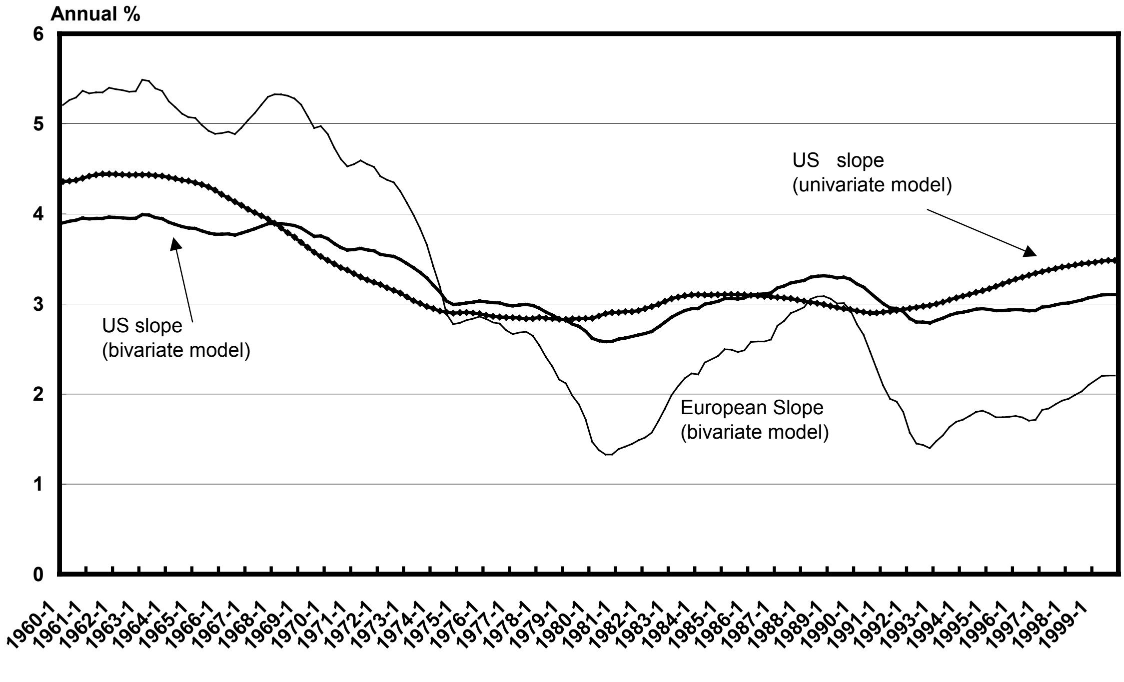
– The community of the “smooth trend” model allows to compare easily the long-term trajectory of the American and European GDPs, because these trajectories are only generated by the value of the stochastic slope (see Graph 1, where the slope is expressed in annual growth rate). In the last twenty years, the American growth trend has become higher than the European one again, in spite of the transitory European jump at the end of the eighties. At the end of the nineties, the American trend growth appears higher than 3% a year while it was lower by approximately 1 point in the European case. The slope of the European trend is twice to three times more volatile than the American one, but the correlation between the innovations which affect them is very strong, almost equal to 1: Europe seems to be more sensible to structural shocks that are widely common. The very high correlation between the American and European trend growths does not exclude a lower value for the second one, which means that Europe is much more vulnerable to negative shocks. The fact that the non-constrained correlation between the contemporary innovations generating the American and European slopes is very close to 1 suggests that we might constrain that correlation to be equal to 1, which means assuming a cointegrated relation between the trends of the two zones. However, if we add such a constraint, the quality of the estimation is worsened, in particular because it imposes an excessive correlation between the slopes at the end of the period. Consequently we kept the non-constrained estimation that shows both an important similarity between European and American trends and a higher sensitivity of Europe to shocks.

– The long cycle, of about ten years and which is the fundamental element of the American short-term economy, is generated by innovations whose variability is three times higher in the US than in Europe. They are positively but slightly correlated between the two zones. The long cycle is clearly similar but non common. The short European cycle, whose volatility is sufficient to impact the global cycle, is clearly more correlated to the American one, but the latter is mostly dominated by the long component of the American fluctuations. If we compare the American and European global cycles, we can remark no systematic synchronisation (Graph 2). After the typical synchronisation following the oil shocks, substantial lags between the two zones appear and persist: the European recovery comes later than the American expansion in the nineties as in the eighties. The European fluctuations are more damped than the American ones too.

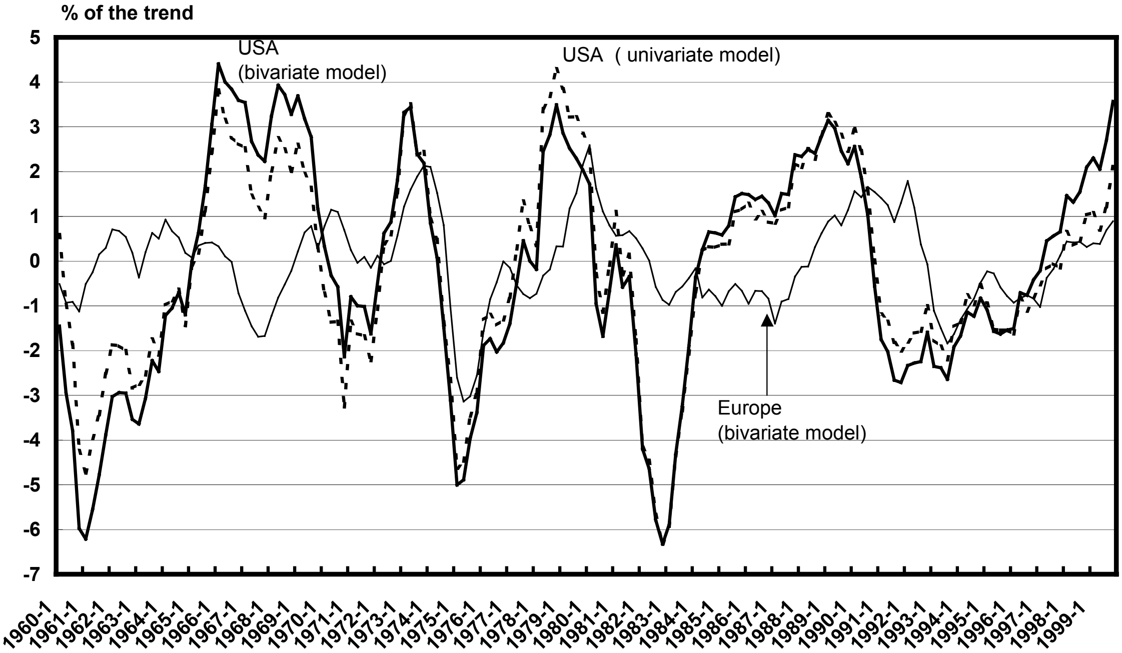
– By contrast with the American univariate model, where it was not necessary, the irregular component improves the model, by allowing to take account of idiosyncratic events that differentiate, though not persistently, the American and European economic situations.

The model "fairly" decomposes a lower European growth than the American one during the last twenty years into the long-term effect and the cyclical one. Europe is weaker at both levels, which is not a recent feature that could be explained by the "new economy" alone: it is a situation that progressively emerges in the seventies and eighties and reappears persistently. Nonetheless, this is not contradictory with more violent crises in the US than in Europe, because the American economy is more cyclical, if this cyclicity is measured by the variability of the impulses generating the cycle.

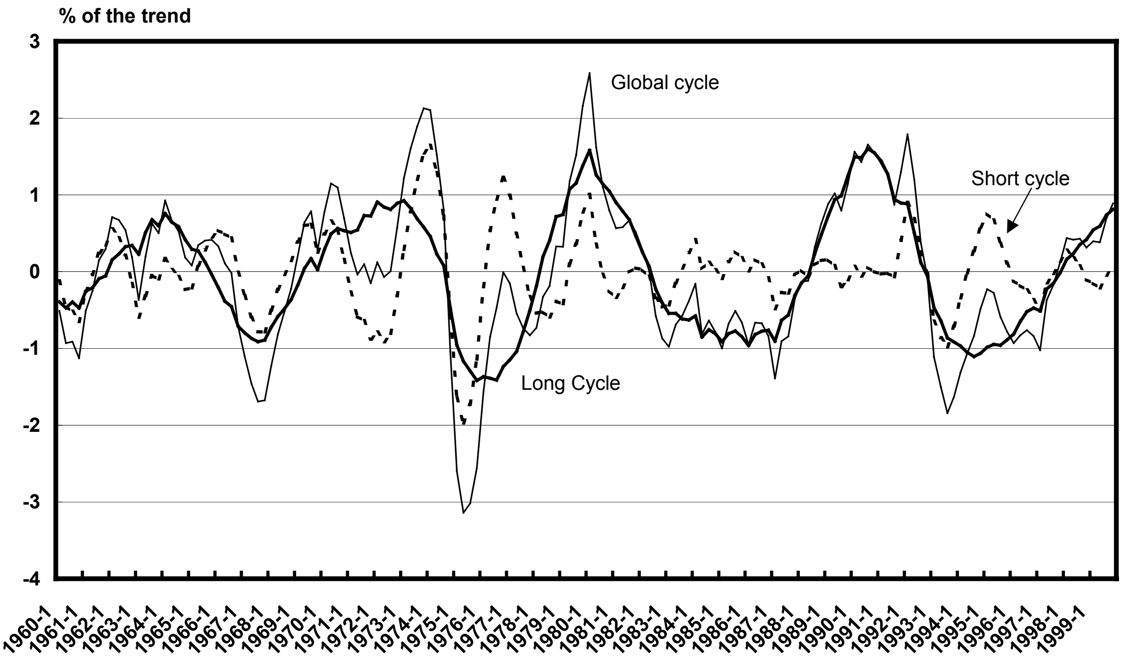
1.Slopes of the trends of US and European GDP



2. US and European global cycles



3. "Short" and "long" components of the European cycle



3.2. Behind the duality of the European cycle: investments and inventories

The cycles literature has for long included the double reference to Kitchin and Juglar cycles, respectively associated to fluctuations in inventories and fixed capital. Therefore, one can wonder whether this double reference matches up with the duality of the European cycle that we described above.

Graphs 4 and 5 show the short and long cycles of the euro-zone together with the respective contribution of inventories variations (all agents) and investments (Gross Fixed Capital Formation of business sector or of all agents) to the global cycle of the euro-zone. If the GDP can be decomposed into elementary aggregates, its cycle *C*, measured as a ratio to the trend, can also be decomposed into corresponding contributions. The contributions are measured very simply by dividing the considered aggregate by the trend of the GDP:

$$C = \frac{GDP}{T} = \frac{\sum_{i=1}^{n} A_i}{T} = \sum_{i=1}^{n} \frac{A_i}{T} = \sum_{i=1}^{n} CONT_i \qquad [13]$$

where A_i denotes the sub-aggregate *i* of the GDP and $CONT_i$ the cyclical contribution of this component.

In Graphs 4 and 5, the cyclical contributions of investment and inventory variations are calculated from two distinct sources, over two distinct periods, given the fact that a perfectly unified frame is difficult to build from the current state of European statistical information. We chose to use completely the available datasets, even if they are imperfectly coherent:

– Over a long period, but with incomplete data (graphs 4 and 5), the contributions of investment and inventory variations to the European cycle have been measured by the European aggregates "business sector investment” and “inventory variations”. They have been constructed for the 10 euro-zone members using the same method as for GDP previously, from the national series available in the BSDB database of OECD. The national aggregates at constant prices have been converted in dollars 1995 using the purchasing power parity constructed for the GDP. Such a method is rough but it is sufficient for the suggestive parallel we propose here. It cannot be applied on the entire period, because of missing values for some countries.

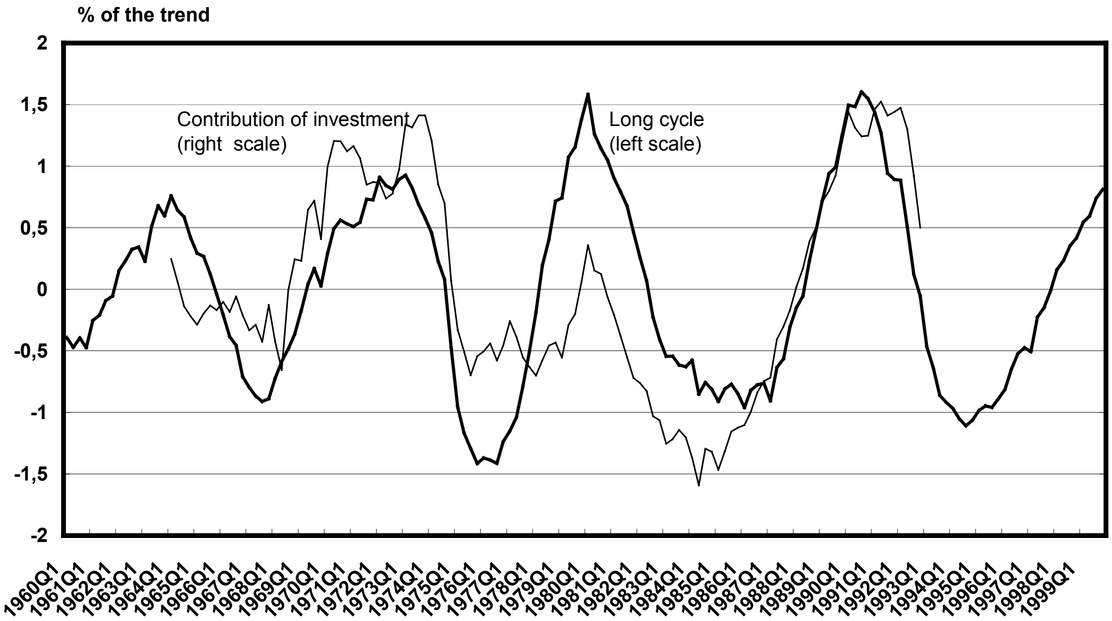
– Over the shorter period of the nineties, when the data are complete, quarterly accounts of the euro-zone are directly given by Eurostat in constant Euros of 1995. They can be used to calculate the same contributions, after converting the European GDP trend into the same currency (Graphs 4 bis and 5 bis[8]).

[8] Graph 4 bis depicts the contribution of total investment (including all agents) to the European cycle, whereas over long period, it is the firms investment only that appears the most correlated to the long European cycle.

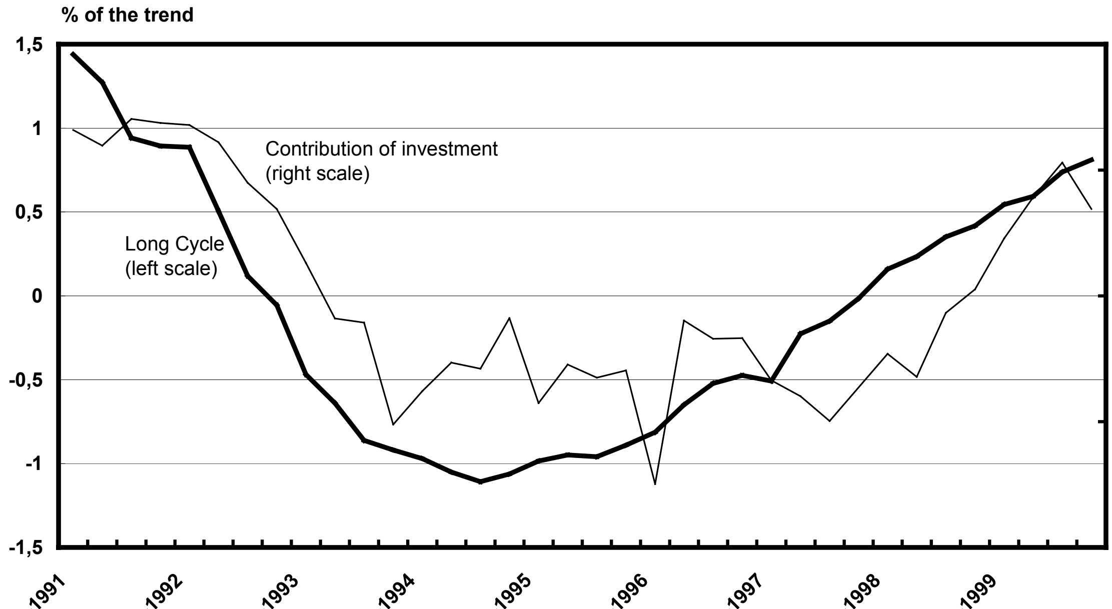
The graphs clearly reveal, from distinct sources, a common result, even if it remains suggestive. They corroborate the dominant role of investment and inventory variations respectively in the long and the short cycles of the GDP. We underline that, even if investment on one side, inventories variation on the other side, were respectively the first sources of impulse for the long cycle and the short cycle, it would not be a sufficient reason to expect a perfect correlation between each cycle and the contribution of the variable that generates it. Indeed, all the cyclical propagation mechanisms, involving intermediary variables, could modify the apparent correlations. The strength of the observed correlations is thus an argument in favour of the parallel we made and clarifies the contents of the duality of the European cycle. The long European cycle is preferably associated with investment fluctuations and the short cycle with inventory variations but we cannot precise whether the parallel indicates a causal impulse or/and a preferential propagation way.

Graphs 4 and 5, linked with Graph 3, show that the two cyclical components can either amplify each other (during the first oil shock or the 1993 recession for instance) or compensate and even neutralise each other (in 1994-1995, recovery in inventories is widely neutralised by the inertia of investment). In the mid-nineties, the two cyclical components have been disconnected: the persistent inertia of European investment, after the beginning of the decade, is opposed to the sudden jumps of the economic situation based on inventory behaviour. If they want to stabilise growth, the authorities in charge of the European macroeconomic policy should not be indifferent to the possibility of such a distortion.

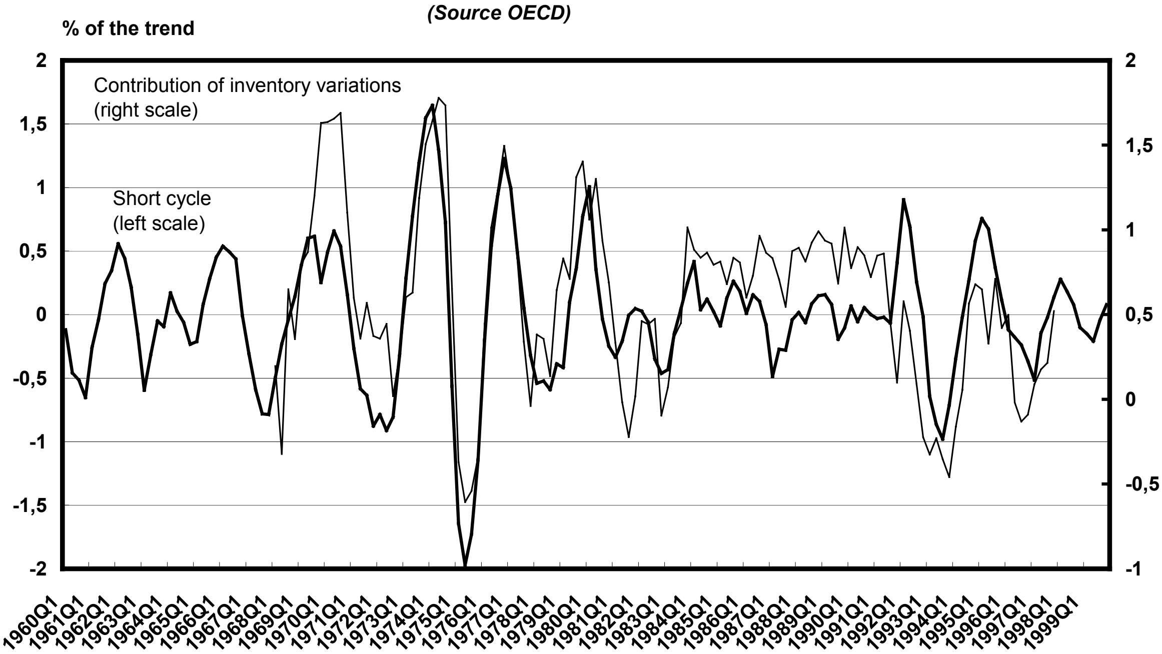
4. Long European cycle and contribution of firms' investment to European GDP global cycle (Source OECD)



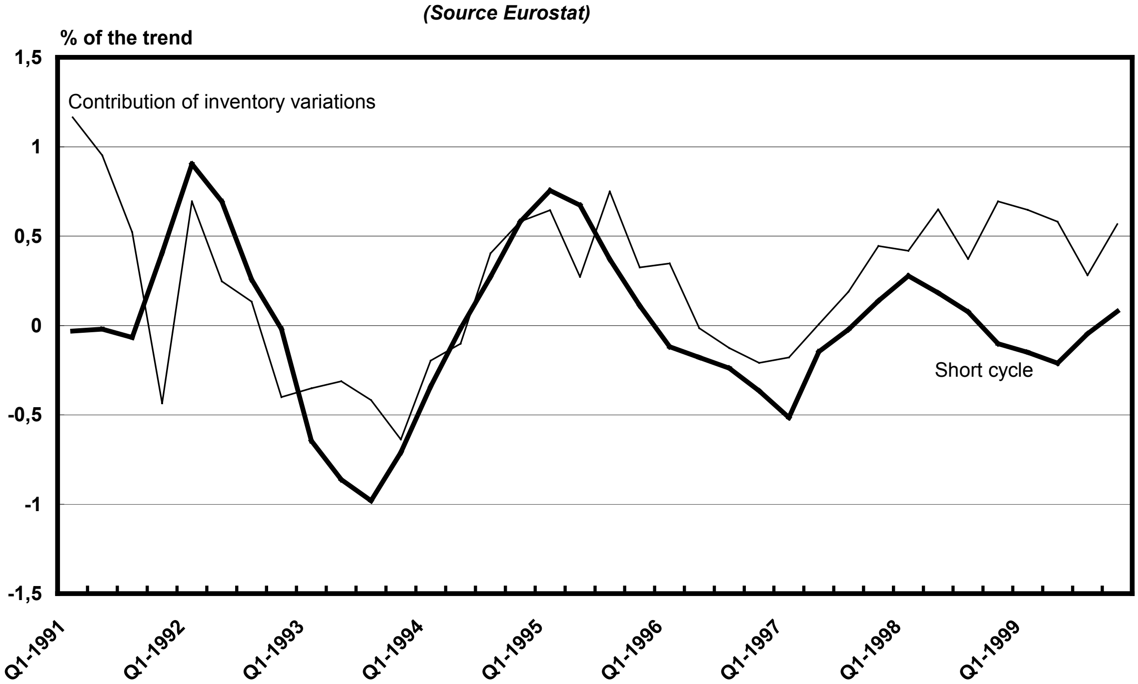
4 Bis. Long European Cycle and contribution of total investment to European GDP global cycle (Source Eurostat)



5. Short European cycle and contribution of inventory variations to European GDP global cycle
(Source OECD)



5 bis. Short European cycle and contribution of inventory variations to European GDP global cycle
(Source Eurostat)



4. Apparent similarities and differences among the national cycles

The fact that cyclical movements appear clearly when analysing the European economic activity does not imply that these movements are shared in an uniform way by all the member countries of the European Monetary Union. Comparing the national cycles allows to say whether it is possible to talk about an European cycle, as an economic movement shared by the entire set of the euro-zone countries. Nonetheless, the strong similarities between the national economies within the euro-zone does not mean that the set of member countries can be reduced to an uni-dimensional economic space, which would only be animated by cyclical movements perfectly common among the countries.

4.1. Similarity of the univariate models

We first decomposed every national GDP using the univariate framework. The objective is not to get for each country an excellent split from a statistical point of view. It is rather to see how much the estimation of those national univariate models spontaneously show strong similarities between the countries even if they are not constrained to a strictly uniform specification. Quality diagnoses actually remain quite often mediocre (see Table 2). They show that some national particularities, especially for small countries, are badly taken into account by the general form of the model we employed, despite the use of dummies concerning well identified events. We do not seek here to improve at any price the specification of each national model (which would imply the use of specific explanatory factors), but to pick reasonable and commensurable similarities between little constrained national splits.

Comparing the national univariate estimations gives some information:

– Ireland and Luxembourg are clearly special cases. They are small countries, with specific features: the vigour of the Irish catching up “distends” the cycle, whose period appears to be excessively long to be compatible with a short-term oscillation and to be correctly estimated from forty years long series. The particularities of Luxembourg’s economic structure show the opposite characteristic. Moreover, bad autocorrelation statistics, especially in the case of Luxembourg, demonstrate that the general specification explains with difficulties the particular dynamics of those two economies. Luxembourg and Ireland will therefore be let aside for the rest of the study which will be restrained to the other ten countries of the euro-zone. Univariate results concerning the United Kingdom will be given also, because its short-term dynamics is historically correlated to the American one. So the UK may be useful as an external reference, although estimating the British split is more difficult than in the US case (Blackburn and Ravn, 1992).

– Concerning the form taken by the national univariate models, the slowly moving smooth trend model is predominant within the ten euro-zone countries. It prevails for Germany, France, Italy, the Netherlands, Finland and Portugal. Austria and Belgium are characterised by a segmented trend: a deterministic slope with a break caused by the first oil shock. The model of the Greek and British trends is specific: it is a random walk with drift, i.e. a trend with constant slope but whose level can be affected by shocks. Spain is a special case: it was impossible to estimate correctly an unobserved components model for this country, and we had to extract the trend, quite smooth, using the Hodrick-Prescott filter, that can be considered as a special constrained case of such models[9]. This difficulty may be linked to the difficulties of the retropolation of the long Spanish quarterly GDP series. Graph 6 presents the estimated trajectories of the slopes of the national trends, expressed in yearly rates. In the eighties and the nineties, a convergence appears at around 2 to 2,5% a year. However, the complete range seems wider at the end of the period than it was in the mid-eighties. It runs approximately from 1.5% a year (Germany, Italy) to 3.5% a year (Spain, the Netherlands, Portugal).

– Except for the United Kingdom, Luxembourg and Ireland and, for methodological reasons, for Spain, the nine countries show the cyclical duality identified for the aggregate cycle. Confronting long and short cycles with the respective cyclical contributions of investment and inventory confirms the relevance of such a split of the cyclical movement.

– The estimated period is generally about ten years for the long cycle. However, it admits a non-negligible dispersion around the decade. It is yet visibly shorter in the Dutch case and the one, extreme, of Luxembourg while longer in the Austrian case, and the Irish one, equally extreme. The variance of impulses is quite dispersed among countries.

– The period of the short cycle, of about three years, appears quite homogeneous, except in Finland where it is much longer. The variance of the shocks driving this cycle is particularly high in Italy and the Netherlands, where they compete with the shocks generating the long cycle. The double rhythm of the cyclical components noticed at the euro-zone level and its economic signification can be found as well for the member countries. The long cycle, and more slightly the short cycle, are general enough, and their national characteristics close enough, to be the expression of similar, or even common, cycles at the European scale.

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[9] Harvey and Jaeger (1993) note that the cycle obtained from the Hodrick-Prescott filter corresponds to the optimal estimation of the irregular component ε_t in a model of the following form:

$$y_t = T_t + \varepsilon_t \quad ; \quad T_t = T_{t-1} + \beta_{t-1} \quad ; \quad \beta_t = \beta_{t-1} + \zeta_t$$

It is a smooth trend model, without explicit stochastic cycle. The ratio $\sigma_\varepsilon^2 / \sigma_\zeta^2$ corresponds to the smoothing parameter of HP method, the value of which is imposed *a priori* and usually fixed at 1600 for quarterly series.

Table 2. ***Univariate Trend-cycle split of national European GDPs (60Q1-99Q4)***

	Germany	*Austria*	*Belgium*	*Spain*	*Finland*	*France*	*Greece*	*Netherlands*	*Eire*	*Italy*	*Luxembourg*	*Portugal*	*UK*
Diagnoses													
$\sqrt{\boldsymbol{PEV}}$	0.71	1.09	0.34	-	1.10	0.60	0.56	0.86	0.67	0.79	0.89	1.13	1.02
$R^2{}_d$	0.56	0.19	0.68	-	0.17	0.79	0.67	0.07	0.29	0.37	0.22	0.18	0.04
N_{DH}	0.98	39.9 **	11.8 **	-	5.44	13.2 **	5.76	58.1 **	0.07	10.4 **	8.13 *	2.08	41.8 **
Q(p,q)	8.6 *(p=12, q=6)*	8.9 *(p=13, q=6)*	139.6 ** *(p=11, q=6)*	-	14.9 * *(p=13, q=6)*	5.3 *(p=13, q=6)*	133.2 ** *(p=12, q=6)*	31.9 ** *(p=13, q=6)*	158.79 ** *(p=8, q=6)*	6.22 *(p=13, q=6)*	198.6 ** *(p=9, q=6)*	15.5 * *(p=13, q=6)*	12.9 * *(p=11, q=6)*
Parameters													
σ_ε	-	0.58	-	-	0.36	0.25	-	0.35	-	0.05	-	0.46	0.30
σ_η	-	-	-	-	-	-	0.28	-	-	-	0.75	-	0.56
σ_ζ	0.07	0.0	-	-	0.05	0.07	-	0.10	-	0.05	-	0.08	0.0
Long cycle													
σ_κ	0.61	0.79	0.18	-	0.88	0.35	0.25	0.25	0.65	0.44	0.35	0.71	0.69
ρ	0.94	0.94	0.99	-	0.98	0.97	0.99	0.97	0.998	0.96	0.98	0.96	0.95
Period (quarters)	34.5	84.8	41.9	-	46.2	44.0	36.4	23.8	92.5	33.8	18.5	33.2	44.3
Short cycle													
σ_κ	0.04	0.0	0.20	-	0.0	0.11	0.26	0.37	-	0.41	-	0.13	-
ρ	0.998	1	0.96	-	1	0.96	0.97	0.85	-	0.91	-	0.99	-
Period (quarters)	14.7	12.1	11.7	-	19.4	11.4	11.6	10.6	-	11.6	-	11.9	-
Observations	Dummy for the level of trend in 91Q1	Deterministic trend with break of slope in 74Q1	Deterministic trend with break of slope in 74Q1	Trend estimated by HP filter		Dummies for the irregular component in 63Q1 et 68Q2	Deterministic trend with break of slope in 73Q3		Deterministic trend	Dummy for the irregular component in 69Q4			

Key : seeTable 1.

4.2. The aggregation of national cycles meets the cycle of the aggregate

The national cycles that we estimated with univariate models can be aggregated, using as a weight for each country its share in the European GDP, measured in purchasing power parity[10]. We compare now this aggregated cycle with the cycle of the aggregate European GDP that was obtained from the bivariate model (with the American GDP).

Such aggregation and comparison have been carried out both for the long cycle (aggregation of the ten euro-zone countries, excluding Ireland and Luxembourg) and for the short cycle (aggregation of the same countries, apart from Spain, for which the single cycle taken from Hodrick-Prescott method has been considered as the long cycle). In both cases, as well as for the global cycle which is the sum of the short and long ones, the correspondence between the results of the two methods is remarkable (Graphs 7, 8 and 9). The amplitude of the long cycle of the aggregate is slightly damped comparatively to the aggregation of national cycles. Such correspondence is a sign of robustness, in favour of our way to identify the European cycle: the cycle is not an artefact that would only come from the imperfect measure of the European aggregate cycle or from statistical peculiarities specific to some countries. The cycle of the European aggregate, that is dual, shows cyclical movements which spread similarly among a large majority of euro-zone countries. It reveals the diffusion of the movements within the entire European space.

A set of national graphs, in annex, permits to compare, country by country, the global national cycle with the European cycle obtained from the aggregation of the ten national cycles, called "average cycle". Some countries are more than others representative of the European aggregated cycle. The Belgian cycle is remarkably correlated to the European average cycle and could be considered as a coincident indicator. On the other hand, the cyclical movements of other small countries are sometimes marked by noticeable particularities, possibly linked to specific shocks: for instance, Finland suffered from a particularly violent recession after the Soviet Union collapse, at the beginning of the nineties, before a strong recovery.

The notion of conformity of a national cycle with the European average cycle can be clarified and quantified. The volatility of the European average cycle, measured by its empirical variance over the whole period, can be decomposed into contributions of each national cycle to the variance. Each of the contributions, given as a share of the global variance, is the product of the weight α_i of the country in the European GDP, by an indicator of conformity between the national cycle and the European one. This indicator is itself the product of the

[10] For coherence purpose, the shares are the ones we already used to construct the European GDP series. They correspond to GDP measured by purchasing power parity in 1995 and are fixed on the whole period.

correlation coefficient ρ between the national and European cycles by the relative volatility of the former, measured as the ratio between its standard error σ and the European cycle one (see box). If the national cycle is perfectly conform to the European cycle, the indicator of conformity is equal to 1, but the converse is not true: a given national cycle can be poorly correlated with the aggregate cycle but more variable, so that the indicator will be close to 1. This is the case for Finland, but a complete analysis of the information prevents from misled conclusions…

Box 1. Computation of the contributions of national cycles to the aggregate European cycle

$$C = \textit{European cycle} = \sum_i \alpha_i C_i = \sum_i \alpha_i \textit{ national cycles}$$

$$\textit{Volatility of European cycle} = \sigma_C^2 = \operatorname{cov}(C, \sum_i \alpha_i C_i) = \sum_i \alpha_i \ \rho_{C,C_i} \ \sigma_C \ \sigma_{C_i}$$

$$\textit{Contribution of country i to the volatility of European cycle} = \alpha_i \ \rho_{C,C_i} \ \sigma_C \ \sigma_{C_i} / \sigma_C^2 = \alpha_i \ \rho_{C,C_i} \ (\sigma_{C_i} / \sigma_C)$$

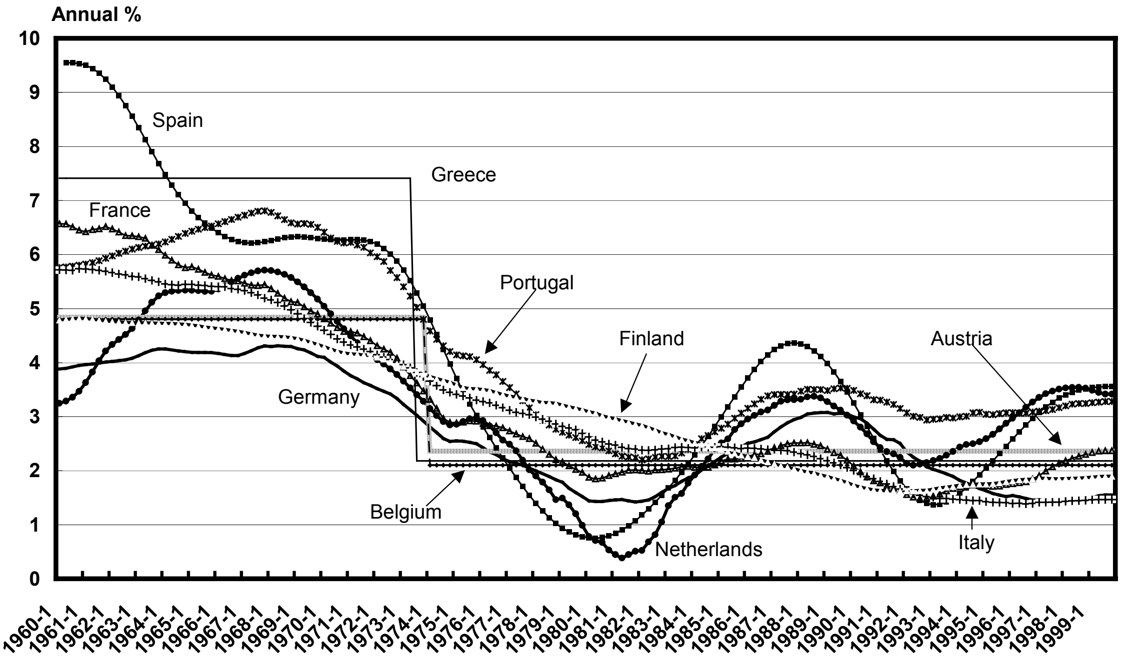
$$\textit{Contribution cured of country's weight (or conformity)} = \textit{Contribution} / \alpha_i = \rho_{C,C_i} \ (\sigma_{C_i} / \sigma_C)$$
$$= \textit{Correlation of national cycle with European cycle} \times \textit{compared volatility}$$

Table 3 gives the results of the calculations concerning the global cycle (sum of the short and long components). It corroborates that the Belgian cycle is representative of the European one. Indeed, its conformity is a balance between high correlation with the European average cycle and a comparable volatility. The complete contribution of a country to the European cycle is naturally proportional to its size. The German cycle contributes heavily to the European cycle, but the Italian contribution comes second, before the French one, in spite of a lower correlation with the European cycle. The reason is that Italy amplifies distinctly the European fluctuations while France tends to damp them a little (see the graphs in annex). To watch the European cycle thus means to watch specially the countries whose cyclical volatility is higher.

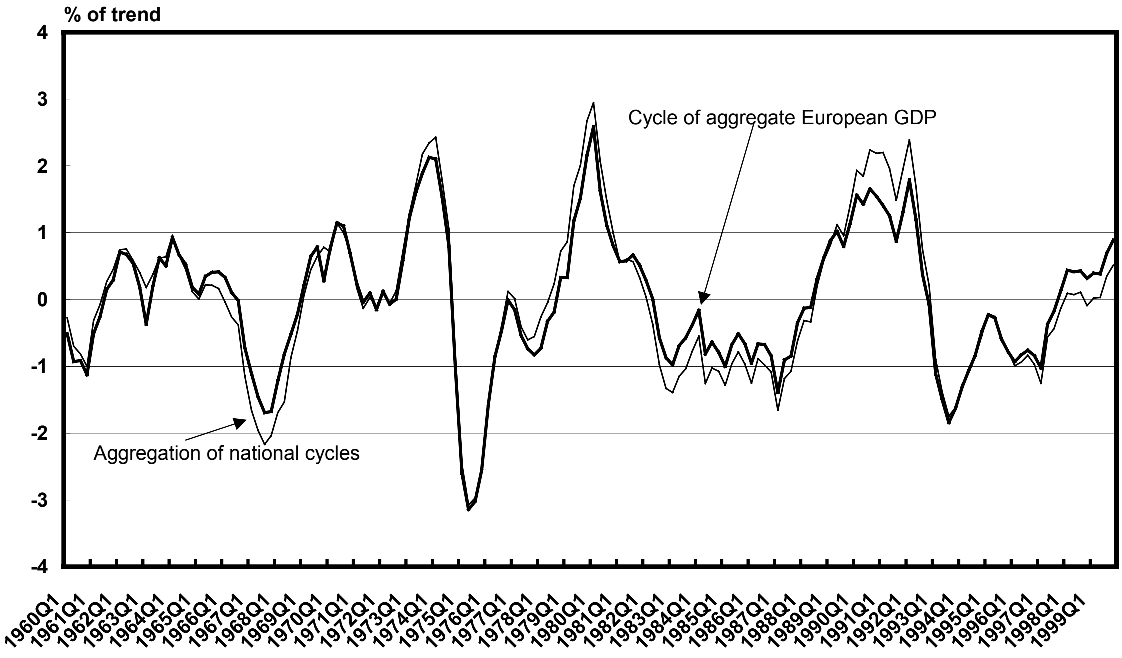
Table 3. ***Contribution of national cycles to average European cycle (60Q1-99Q4)***

	Germany	*Austria*	*Belgium*	*Spain*	*Finland*	*France*	*Greece*	*Netherlands*	*Italy*	*Portugal*	*euro-zone (10 countries)*
Standard error of cycle (in % of trend)	1.68	1.96	1.56	1.24	4.06	1.12	2.04	1.06	1.79	2.54	1.18
Volatility relatively to European cycle = A	1.43	1.67	1.33	1.05	3.45	0.95	1.73	0.90	1.52	2.15	1
Coefficient of correlation with European cycle = B	0.86	0.62	0.83	0.62	0.33	0.85	0.53	0.50	0.74	0.70	1
Conformity with European cycle **C=A x B**	1.21	1.03	1.10	0.66	1.15	0.81	0.91	0.45	1.12	1.52	1
Weight in European GDP in % = D	30.3	3.0	3.9	10.4	1.8	20.9	1.6	5.7	20.1	2.3	100
Contribution to European cycle in % = C x D	36.7	3.1	4.2	6.8	2.1	17.0	1.4	2.6	22.6	3.5	100

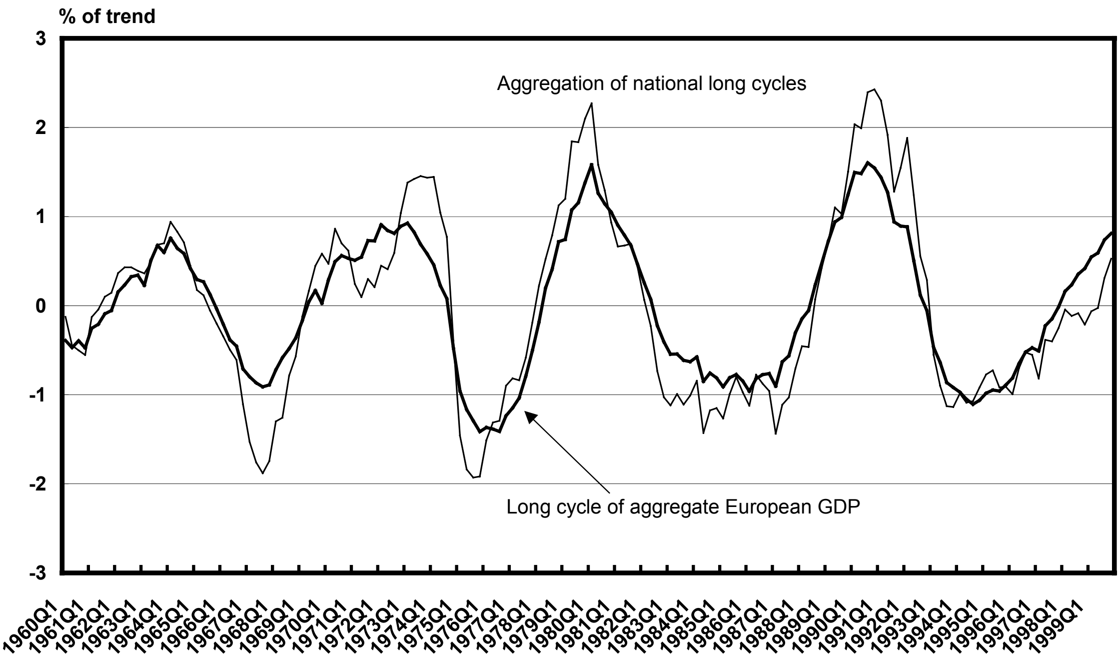
6. Slopes of the trends of European national GDPs



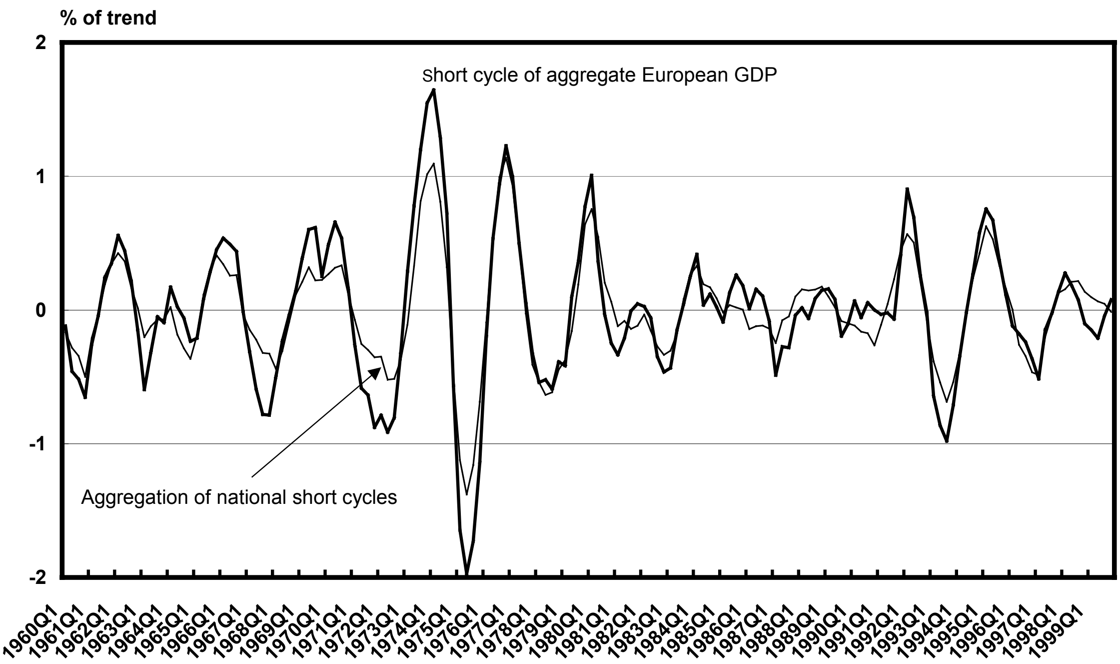
7. European Global Cycle



8. Long Cycle of European GDP



9. Short Cycle of European GDP



5. Multivariate approach: the similar national cycles are generated by a small number of common impulses

5.1. An “imperfectly optimal " currency area

If we consider the three principal countries of the euro-zone – Germany, France and Italy – they clearly do not form an OCA. The estimation of the trivariate model, reproduced in Table 4, makes it possible to state more precisely the contents of this imperfection. This model, which presents the classical form of "smooth trend" and a rather good statistical quality, is estimated without imposing any constraint on the variance-covariance matrices of the innovations. It emphasises a strong contrast between the strength of the correlations between the national innovations of some components and their weakness for others:

– The innovations affecting the trend slopes of the three countries are very positively, but not perfectly, correlated. The strength of this correlation reflects the community of the long run European history, already tangible through univariate models. To impose a perfect correlation would however simplify excessively this community, in particular at the end of the period, when France appears more reactive than its two partners with a clear renewal of growth trend (the strongest volatility of the innovations affecting its trend is also an indicator of this reactivity). At the end of 1999, the growth trend estimated for France appears a little higher than 3% per annum but nearer to 2% per annum for the two other countries.

– At the other extreme of the spectrum of the frequencies, the shocks impelling the short cycle (with a period of about three years) are rather strongly correlated between the three economies. This similar cycle is largely synchronised, even if it would be excessive to impose a perfect community. This short cycle results from fluctuations of storage, which are quickly propagated from one country to another through trade flows.

– On the other hand, the long cycle, whose duration is estimated from seven to eight years, is of similar nature in the three countries, but it is clearly not a common cycle. The shocks which impel it are slightly correlated between the three economies. The correlation is significantly, though poorly, positive only for the French-German couple. This result reveals distortions between the economic situations of the three economies during the past decades.

Obviously, the global fluctuations of the three economies, which incorporate the two cyclical frequencies and the changes of their trends, are more strongly correlated than the shocks impelling the long cycle only, since the various former correlations interfere in this general movement. But it is important to notice that the fundamental rhythm of the business dynamics, associated with the long cycle and the fluctuations of investment, expresses the most differences between the three economies. The convenient monitoring of this rhythm by the authorities responsible for the European economic policy would be complicated, if this plurality were to remain as in the past.

Nevertheless, this statement also ought to be moderated. When one moves from the three principal countries to the ten selected countries of the euro-zone, the "dimension" of the European cycle does not jump from three to ten. The other smaller countries are associated preferentially with one of these three principal countries.

5.2. Under the national long cycles: a symmetrical common component and, at least, two sources of asymmetry

The canonical model of trend-cycle split is now estimated in a multivariate dimension by using the GDP series of the ten countries of the euro-zone (except Ireland and Luxembourg) that express a strong cyclical similarity. The former analyses showed that this similarity does not exclude any diversity. The multivariate approach considering ten countries makes it possible to characterise more completely this combination of unity and plurality, by testing the common character, or not, of the impulses that generate the similar national cycles.

5.2.1. *The search for common cycles*

In this multivariate modelling framework, each stochastic component – slope of the trend, short cycle, long cycle – which contributes to drive the national GDP could be *a priori* the matter of an effort of reduction to a small number of common factors shared by the various countries. In practice, it is difficult to undertake this research simultaneously for every component, because of the high number of imposed constraints. The choice was made to privilege the search for possible factors common to the national long cycles, as this cyclical component constitutes the fundamental element of the business dynamics of the European countries. However it can express substantial differences between these countries, as showed by the estimation of the trivariate model Germany-France-Italy. On the other hand, no constraint was explicitly imposed on the national trends and short cycles which continue to depend on idiosyncratic impulse factors, even if they express spontaneously strong relationships. Indeed, the idea is to evaluate the degree of community of the impulses for the long cyclical component that expresses the greatest apparent differences between countries.

Table 4. ***Trend-cycle split of the German, French and Italian GDPs (trivariate model, 60Q1-99Q4)***

	Germany	*France*	*Italy*
Diagnoses			
$\sqrt{PEV}$ (Standard error of prediction error)	0.71	0.59	0.76
R^2_d (Relative coefficient of determination)	0.56	0.79	0.41
N_{DH} (Statistic of normality)	0.25	6.71*	10.59 **
Q(p,q) (Box-Ljung Statistic of correlation)	9.61 (*p=13, q=6*)	4.76 (*p=13, q=6*)	9.85 (*p=13, q=6*)
Parameters			
σ_ε (Standard error of irregular component)	0.18	0.30	0.12
$Corr_\varepsilon$ (Coefficient of correlation of contemporaneous irregular components)	Germany / France : 0.22	France/ Italy : -0.38	Italy / Germany : -0.99
σ_η (Standard error of innovations shocking the level of trend)	-	-	-
σ_ζ (Standard error of innovations shocking the slope of trend)	0.10	0.11	0.08
$Corr_\zeta$ (Coefficient of correlation of contemporaneous innovations shocking the slopes of trends)	Germany / France : 0.90	France/ Italy : 0.98	Italy / Germany : 0.85
Long cycle			
σ_κ (Standard error of innovations shocking the cycle)	0.46	0.19	0.45
$Corr_\kappa$ (Coefficient of correlation of contemporaneous innovations shocking the long cycles)	Germany / France : 0.36	France/ Italy : -0.04	Italy / Germany : -0.11
ρ (Damping factor of the cycle)	0.94		
Period of the cycle in quarters	30.4		
Short cycle			
σ_κ (Standard error of innovations shocking the cycle)	0.24	0.19	0.39
$Corr_\kappa$ (Coefficient of correlation of contemporaneous innovations shocking the long cycles)	Germany / France : 0.41	France/ Italy : 0.91	Italy / Germany : 0.74
ρ (damping factor of the cycle)	0.93		
Period of the cycle in quarters	13.2		
Observations	Dummy for the level of trend in 91Q1	Dummies for the irregular component in 63Q1 et 68Q2	Dummy for the irregular component in 69Q4

Key**:** see Table 1.

We have looked, step by step, up to which point the ten similar national long cycles could be generated by a lower number of common impulse factors, i.e. the elementary and independent innovations that tilt them at each period. Each one of these common impulses generates a common cycle and every national long cycle is a specific combination of these common cycles – it is this combination that characterises each country. Reducing the number of common independent impulses amounts to introducing constraints on the covariance matrix of the long cycle's innovations. When the rank of this ten dimensions matrix loses one unit, the number of common factors so does. The minimal rank which is obtained corresponds to the minimal number of common factors which can be reached. This rank has been reduced up to the point where the introduction of an additional constraint would have seemed inadmissible by considering statistical diagnoses and special criteria appropriate to this exercise: it is indeed, for each country, a question of preserving an estimation of the trend that remains compatible with the one extracted from the univariate model. The search for common cycles ought not to stylise exaggeratedly the pattern of the national cycles.

This method makes it possible to admit up to three common impulse factors which generate the ten national long cycles. An additional reduction, to two or one common factors, is clearly inadmissible and comes up against the irreducibility already recorded of the trio formed by the three principal countries:

– The evolution of the statistical diagnoses of normality and autocorrelation is not the most conclusive argument. On the one hand, in this sequence of multivariate models, whose aim is not to refine national modelling but to wonder about the existence of common impulse factors, the national diagnoses remain overall poor and there is not general diagnosis for the total model; in addition, if one considers a qualitative criterion – number of countries for which the assumptions of normality of the residuals and nullity of their autocorrelation are not rejected at the threshold of 5% or 1% – the variation of this number is never higher than one when an additional restriction is introduced. The quality of models for each given country varies in fact rather little with the number of constraints. On the other hand, the evolution of the relative determination coefficient R^2_d brings more information: the significant and general reduction of this coefficient, when one passes from three to two common factors, indicates that the descriptive quality of the model does not support a reduction to less than three common cycles.

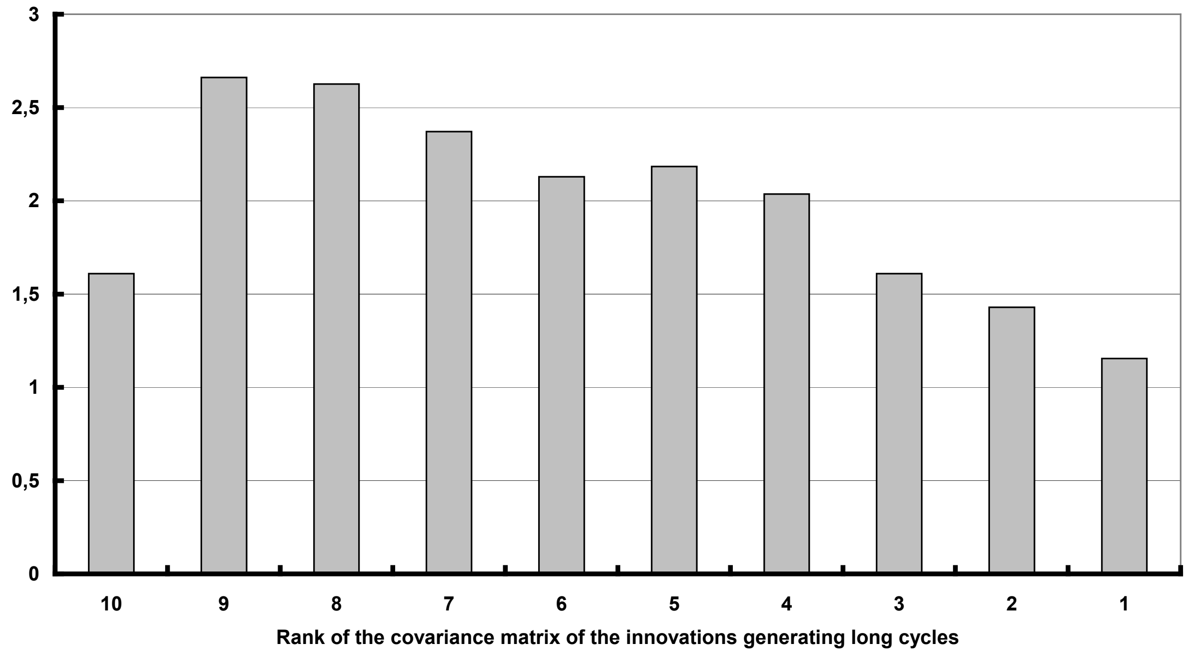
– The evolution of a key parameter, as and when the number of common factors is reduced, confirms this conclusion. It is the standard deviation of the long cycle innovations. If this standard deviation decreases for a country, compared to the standard deviations of the other innovations (of the trend, short cycle and irregular component), that means that the long cycle, although present in the split of the series, plays a reduced role in its dynamics. The estimated standard deviation of the long cycle innovations actually decreases, for a country, when the number of common factors is reduced. By taking the sum of the ten standard deviations, one has a global indicator, whose pattern, according to the number of selected common factors, suggests again that this number cannot be inferior to three: this reduction is already daring (Graph 10). One or two common factors are not sufficient to generate the cyclical dynamics of every national economy.

– A last measurement, simple and intuitive, still confirms this result. One can calculate the coefficient of correlation between two estimates of a long national cycle, the estimate extracted from the univariate model and the one extracted from the multivariate model, for every degree of restriction. A suitable correlation makes it possible to ensure the coherence sought between the various approaches. There again, this correlation decreases when the number of common factors falls. It is logical, since the degrees of freedom available to estimate this cycle are reduced. According to this empirical criterion, we find similar results, confirming that the number of common factors cannot be reduced below three (Graph 11).

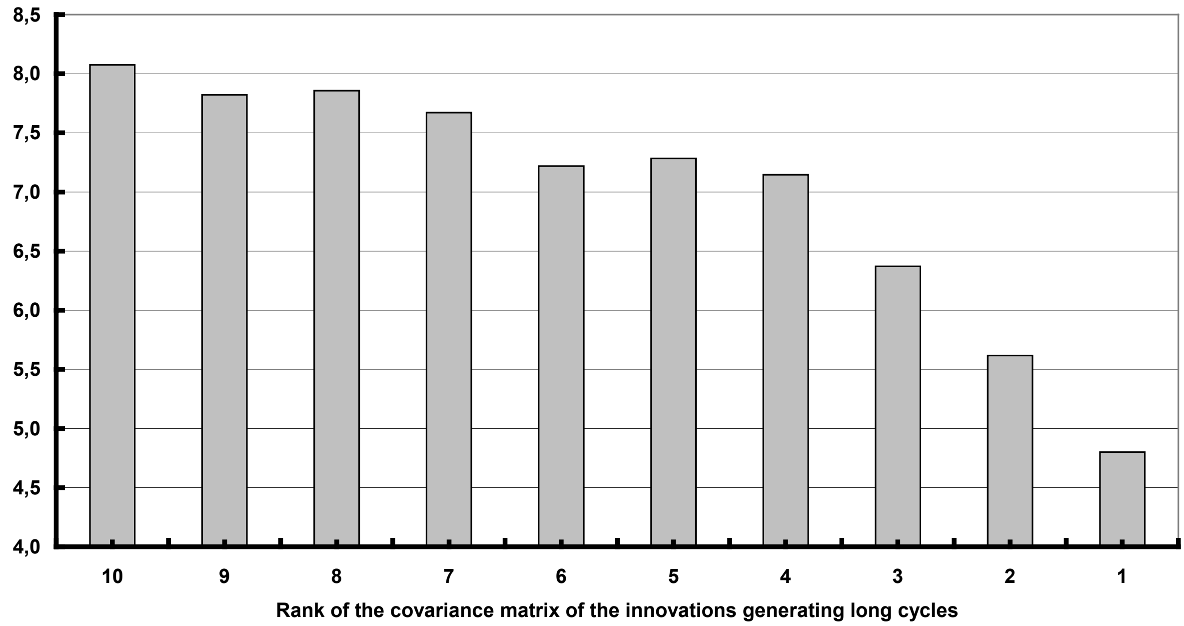
If the euro-zone were an optimal currency area, there would be a single common cycle generating the national long cycles which would be only multiples of this common cycle. It would make clear the perfect symmetry, except for the intensity, of the shocks generating the business dynamics. The euro-zone is not completely an optimal currency area: it is at least of dimension three!

The reduction to a multivariate model that generates the ten national long cycles by a set of three common impulse factors has the advantage of allowing a rather clear interpretation – although this model does not have a decisive statistical advantage compared to a model with four common factors. Table 5 gives the results of this multivariate estimation where the rank of the covariance matrix of the innovations impelling the long cycle is reduced to three. The statistical diagnoses are overall poor – which alerts on the hardness of the constraints imposed to the national splits in this multivariate estimation. It is more interesting to consider the results common to the various countries than the only national results. The characteristics of many small countries resist to the constraints imposed by the multivariate formulation. It would be necessary to introduce *ad hoc* national variables to take them into account. However, again, the two short and long cyclical components appear clearly present in all the European countries.

10. Evolution of the sum of the standard deviations of the innovations generating the ten national long cycles, according to the number of common factors driving these cycles (multivariate model)



11. Evolution of the sum of the ten coefficients of correlation between long national cycles respectively extracted from univariate and multivariate models, according to the number of common factors selected by the multivariate modelling.



5.2.2. *The interpretation of the common cycles*

The impulses which drive the national long cycles, of a decennial nature, are not independent between countries. The estimation of the model makes it possible to obtain the combination of the three elementary common cycles which characterises each national long cycle. The interpretation of this combination is however not immediate, because it is affected by the particular formulation used to represent the influence of the three common factors on the ten national cycles (cf. equation [10]). Because of this formulation, the order of the countries intervenes in the determination of the common factors. One can modify this formulation, thanks to a principal components analysis (PCA) applied to the three elementary common cycles. The aim is to arrive at an interpretable representation of the three independent common cycles, by a change of base in a three-dimension vector space. Whereas the "base" provided by STAMP is arbitrary, the base that results from the PCA is single and interpretable. The three final common cycles correspond to the three axes produced by the PCA; the order of these three cycles corresponds to the share which they take in the variance of the data submitted to the analysis. The PCA makes it possible to identify a three-dimensional base of the national long cycles, which is more easily interpretable. Indeed, when the national long cycles are used like additional variables in the PCA, the co-ordinates of each country related to the three axes authorises this interpretation: each one of these co-ordinates is equal to the coefficient of correlation between the national cycle and the common cycle represented by an axis (Table 6). The expression "common cycles" or "common components" thus concerns from now the three cycles resulting from the PCA. Their interpretation is related to an attentive reading of the national co-ordinates in the space formed by these three components. The common character of a component does not mean that its impact is of the same sign, or symmetrical, on each national cycle:

– The second common component (which is thus not the component explaining the maximum share of the variance of the set formed by the primary common cycles, but only 31%) constitutes the symmetrical European component, that influences positively all the national long cycles. It presents a strong general correlation with each one of them (more than 0.75, except for Italy). The shocks which generate it have a symmetrical nature. This component takes a form close to the European long cycle extracted from the aggregate European GDP, within the bivariate model gathering the United States and Europe (Graph 12)[11]. Their coefficient of correlation is worth 0.83. Thus the symmetrical common component which contributes to drive the national long cycles takes part basically in the aggregate movement of the European GDP.

[11]The amplitude of the cycle produced by the PCA applied to normalised data is however arbitrary. For comparability, the standard deviation of the second common cycle has been standardised by the one of the aggregate European cycle.

– The first common component (41% of the variance) influence very unequally the national cycles. It retraces the intensity of the phase oppositions between two groups of countries : a “Germanic” group (Germany, Austria, Netherlands, but also Greece), to which this component is positively related, and a “Latin” group (Spain, France, Italy, Portugal, plus Finland), to which it is negatively related. Belgium is located at equal distance from these two groups. This common component is carrying a binary opposition since it influences these two groups simultaneously but with different signs. The shocks it retraces, opposite rather than asymmetrical, can counter the diffusion of the influences carried by the previous symmetrical component (Graph 13). It is the case of the German recession of 1966-67 or of the German unification of 1990, whose initial expansive impact moderates the general European deceleration. From 1983 to 1987 also, Germany and Netherlands are in a situation more favourable than France and Italy, frankly sunk into the depression. This variation is explained then by a better competitiveness of the “Germanic” group, comparatively to the “Latin” one still with strong inflation. The policies of disinflation which begin in the latter group will be effective only gradually and have a significant initial cost in terms of fall of activity.

– The third common component (23% of the variance) divides the “Latin” group. It opposes France, to which it is positively related, to the other countries of the “Latin” group, especially Italy. It carries the positive mark of the transitory French revival of 1981-82, before France supports the sacrifices of an adjustment period. On the other hand, it is negatively influenced by the French depression of the nineties, when France became a country with hard currency and “deserted” the Latin camp that rocked on the side of the monetary depreciation during the crisis of the European Currency Mechanism (ECM). In return, the recovery policy engaged by Jospin’s government since 1997 fits clearly and positively in the recent evolution of this third common component, whereas Italy lags behind the European revival.

These two last common components, which retrace the impact of the asymmetrical or opposite intra-European shocks, are deeply related to the European history before the monetary unification. They clearly show the trace of the monetary conflicts within Europe, including during the life of the ECM, whose birth in 1979 did not prevent the recurrence of such conflicts. However, taking into account their nature, it is not excluded that the realisation of the monetary union contributes to dampen the opposite or asymmetrical shocks. The disappearance of reciprocal fluctuations of exchange rates and the establishment of common preferences for weak inflation are factors of reduction of asymmetries, which constitutes an essential difference between the monetary union and the ECM. Moreover, the first common component, which corresponds to the binary opposition between “Germanic” and “Latin” groups, shows a very low amplitude after 1995, i.e. since the end of the ECM crisis.

Table 5. ***Trend-cycle split of national GDP extracted from the multivariate model with restriction to three common factors for the long cycle (60Q1-99Q4)***

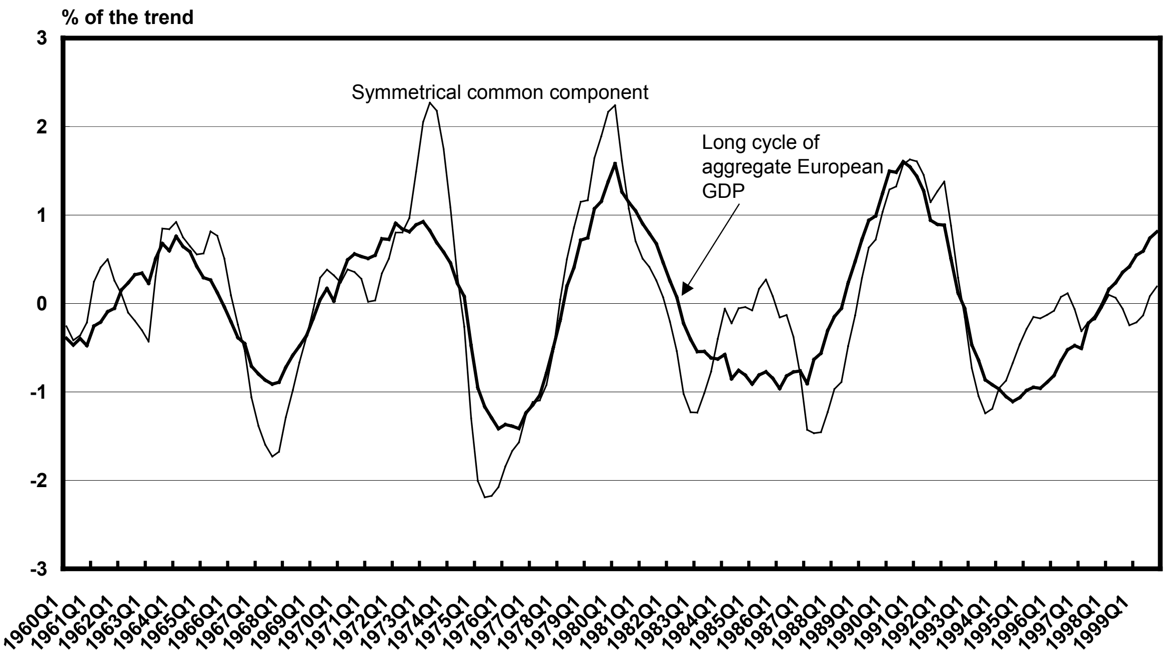
	Germany	*Austria*	*Belgium*	*Spain*	*Finland*	*France*	*Greece*	*Netherlands*	*Italy*	*Portugal*
Diagnoses										
$\sqrt{PEV}$	0.90	1.11	0.58	0.61	1.25	0.92	0.88	0.83	0.90	1.10
R^2_d	0.30	0.17	0.07	0.41	-0.05	0.50	0.19	0.13	0.19	0.22
N_{BS}	1.03	110.30 **	21.07 **	39.36 **	6.13 *	57.59 **	179.40 **	61.25 **	6.37 *	11.72 **
Q(13,6)	43.1 **	14.3 *	188.6 **	111.7 **	61.8 **	11.2	168.0 **	36.7 **	49.8 **	63.7 **
Parameters										
σ_ε	0.38	0.61	0.28	0.29	0.64	0.48	0.41	0.45	0.47	0.61
σ_ζ	0.10	0.14	0.08	0.15	0.16	0.11	0.12	0.10	0.11	0.15
Long cycle										
σ_κ	0.26	0.14	0.10	0.08	0.09	0.30	0.09	0.12	0.29	0.12
ρ	0.90									
Period (quarters)	39.3									
Short cycle										
σ_κ	0.45	0.42	0.26	0.22	0.54	0.32	0.43	0.33	0.31	0.41
ρ	0.90									
Period (quarters)	12.7									
Observations	Dummy for the level of trend in 91Q1					Dummies for the irregular component in 68Q2			Dummy for the irregular component in 69Q4	

Key: see Table 1.

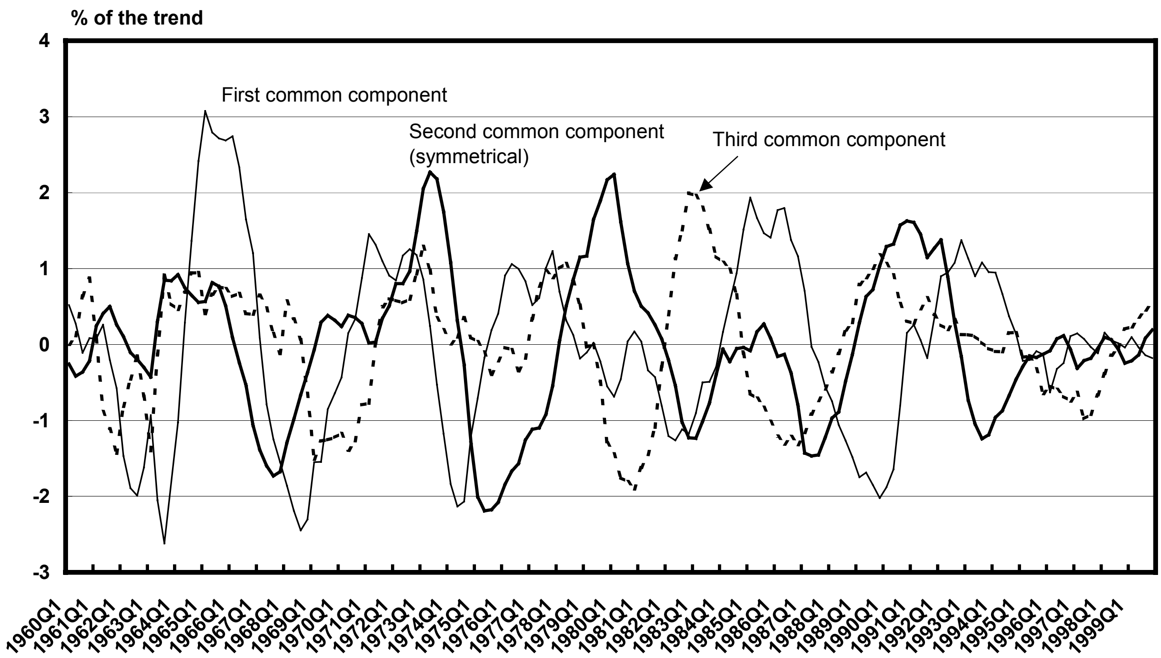
Table 6. ***Co-ordinates of the long national cycles extracted from the multivariate model relatively to the three principal axes (or common components)***

	Germany	*Austria*	*Belgium*	*Spain*	*Finland*	*France*	*Greece*	*Netherlands*	*Italy*	*Portugal*
First common component	0.45	0.43	0.00	-0.40	-0.32	-0.33	0.63	0.31	-0.74	-0.27
Second common component	0.89	0.89	0.97	0.84	0.89	0.82	0.77	0.95	0.48	0.92
Third common component	-0.01	-0.15	-0.23	-0.36	-0.33	0.47	0.07	-0.03	-0.47	-0.29

12.Long cycle of aggregate European GDP and symmetrical common component of national cycles



13. The three common components of long national cycles



In order to specify the respective role of the three elementary common components in the generation of the European long cycle, this cycle, calculated as the aggregate of the long national cycles extracted from the multivariate model, can be expressed directly according to the three common components. The coefficients of this additive split result from the estimation of the multivariate model and of the principal components analysis:

$$European\ long\ cycle = \sum_{i=1}^{10} \alpha_i \ long\ national\ Cycle_i$$

$$Long\ national\ cycle_i = \sum_{j=1}^{3} \beta_{ij} \ Common\ component_j \qquad [14]$$

$$European\ long\ cycle = \sum_{j=1}^{3} \left(\sum_{i=1}^{10} \alpha_i \ \beta_{ij} \right) Common\ component_j$$

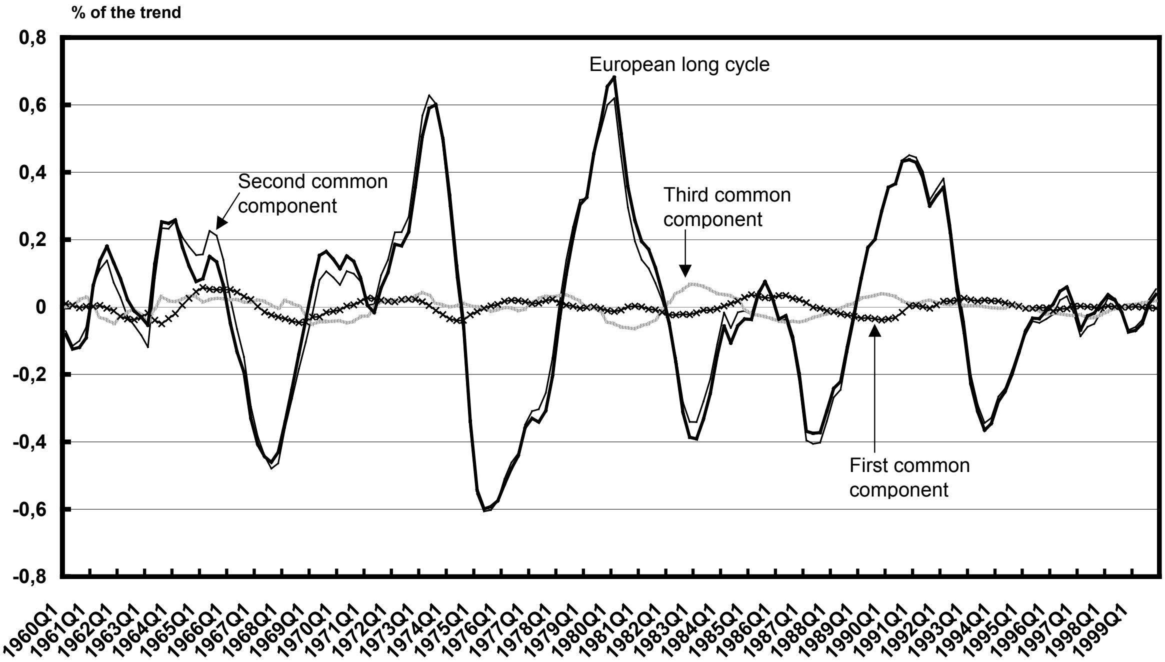
The European long cycle obtained in that way presents a pattern close to the one that results from aggregating the long national cycles produced by the univariate modelling[12]. The "average European cycles" obtained by these two methods are very similar since their coefficient of correlation is worth 0.90. The former split gives additional information, by clarifying the contribution of each common component to the European long cycle. One can then visualise the European cycle as the sum of the three contributions corresponding to each common component, weighted by a complex coefficient which takes into account the weight of each country and the role of the component in the cycle of this country (Equation 14 and graph 14). This coefficient can have a positive, null or negative value. The global impact of a common component on Europe can indeed cover compensations between a positive impact on some countries and a negative one on others.

The contribution of the symmetrical common component almost merges with the European long cycle itself, although this component explains only less than one third of the total variance of the original common cycles identified by the multivariate estimation (Graph 14). This observation confirms the essential role of this symmetrical component for the aggregate movement of the European GDP, although it is far from exhausting the whole national dynamics: the national long cycles, taken one by one, give a much more significant role (although differentiated according to the country) to the two other common components that retrace the evolutionary oppositions between Germanic, Latin and French groups.

[12] The amplitude of the European long cycle calculated in that way seems weaker than the usual one of the European cycles. In the multivariate modelling framework, the importance of restrictions induces a loss of amplitude for the national cycles and, in consequence, more erratic national trends. The weakness of the standard deviations of long cycles in table 5 reveals this problem. The present calculus informs about the compared roles of the three common components in the generation of the European cycle, but not about its amplitude.

The aggregate European cycle results from the propagation of simultaneous and symmetrical impulses, but this both average and common cycle, within the euro-zone, explains only a small third of the total variance of the national short-term dynamics. These dynamics are affected by opposite shocks that tend to compensate each other at the European scale, but also to lessen during the most recent years.

14. Contributions of the three common components to the aggregate long cycle of European GDP



6. Towards the end of asymmetrical shocks?

The multivariate approach has permitted to decompose the European growth cycle into three common components: a symmetrical one and two asymmetrical or rather opposite components. The symmetry of the shocks which impel the European short-term evolution can be studied more accurately by considering the sequences of innovations. Indeed, when the trend-cycle split has been estimated, each sequence of innovations related to a stochastic component of the model can be extracted from the results of the estimation[13]. This sequence is a particular sample among all samples potentially generated by the probabilistic law of the innovations (a "white noise"); but this particular sample should reflect all various historical shocks that actually affected the considered stochastic component. We are interested here in studying the sequence of innovations related to the long cyclical component. The propagation of these innovations depends on the structural parameters (frequency and damping factor).

The various approaches used to estimate European fluctuations permit us to extract their sequences of innovations from various models. The consistency of the results is not straightforward and two main questions appear:
– Behind the impressive similarity between the aggregate euro-zone cycle and the aggregation of national cycles, can we discern a high and increasing symmetry between sequences of shocks driving long national cycles ?
– On the contrary, is the existence of three common components generating all national long cycles, according to the multivariate modelling, the sign of persistent asymmetry between national shocks?

Trying to answer to these questions, two synthetic diffusion indicators have first been built from innovations sequences related to national univariate long cycles, in order to see whether a significant increasing symmetry is emerging between these independently estimated univariate models. For each quarter, we might distinguish, among euro-zone shocks, significantly positive shocks (their number is noted *Pos*), significantly negative (respectively *Neg*) and insignificant ones[14]. Two indicators are computed with these variables, after transformation by a moving average over 12 quarters, in order to evaluate the intensity and the nature of shocks in the vicinity of each quarter. Countries are not weighted by their size because our aim is to measure the diffusion of shocks in all countries. The length of the moving average is chosen shorter than the average cyclical duration, but long enough to indicate the main feature of shocks around each quarter (shorter windows would give too

[13] For a given cycle, innovations computation is formalised in Fayolle and Mathis (1993).
[14] For a given country, we call "significant" a shock with an absolute value twice greater than the standard error of the shocks sequence.

erratic information). This smoothing operation permits too to take account of diffusion delays for common shocks, when they do not happen exactly at the same time in each country.

These indicators are defined as follows :

– The simultaneous-shocks indicator (*Sim*) gives the rate of significantly shocked countries, indifferently in an expansive way or a recessive one, using moving average over 12 quarters centred around the current quarter:

$$Sim_t = \frac{100}{12} \times \sum_{i=-5}^{6} \frac{Pos_{t+i} + Neg_{t+i}}{10} \qquad [15]$$

– The opposite-shocks indicator (*Opp*) is built by using the absolute difference |*Pos-Neg*| between numbers of expansive and recessive shocks, divided by the number of significantly shocked countries. These variables are again measured by moving average over 12 quarters :

$$Opp_t = 100 \times \left(1 - \frac{\sum_{i=-5}^{6} \left| Pos_{t+i} - Neg_{t+i} \right|}{\sum_{i=-5}^{6} \left(Pos_{t+i} + Neg_{t+i} \right)} \right) \qquad [16]$$

This second indicator evaluates, when significant shocks happen in some countries, how much these shocks are opposite for the concerned countries. It is equal to 100 when shocks are completely opposite in the zone (*Pos=Neg*) and zero when they are all purely symmetrical (*Pos=0* or *Neg* = 0).

Significant shocks on a given period will be considered as perfectly symmetrical, when they are simultaneous (*Sim=100*) and with a same sign for all countries (*Opp=0*). Graph 15 shows the evolution of these two indicators. A loss of observations at the beginning and at the end of the observed period is explained by the use of moving averages.

Among clearly symmetrical shocks, in a recessive way, we can find the two oil shocks. In the 1980s and the 1990s, diffusion of simultaneous significant shocks is decreasing progressively. However, when shocks happen, they have still a significant opposite effect: in particular, from 1982 to 1985, we observed dissimilar short-term dynamics and heterogeneous national economic policies; afterwards, from 1990 to 1992, Europe went from the German reunification to the ECM crisis. Although the symmetry has been improved relatively to the 1960s, it has now not completely been achieved.

At the end of the period, the increase in the opposite-shocks indicator has to be considered carefully. Indeed, since the end of the ECM crisis in 1995, the intensity and the diffusion of shocks have been very low: the simultaneous-shocks indicator decreases below 10%. Nonetheless, among this small set of shocks, a noticeable opposition appears. We know, for example, that the slowdown which followed the 1997-98 Asiatic crisis (this event influences indicators at the beginning of 1997, because of the smoothing procedure) was harder in Germany than in France. Europe with a single currency seems less vulnerable to shocks, but this evolution does not exclude differences of sensitivity inside the zone.

Is this outlook compatible with the results of the multivariate modelling ? By extracting innovations of the three common components from this approach, we should obtain one symmetrical shocks sequence and two sequences of "Germanic-Latin" and "intra-Latin" opposite shocks. From these sequences, we can build two new indicators reflecting shocks intensity rather than shocks diffusion, by identifying intensity with innovations volatility, i.e. their empirical variance measured over 12 quarters moving windows:

– Innovations volatility of the symmetrical common component indicates the importance of symmetrical shocks.

– The sum of the two other common components volatility indicates the importance of opposite shocks.

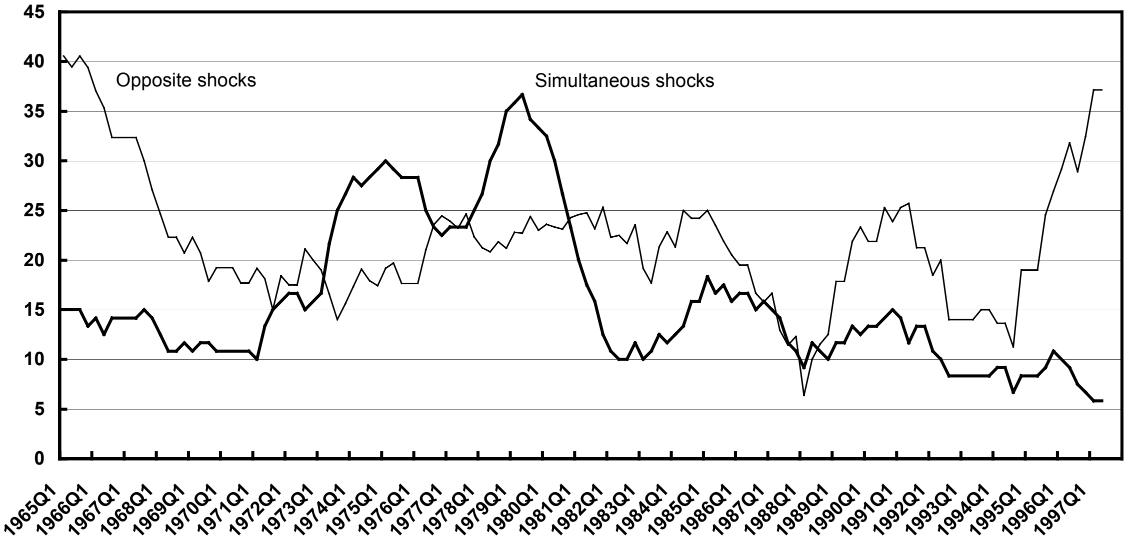
Both indicators (graph 16) show similarity with diffusion indicators derived from univariate models, although these *ad hoc* empirical methods should be compared carefully. However the volatility indicator of opposite shocks shows a trend of decreasing intensity, since the sixties. This trend was interrupted from the German reunification to the ECM crisis. We can notice too that the volatility indicator of symmetrical shocks shows an increase between 1991 and 1993 with a slight lag. During this period, we observe at the same moment:

– European divergences stimulated by monetary and financial tensions generated by the German reunification.

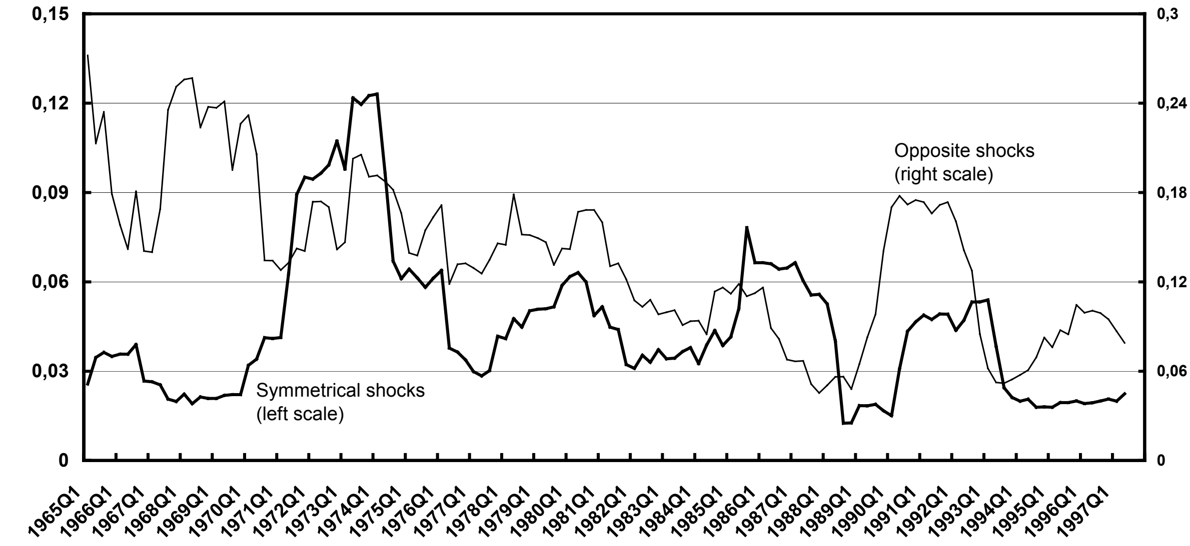
– Common recessive influences like the small oil shock induced by the Gulf war and the common pro-cyclical policies generated by the Maastricht treaty.

This interaction between common and opposite shocks did not simplify the reading of European short-term tendencies during the early nineties. At the end of the period, since 1995, we notice again, but in a less impressive way than by using diffusion indicators, a contrast between a decrease of shocks intensity in all European countries and a limited increase of opposite shocks volatility.

15. Indicators of diffusion of the simultaneous and opposite shocks (from univariate models)



16. Indicators of volatility of symmetrical and opposite shocks (from multivariate models)



These remarks bring us to seek links between shocks sequences and economic policy indicators. For example, we will verify the interaction between symmetrical shocks and the German monetary policy. We consider the quarterly first differences of short-term and long-term interest rates in Germany as monetary policy indicators. Indeed, this monetary policy played a leading role in Europe. Computing crossed-correlation coefficients of these variations with the symmetrical shocks sequence extracted from the multivariate model, we find, for short-term interest rates, two significant correlation coefficients (Table 7):

– The instantaneous correlation coefficient, equal to 0.2 , shows the Bundesbank's reaction to a symmetrical positive shock in Europe.

– A significant and lagged correlation, equal to –0.2 , associated with a negative impact (lagged of around four or five quarters) of an increase in German interest rates on the European GDP.

We obtain an analogous result with the variation in spreads. The spread between long and short-term German rates influences the Germanic-Latin opposite shocks sequence too. The multiple channels of transmission of the monetary policy simultaneously influence the common trajectory of the European countries and their oppositions. This confirms the actual sensitivity of the European business situation to interest rates tensions, although an analogous role of exchange rates did not empirically appear.

Table 7. ***Correlation between symmetrical shocks and German monetary policy indicators***

	Lagged sequence of symmetrical common component innovations						
	Innov	*Innov(+1)*	*Innov(+2)*	*Innov(+3)*	*Innov(+4)*	*Innov(+5)*	*Innov(+6)*
Quarterly short-term interest rates differences	0.20*	0.07	-0.04	-0.10	-0.20*	-0.19*	-0.07
Quarterly spread differences	-0.14	-0.04	0.05	0.08	0.20*	0.20*	0.10

Key: correlation coefficients are computed between 1960Q1 and 1999Q4 and are followed by * when they are significant (the threshold is equal to 0.16 over the considered period).

If, until the creation of the Euro, destabilising shocks on Europe were mainly linked to the asymmetrical definition of the monetary policy and to the subsequent exchange tensions, such shocks should vanish after the monetary union. The European business situation would become simultaneously quieter and more homogeneous, conditionally to a relevant monetary policy. If former results and indicators do not allow us to certify such a conclusion, their careful interpretation seems to strengthen the possibility of such an evolution.

Conclusion

What do we learn from the application of Structural Unobserved Components Models to every national GDP and to the global GDP of the euro-zone, using quarterly national accounts over four complete decades, from 1960 to 1999 ?

1– When the whole aggregate euro-zone is considered, within a bivariate modelling framework applied to the US and the euro-zone, cyclical movements can be easily extracted. Two main remarks can be made about the split so obtained:
a) With such a retrospective split, the European growth trend seems to be lower than the American one at the end of the nineties, and this hierarchy did not begin only with the recent "new economy", but earlier, during the seventies and eighties : the United States have become again the OECD growth leader. The European Central Bank (ECB) can use such results to legitimate the conservative nature of its monetary rule. But this vision accepts a durable American leadership, thanks to a persistent advantage perhaps coming from the « new economy », in spite of the American tendency to stronger cycles.
b) The euro-zone cyclical movement shows a noticeable duality. It can be decomposed into two distinct cyclical components. The first one has a 3-years mean duration and relates to the erratic fluctuations of inventory variations; the second one has a 10-years mean duration and is well correlated with investment fluctuations. Both cyclical components can, in different circumstances, amplify each other (for example, during the first oil shock or the 1993 recession) or, on the contrary, compensate each other (in 1994-95, the inventory recovery is mainly neutralised by the inertia of investment). This interaction is obviously meaningful for the monetary policy: too quick an ECB reaction to "technical recoveries", while revival of investment is still fragile, could interrupt the latter and, therefore, depress potential growth outlook (this takes more sense since the 1993 recession that has shown that firms can strongly contract their inventories, in a situation of low inflation and high interest rates). Moreover, the European lag behind the American growth seems largely conditioned by the relative lack of investment in Europe.

2– European cyclical movement is not only an aggregate phenomenon, but results from cyclical impulse factors which are partially shared by the euro-zone countries. We could imagine that a given country, the GDP of which is obviously included in the European aggregate GDP, would have a cycle desynchronised with the aggregate cycle. This is for example the case for Luxembourg and Ireland, small countries with strong idiosyncrasies. Nonetheless, considering the other ten countries in the euro-zone, the double cyclical movement of the European GDP is largely diffused into all member countries:

a) National univariate models show a double cyclical movement (a short 3-years cycle and a long 10-years cycle), which confirms the double pattern identified for the aggregate European GDP. The characteristics of national cycles, in particular their period, seem generally similar, although their amplitudes and their phases can be significantly different. Past changes in growth trend were generally very similar too, although the interval of European growth trend rates becomes larger at the end of the period, between 1.5 and 3.5% by year. We note also a remarkable coincidence between European cycles directly extracted from the aggregate European GDP and those computed by aggregation of weighted national cycles. This coincidence is verified, whether we are interested in short cycles, in long cycles or in the global cyclical movement which sums these two elementary cycles. The cyclical movement of the global European GDP looks like an « averaged » European cycle, where national asymmetries disappear.

b) The multivariate approach, applied to ten countries, shows that national cycles are not only similar. They can be reduced to a low number of common impulse factors. Short national cycles are fundamentally synchronised: this can be related to the interdependence of European inventory behaviours through trade flows. Considering now only long cycles, whose periods are always approximately equal to ten years, but with possible significant time shifts between countries, the ten similar national cycles could be reduced to three common cycles. Each national long cycle is a specific combination of these common cycles. The three common cycles have the same structural characteristics (period and damping factor) but each one is driven by its own innovations (or shocks) sequence, independent from the two others. If the euro-zone (limited to ten countries) was an optimal currency area, we would extract a single common cycle : this would show a perfect symmetry of shocks. The euro-zone is not completely an optimal currency area: it has at least three dimensions! The three common cycles can be expressed in an interpretable form. One of these three common cycles draws the propagation of symmetrical shocks and contributes mainly to the aggregate European long cycle. However this cycle explains only one third of the global variance of national long cycles. These ones are related as well (with various degrees) to the other two components, which draw the propagation of shocks with opposite signs: between the “Germanic” group and the “Latin” group on the one hand; between France and the rest of the “Latin” group on the other hand. Asymmetries, or clear oppositions, remain strong in Europe over the considered period, although they are diminishing after 1995.

3– Innovations, or shocks, driving cyclical movements can be extracted from estimations. Sequences of shocks can be used for building simultaneity indicators, measuring symmetry or opposition of shocks in the euro-zone. When such indicators are built from national univariate models, these ones are called diffusion indicators and measure how much symmetrical or opposite shocks diffuse in the global zone; when they are built from the three common cycles extracted from the multivariate model, these ones are called volatility indicators and they measure the intensity of symmetrical or opposite shocks hitting the zone. In both cases, these indicators seem to show, over the last forty years, simultaneously a decrease of vulnerability of euro-zone countries to various shocks and the convergence of national reactions to these shocks. Nonetheless this double trend seems irregular and reversible: the German reunification, the ECM crisis of 1992-93 and, at a lower degree, the Asiatic crisis in the years 1997-98 were occasions to return to national divergences. However, the monetary or financial nature of major shocks that troubled the European situation in the past let us think that the European vulnerability can significantly decrease thanks to monetary union. The European business situation would then be quieter and more homogeneous.

Nevertheless, this evolution is only a possible evolution that has not been corroborated yet by the analysis of observed facts. The cyclical movement in Europe seems plural for two reasons : it mixes short oscillations, linked to inventory behaviours, and slower fluctuations, corresponding to the fundamental rhythms of capital accumulation; cycles of member countries in the euro-zone are partially unified, but cannot be reduced yet to a single common cycle. A well balanced policy mix can not be indifferent to this plurality. The system of indicators, which contributes to its definition, should be calibrated in order to help the authorities to distinguish the components of quite complex dynamics. The ECB should try to distinguish, in the global dynamics of the euro-zone, between very short-term oscillations and more fundamental fluctuations, in order not to hinder a durable expansion because of an excessive inflation aversion stimulated by a transitory acceleration of growth. This plurality of the European cycle is also an argument in favour of sufficient national fiscal autonomy, provided that governments are able to coordinate themselves, as there are less than twelve national independent dynamics.

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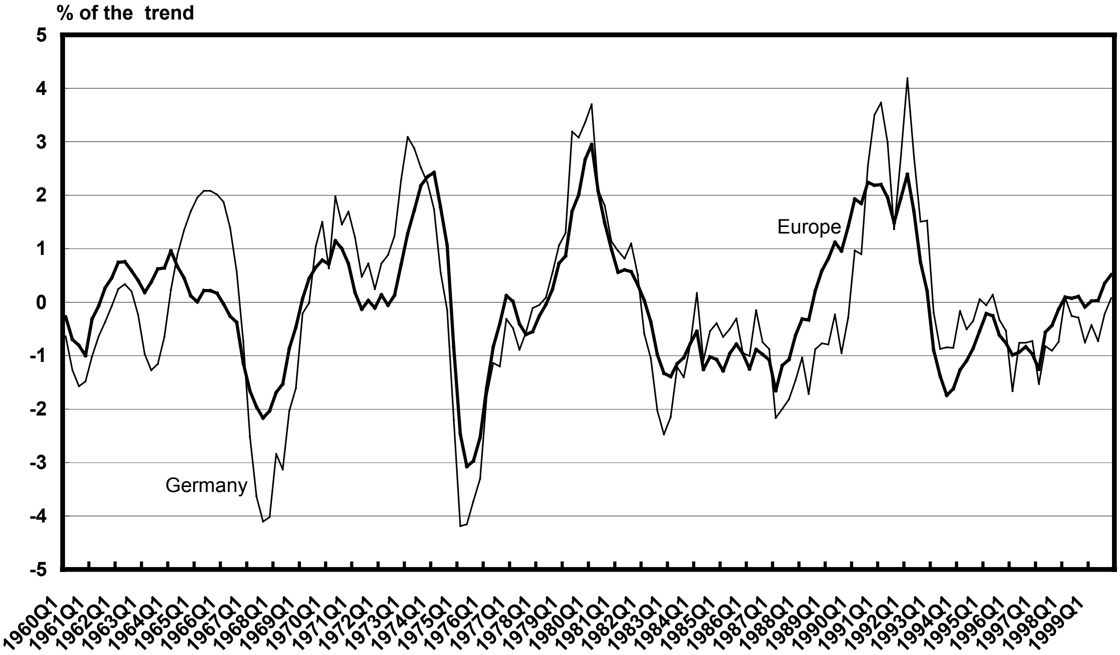
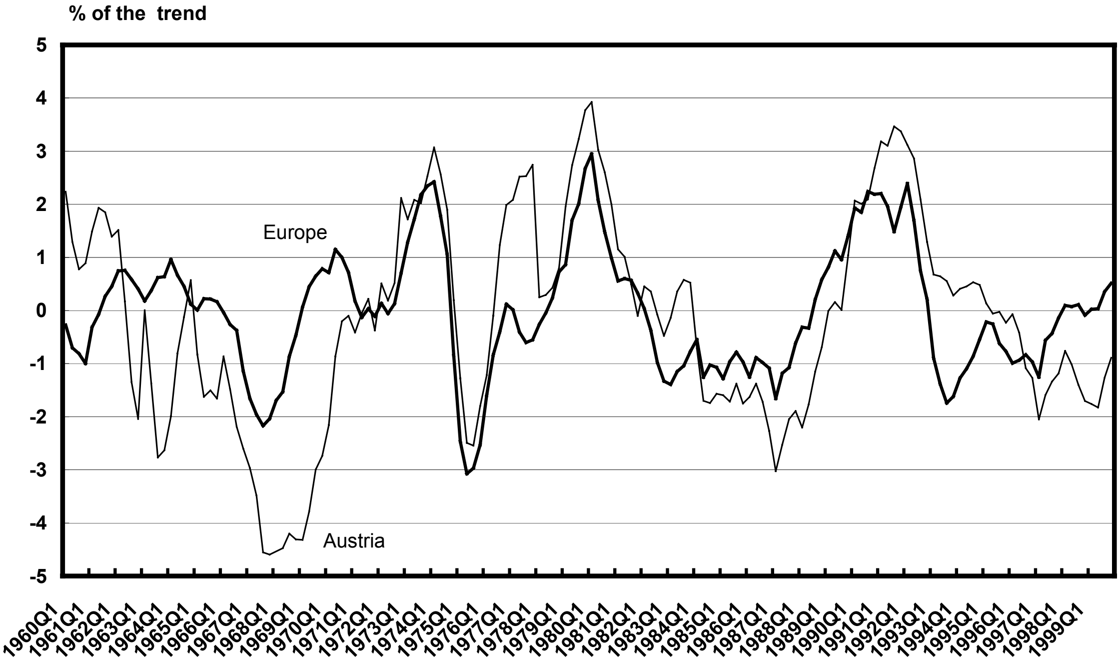
Annex:
The global cycles of euro-zone and member countries

Key: The global cycle of each country is the sum of the long cycle and the short cycle, if both are identified. In the case of Spain, it is the deviation between the GDP and its trend extracted by the Hodrick-Prescott method. The global cycle of the euro-zone is the average cycle, obtained by aggregation of the ten national cycles, weighted by Purchasing Power Parity GDP of 1995.

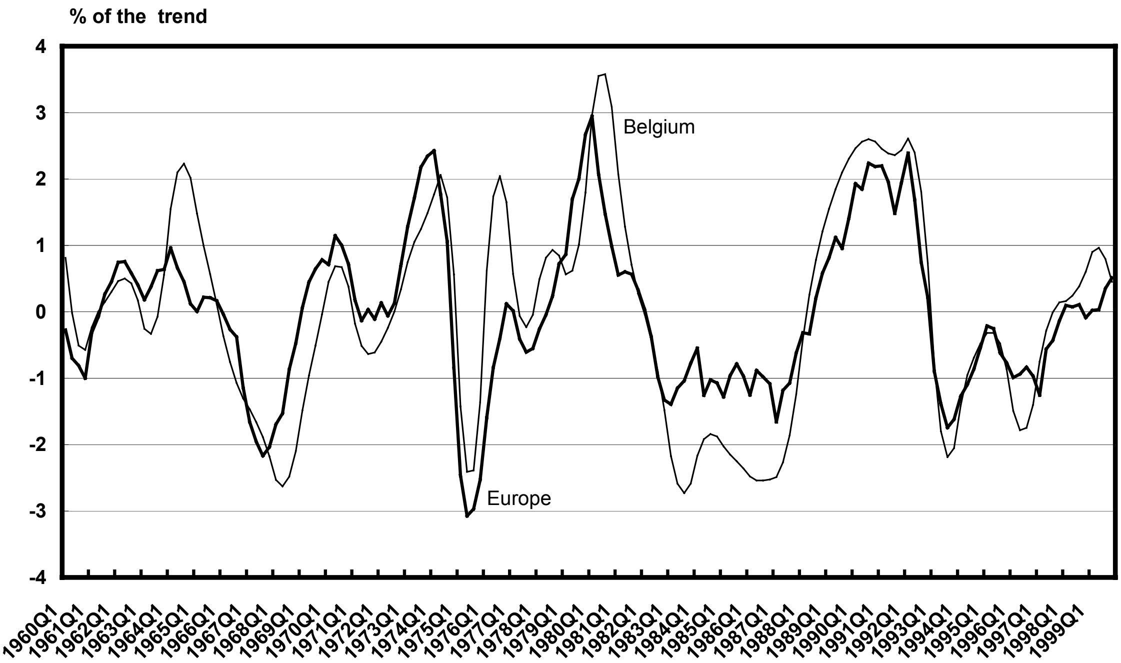
A1. The German and European global cycles



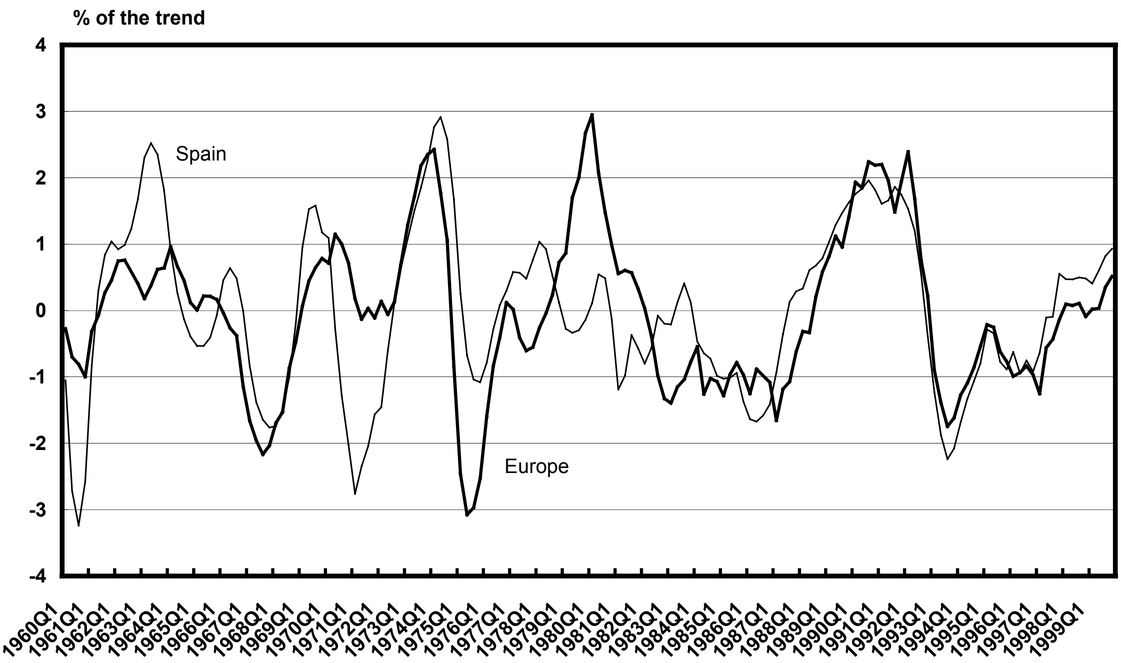
A2. The Austrian and European global cycles



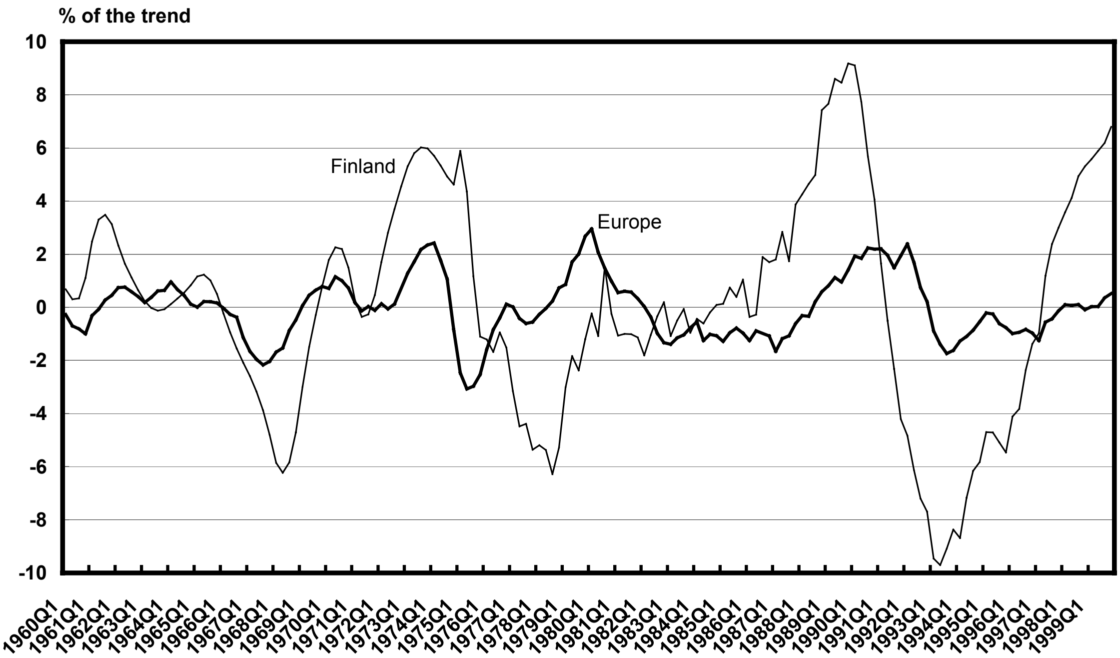
A3. The Belgian and European global cycles



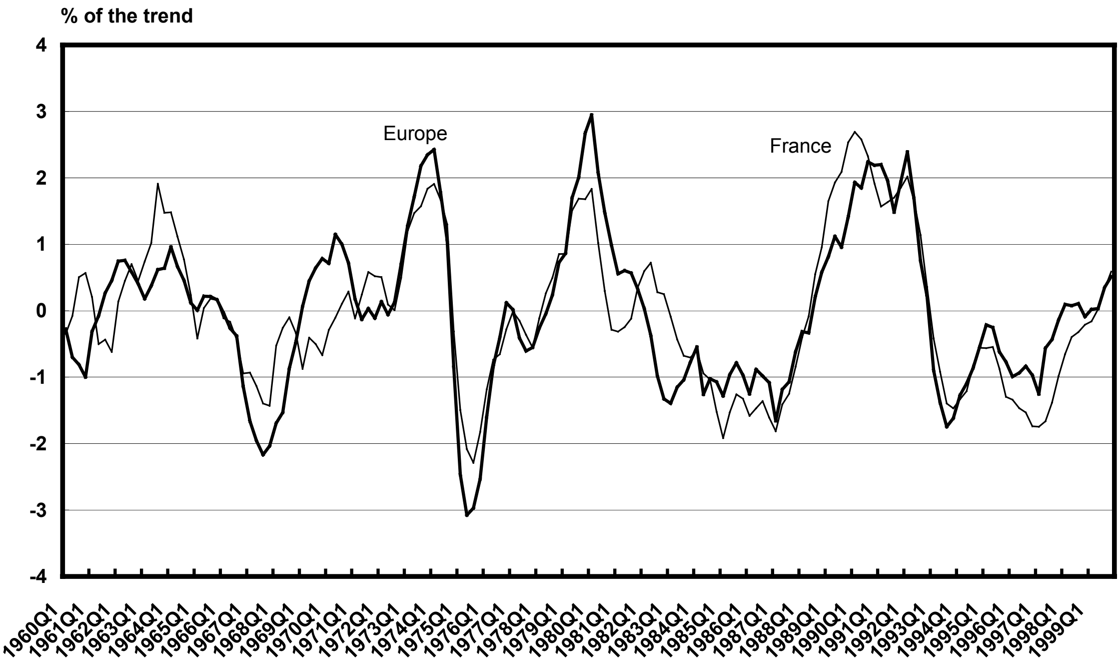
A4. The Spanish and European global cycles



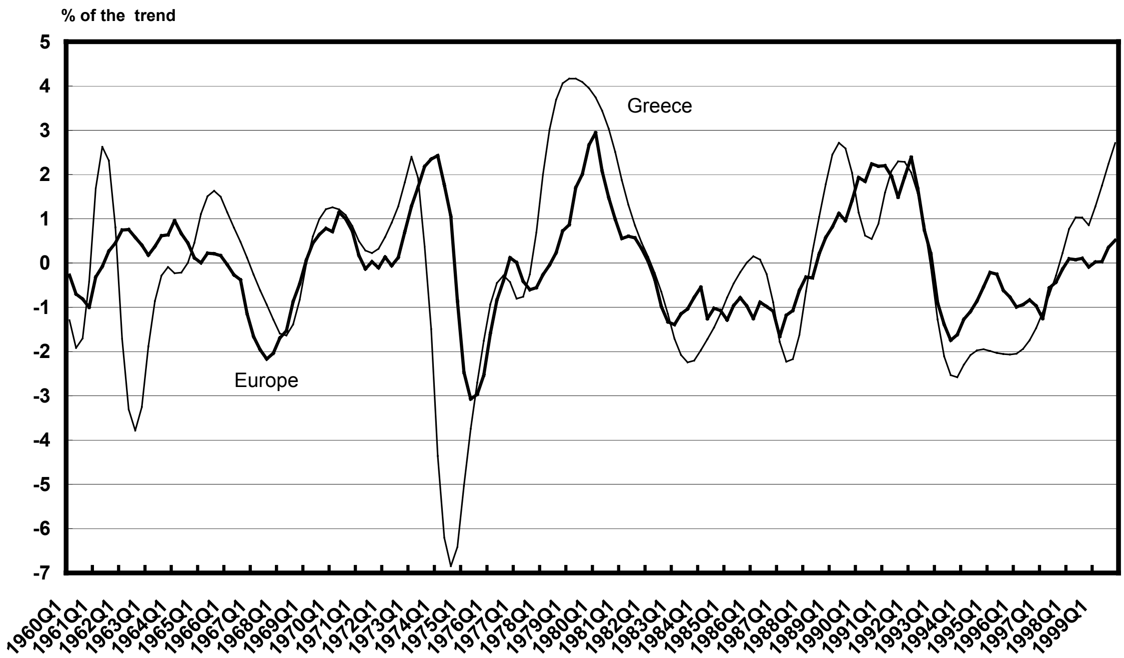
A5. The Finnish and European global cycles



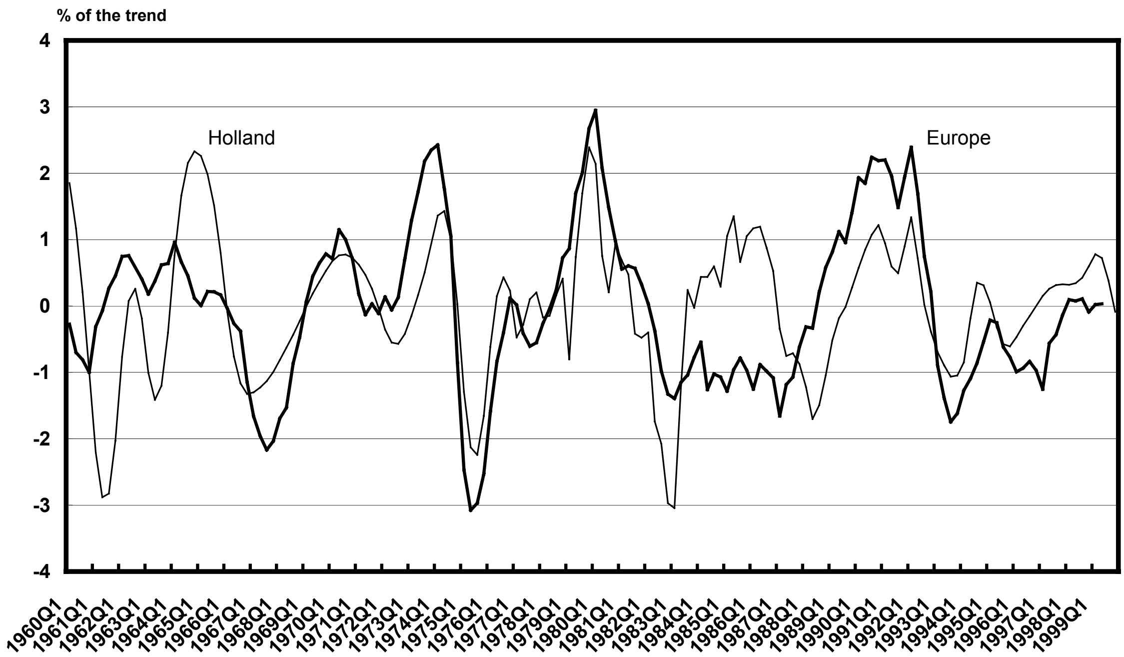
A6. The French and European global cycles



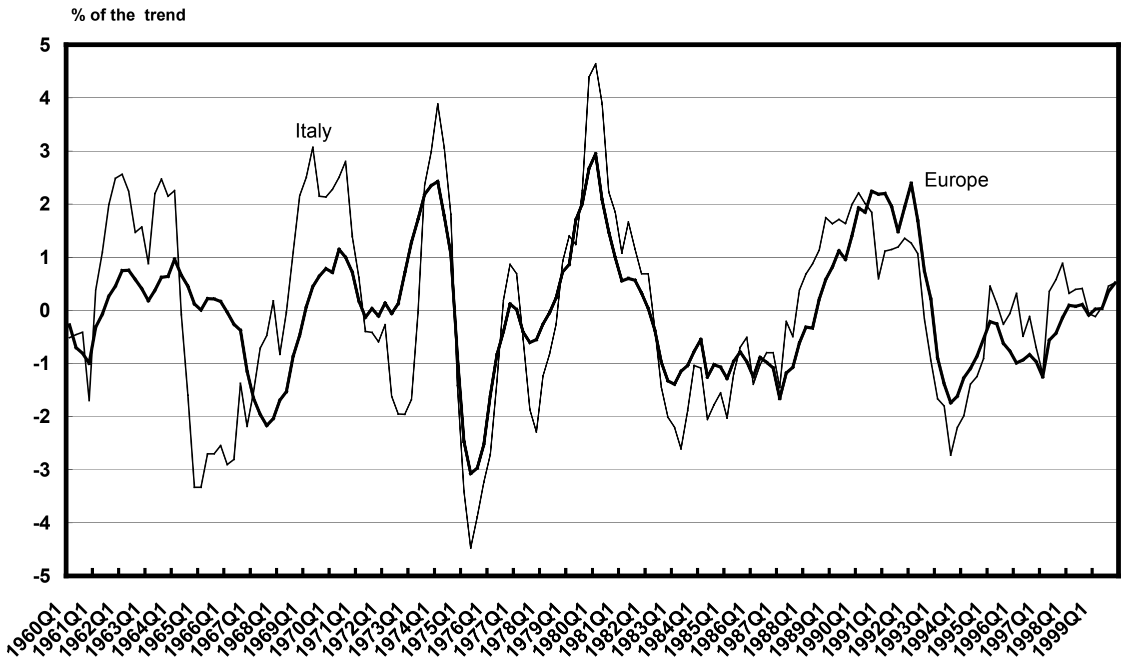
A7. The Greek and European global cycles



A8. The Dutch and European global cycles



A9. The Italian and European global cycles



A10. The Portuguese and European global cycles