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Bettina Becker and Stephen G. Hall

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Dept Economics
Loughborough University
Loughborough
LE11 3TU United Kingdom
Tel: + 44 (0) 1509 222701
Fax: + 44 (0) 1509 223910
http://www.lboro.ac.uk/departments/ec

Loughborough University

How Far From the Euro Area? Measuring Convergence of Inflation Rates in Eastern Europe

Bettina Becker[a] and Stephen G. Hall[b]

Abstract

We present a common factor framework of convergence which we implement using principal components analysis. We apply this technique to a dataset of monthly inflation rates of EMU and the Eastern European New Member Countries (NMC) over 1996-2007. In the earlier years, the NMC rates moved independently from an average of the three best performing countries over the past twelve months, while they moved somewhat closer in line with them in the later years. Looking at the sample of the EMU and NMC countries as a whole, there is evidence of a formation of convergence clubs across the two groups.

JEL classification: C22, F31

Keywords: Convergence, inflation rates, European Monetary Union, principal components analysis.

[a](*Corresponding author*) Loughborough University. *Address*: Department of Economics, Loughborough University, Loughborough, LE11 3TU, UK. Tel.: +44 (0)1509 222719, fax: +44 (0)1509 223910, e-mail: b.becker@lboro.ac.uk.

[b]University of Leicester. *Address*: Department of Economics, University of Leicester, University Road, Leicester, LE1 7RH, UK. Tel.: +44 (0)116 252 2827, fax: +44 (0)116 252 2908, e-mail: s.g.hall@le.ac.uk.

1. Introduction

Convergence has been a popular theme in applied economics since the seminal papers of Barro (1991) and Barro and Sala-i-Martin (1992). The very notion of convergence quickly becomes problematic from an academic viewpoint however when we try and formalise a framework to think about these issues. In the light of the abundance of available convergence concepts, it would be useful to have a more universal framework that encompassed existing concepts as special cases. Moreover, much of the convergence literature has treated the issue as a zero-one outcome. We argue that it is more sensible and useful for policy decision makers and academic researchers to consider also ongoing convergence over time. Assessing the progress of ongoing convergence is one interesting and important means of evaluating whether the Eastern European New Member Countries (NMC) of the European Union (EU) are getting closer to being deemed ‘ready’ to join the European Monetary Union (EMU), i.e. fulfilling the Maastricht convergence criteria.

In this paper we build on our earlier work (Becker and Hall, 2009) in considering some of the standard definitions of convergence and suggesting an alternative way to think about convergence based on a common factor framework which we implement using principal components analysis. We apply these ideas to a dataset of monthly inflation rates of the EMU countries, the NMC countries and three EU candidate countries (as of pre-2007) over the period 1996-2007. We consider groups between them, and convergence of the NMC countries to the Euro Area aggregate and to a measure of inflation rates of the three best performing countries in the past twelve months, as a close proxy to the Maastricht convergence criterion. Among the questions we ask are, have there been any signs of convergence or divergence of the NMC inflation rates to each other, or to the Euro Area? Are the NMC rates less homogeneous than the Euro Area, and are there subgroups between them?

These are important questions to ask and answer in gauging the likely effects and sustainability of the European currency union, as (partial) convergence of inflation rates is one pre-requisite of joining EMU. Nitsch (2004) suggests that inflation differentials have led to the dissolution of currency unions in the past.

The paper is structured as follows. Section 2 considers the notion of convergence and shows how a common factor approach is a useful and in many ways more natural framework for defining convergence. Section 3 presents the empirical results of our application of this technique to a dataset of monthly harmonised inflation rates of the EMU (as of 2002), the NMC (as of 2006) and three candidate countries. Gradual convergence patterns are examined for the twelve EMU member countries (section 3.1), the ten NMC countries (section 3.2), the NMC countries and EMU averages (section 3.3), the 22 EMU and NMC countries (section 3.3), and the 22 countries plus the three candidate countries (section 3.4). Section 4 concludes.

2. Defining Convergence

While we have a clear idea regarding the importance of convergence as a pre-requisite for economic changes such as the formation of a monetary union and we have a clear intuitive understanding of what convergence means, it is surprisingly difficult to find a satisfactory formal definition of convergence.[1] Hall, Robertson and Wickens (1997) consider a number of formal definitions of convergence which illustrate the difficulty here. So consider the pointwise convergence of two series X_t and Y_t which we might define as occurring when,

$$\lim_{t \to \infty}(X_t - \phi Y_t) = \alpha \qquad 1.$$

[1] In the following, we will draw on our earlier work in Becker and Hall (fc.).

where α is a non stochastic constant which might often be required to be zero. This is a clear definition of convergence but it is unrealistically strong as it requires the two series to exactly move together in the limit. A more reasonable definition would be to think of stochastic convergence or convergence in expectations

$$\lim_{t \to \infty} E(X_t - \phi Y_t) = \alpha \qquad 2.$$

This at first seems like a reasonable definition of convergence but the problem here is that it implies convergence in many quite unreasonable cases. For example if X and Y are both mean zero white noise processes then this definition would suggest that the two series are converged even though they have no relationship. If X and Y are non-stationary then sensible definitions may be offered through the notion of cointegration and the idea that convergence may limit the difference between the two series to a stationary difference either in the limit or over a given interval. However while this is a useful operational notion of convergence again it is limited by only being useful in the case of non-stationary series.

Here we propose a general measure of convergence which is based around the common factor representation of a group of series and which we believe more closely follows the basic conceptual idea which we have in mind when we talk about convergence. Consider a vector of 2 or more variables X which are determined by a set of factors F

$$x_{it} = \lambda_i f_{it} \qquad 3.$$

Then we may give the following definition of when X are converged.

Definition 1: The set of variables X are converged when the general factor representation in (3) may be restricted to the single common factor model given by,

$$x_{it} = \lambda_i f_t + \varepsilon_{it} \qquad 4.$$

and $\lambda_i \neq 0$ *for all i*

where ε_{it} are N specific factors.

The conventional assumption is that f_t and ε_{it} are uncorrelated across all i and t and as Anderson (1963) pointed out this is unlikely to be true of time series data, which is the primary interest here. Geweke (1977) however generalised this model to produce the dynamic factor model in the following way. The assumption is made that f_t and ε_{it} are strictly indeterministic and covariance stationary, which of course allows them to have a constant, time invariant correlation structure. Then by Wolds (1938) theorem there exist two sets of white noise terms z and u_i such that

$$\lambda_i f_t = \sum_{s=0}^{\infty} a_{is} z_{t-s} = a_i^{*} z_t \qquad 5.$$

and

$$\varepsilon_{it} = \sum_{s=0}^{\infty} b_{its} u_{it-s} = b_{it}^{*} u_{it} \qquad 6.$$

hence

$$x_{it} = a_i^{*} z_t + b_i^{*} u_{it} \qquad 7.$$

where b is a diagonal matrix and the variances of z and u are normalised to be unity. This is then the dynamic single factor model. This model is a straightforward representation of one notion of what we mean by convergence. All the elements of X are moving in a similar way although they do each have an idiosyncratic element, as the elements of b^* go to zero the common feature completely dominates the behaviour of x and variables move perfectly together.

Of course not all series will satisfy the conditions for the decomposition in (7) and so Geweke (1977) proposes a formal test of this structure based on the restrictions to the covariance structure of X implied by (7). This test works both for individual intervals in the frequency domain $(\omega_1{}^j, \omega_2{}^j]$, j=1…p and a joint test for all the intervals. Of course in the context of convergence the problem with this test is, that like many other tests, it may not detect a process of developing convergence as it is designed to detect complete convergence over the entire sample being tested.

To consider this process of gradual convergence we can return to the general factor model (3)

$$x_{it} = \lambda_i f_{it} \qquad 8.$$

and define the factors to be orthogonal to each other. If the factors are then ordered so that the first factor is calculated to have the maximum explanatory power, the second factor has the next highest power and so on (as in a principal components analysis) then the notion of on going convergence becomes rather straightforward. Pointwise convergence, as defined above would imply that in the limit the first factor would be a complete explanation of X and so all the factors other than the first one would be zero. This would then collapse to the single factor model (7) where b=0. Convergence in expectations would imply that the expected value of all the factors except the first one would be zero and again in terms of (7) this would mean that the single factor model be accepted but the b would not be restricted to zero. However in a practical sense the usefulness of this approach becomes more obvious when we realise that there is a direct measure of the degree of convergence between the series in the form of the %R^2 of the first factor. This shows the % of the total variation of X which is explained by the first factor. Pointwise convergence would imply that this is 1 and in general the closer this is to 1 the more complete is convergence between the set of series. This then allows us to deal with the problem of using convergence in expectations. Consider the case of n, mean zero IID distributed series; the expectation of the difference between these series on a pairwise basis would be zero so they would all meet the condition for convergence in expectation, despite the fact that they are completely unrelated to each other. However in the factor representation the $\%R^2$ for the first factor would be 1/n as each factor would have equal explanatory power. The single factor model would be rejected and this would indicate that there was no common underlying driving force linking the n series together. If the series began to move together then the explanatory power on the first factor would rise and so this becomes a natural metric for the extent to which convergence has occurred.

Definition 2: Convergence is taking place between a vector of 2 or more series over any given period 1 to T if the $\%R^2$ of the first principle component calculated over the period 1 to T-t is less than the $\%R^2$ of the first principal component calculated over the period T-t to T, $0<t<T$.

This approach also works regardless of the Stationarity properties of the data. So in the I(1) case, if we have pairwise cointegration between the set of series so that between the n series there are n-1 cointegrating vectors then in ECM form the model may be written as

$$\gamma(L)(1-L)X_t = \Pi X_{t-1} + \upsilon + \varepsilon_t \qquad 9.$$

where Π has rank n-1 and υ is the deterministic component.

The moving average equivalent of this is

$$(1-L)X_t = C(L)(\varepsilon_t + \upsilon) \qquad 10.$$

and the C matrix may be decomposed into

$$(1-L)X_t = C(1)(\varepsilon_t + \upsilon) + (1-L)C^*(L)(\varepsilon_t + \upsilon) \qquad 11.$$

where C(1) has rank 1 and so there will be one common stochastic trend which is the dominant first factor in the factor representation. Asymptotically as the variance of this non stationary trend will dominate any stationary terms the $\%R^2$ will go to one and convergence in expectation is clear. Over a small sample the size of the $\%R^2$ will be an indicator of how important the common stochastic trend is relative to the noise in the series, again it becomes a direct measure of how much convergence has taken place. If any factor other than the first one shows signs of non-stationarity then this would imply less than n-1 cointegrating vectors and hence full pairwise cointegration would not exist.

3. Empirical Application

In this section, we implement the common factor technique using principal components analysis and applying Definition 2 to identify gradual convergence processes over time. We apply this technique to a dataset of monthly harmonised consumer price inflation (HCPI) rates of the twelve EMU countries as of 2001,[2] the ten NMC of the European Union as of pre-2007,[3] and the three candidate countries of the EU as of pre-2007, Bulgaria, Romania and Turkey.[4] The data begin in January 1997 for all countries except Bulgaria, for which the data

[2] These are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain.

[3] These are Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.

[4] Slovenia joined EMU in January 2007, and Cyprus and Malta joined after the end of our sample period, in January 2008, and Slovakia will join in January 2009. Bulgaria and Romania joined the EU in January 2007.

are available from January 1998 only. Earlier HCPI data were not available from Eurostat. For each country sample under investigation, we conducted principal components analyses over a variety of time windows to examine gradual convergence or divergence through time. The windows are, the total period (01/1997–12/2007), two consecutive subperiods (01/1997–12/2001 and 01/2002–12/2007), three consecutive subperiods (01/1997–12/2000, 01/2002–12/2004 and 01/2005–12/2007) and seven moving five-year windows. Where Bulgaria is included in the sample, the earlier samples begin in 01/1998.

3.1 Gradual Convergence Patterns of EMU Inflation Rates

Table 1 shows the $\%R^2$ of the first principal component of the inflation rates of the twelve EMU countries. Over the sample period as a whole, inflation rates are not moving together very closely, as indicated by a low $\%R^2$ (0.48). Examination of the subperiods reveals that in the period that includes the inception of EMU, inflation rates moved relatively more together than did post-EMU inflation rates. Most of the divergence is due to the time period 2001-2004 that includes most of years of the European recession. Fig. 1 shows the $\%R^2$ of the EMU12 inflation rates over the seven moving windows in graphical form. There seems to be a break between the first three and the last four windows, with inflation rates moving much closer together in the time periods that include the year of the inception of EMU, with a $\%R^2$ above or close to 0.6, while it is either below or only just above 0.4 over the later time windows. Between the beginning and the end of the sample period, inflation rates diverged substantially, as indicated by the fall of the $\%R^2$ from 0.65 over 1997-2001 to 0.35 over 2003-07.

We intended to include Croatia and Macedonia in our sample of candidate countries, but HCPI data for these two countries are not available from Eurostat.

Fig. 2 presents the individual country weights of the first principal component.[5] We see that over the period 1997-2007 as a whole (panel a), Finland, the Netherlands and in particular Greece moved least closely with the other countries, although there was little co-movement overall. Greece is the only country whose inflation rate moved in the opposite direction than the other countries' rates on average, as indicated by the opposite sign of its weight. Panel f reveals the disintegrating effect associated with the recession years, and shows French inflation moving in the opposite direction than the others on average, if moving at all. The disintegration appears to subsequently have gained momentum (panels g and h), suggesting the emergence of two convergence clubs whose inflation rates moved into opposite directions. One of these groups includes most of the countries often called the 'core' Euro Area countries, Austria, Belgium, France, Germany and Luxembourg, whereas the other includes the 'periphery' countries. Over the final time window, 2003-97 (panel i), all inflation rates moved into the same direction on average but at very different frequencies, with Spain's rate moving much more than the average. Overall, it is clear that inflation rates showed some signs of convergence around the inception of EMU and in the early EMU years, but that little signs of convergence can be detected as we move on in time.

3.2 Gradual Convergence Patterns of the New Member Countries' Inflation Rates

Table 2, panel a, compared with Table 1, shows that for the investigation period as a whole, there is a somewhat surprising similarity between the extent to which the inflation rates of the EMU and those of the NMC, respectively, are converged to each other or not, as indicated by the %R^2's of the first principal component over 1997-2007 (0.48 for each group). We can also observe that the %R^2's moved in the same direction between the various time periods, i.e. as the EMU inflation rates moved less closely together, so did the NMC inflation rates.

[5] We are presenting a selection of subperiods; full results are available upon request.

The periods including the recession years are associated with less divergence for the NMC than for the EMU group. Fig. 3 (grey bars) presents the $\%R^2$ of the first principal component for the moving time windows. The results suggest that there has in general been relatively less change in the level of convergence or divergence over time than for the EMU countries, with the $\%R^2$'s all moving between 0.4-0.6. There is also no apparent break over time. The NMC inflation rates diverged gradually until 2001-05, after which they began to move more closely together with each other again. Between the first and the last seven-year windows, we can observe some small divergence ($\%R^2$ of 0.59 over 1997-2001 compared with 0.5 over 2003-07), but this is much less pronounced than that for the EMU group. Comparison between Figs. 1 and 3 further indicates that the NMC inflation rates moved less in line with each other than did the EMU rates in the early years of EMU (1997-2001, 1998-2002, 1999-2003), but that the NMC countries moved much in sync with each other in the later years, and in particular over the last window of our sample (2003-07).

Fig. 4 presents the country weights of the first principal component for the NMC sample. Panel a indicates that over the period as a whole, the inflation rates of Cyprus, Latvia and Slovakia moved much less than the average, whereas the rates of the Czech Republic, Hungary and Poland moved more. However, all rates tended to move in the same direction on average, as indicated by all weights having the same sign. The next two panels support the finding of divergence from Table 2 and suggest the formation of two general convergence clubs over time, whose inflation rates move into opposite directions. Interestingly, one of these consists of the three countries that have joined EMU by now (at the time of writing this paper), Cyprus, Malta and Slovenia, plus Slovakia which will join in 2009. The next panels confirm the evidence from Table 2 that there was not much change in the extent of convergence or divergence through 1999-2003 and 2002-06, although the individual country weights change gradually, and in particular towards the end of the period. Overall, comparison of the first and last time windows (1997-2001 and 2003-07) suggests formation of two broad convergence clubs into new / soon-to-be EMU members and non-members.

3.3 Gradual Convergence Patterns of the New Member Countries' Inflation Rates towards EMU Rates

For the assessment of whether, from an inflation point of view, EU member countries are ready to join EMU, it does of course not matter how converged the countries are to each other, but how converged they are with EMU. To get a first idea of convergence of NMC inflation to EMU inflation, we examine potential co-movements between the inflation rates of the NMC countries as a group and the aggregate EMU or Euro Area inflation rate. We consider the ratio of each new member country's inflation rate to the average EMU rate. So if in this factor model the $\%R^2$s are relatively constant over consecutive time periods, this means the NMC inflation rates move closely together with the average EMU rate. As we have ten principal components in our model, complete convergence would imply a $\%R^2$ of 1/10 of each component, so if we find that the $\%R^2$ of the first principal component for the Euro rates exceeds 1/10 in the starting period, then a fall of the $\%R^2$ over time towards 1/10 would imply gradual convergence of the national inflation rates of the NMC to the EMU average rate.

Table 2, panel b, presents the $\%R^2$ of the first principal component of the NMC/EMU inflation ratios. The results suggest that as a group the NMC were relatively diverged from the EMU average over the investigation period as a whole ($\%R^2$ of 0.64). As the inflation rates of the NMC move less in line with each other between 1997-2001 and 2002-07 (panel a), they move more in line with the EMU average (panel b). Fig. 3 (white bars) shows that for the time periods that include the year of the inception of EMU, the NMC countries were much less converged to the EMU average than in the later periods. However, as the NMC rates converge to each other somewhat from 2001-2005 through to 2003-07 (grey bars), they move less in line with the EMU average. Between the first and the last time windows, the NMC rates diverged slightly, while there was some convergence towards the EMU average. One reason for this may be that some NMC countries were on average more converged with EMU members than with other NMC countries.

However, what is relevant for EMU entry is of course not whether a country's inflation rate is well converged with the average of the EMU inflation rates. Rather, the inflation convergence criterion of the Maastricht treaty requires a country's inflation rate to be close to, that is 1.5 percentage points around, the average rate of the three best performing EMU countries over the past year for the three consecutive years prior to the country's EMU entry. This often means that an aspiring new EMU member will be required to exhibit a substantially lower inflation rate than existing EMU members, and hence its inflation rate may need to be below rather than close to the EMU average. We created a monthly series of the average inflation rate of the three BPC over the past twelve months to get some idea about convergence under the Maastricht criterion. Use of this series moved the beginning of the sample period forward to 01/1998. We then conducted principal components analyses over the various time periods of the ratio of each NMC country's inflation rate to the BPC average rate.

Panel c' in Table 2 presents the %R^2's of the first principal components of the NMC to BPC inflation ratios. For comparison, panels a' and b' report the results of the previous two NMC analyses for the later start period of 1998. Over the whole period, 1998-2007, the inflation rates of the NMC countries as a group did not move much in line with the BPC average (%R^2 of 0.56). However, they were marginally more in line with the BPC than with the average of all EMU. Inspecting the results through time, Fig. 3 (black bars) suggests some shift over time: In the early years of EMU, the NMC inflation rates moved rather independently from the BPC average, as indicated by the relatively high %R^2s, while rates moved somewhat more closely in line with the BPC over the later periods. Between the first (1998-2002 in this case) and the last five-year windows, as the NMC inflation rates diverged from each other slightly, they experienced some convergence towards the BPC average (%R^2 of 0.67 in 1997-2001 compard with 0.46 in 2003-07). One reason may be that the countries which joined EMU in 2007/08 moved closely in line with the existing EMU members in the run-up to joining.

Fig. 5 shows the country weights for the whole period (panel a) and the first and last five-year moving windows (panels b, c).[6] As explained in section 2, in the present type of factor model, increasing convergence of the NMC inflation rates as a group to the BPC average rate would imply a more random distribution of the weights for the NMC countries over time. This is clearly the case when we compare panels b and c. Moreover, these results support the earlier finding of the formation of convergence clubs over time. The positive sign of the weights in panel c indicates that as the average inflation rate of the BPC moved up, so did, on average, the inflation rates of Cyprus, Malta and Slovenia, which have all joined EMU by now, and Slovakia, while the inflation rates of the remaining NMC countries moved down.

3.4 Gradual Convergence Patterns of the New Member Countries' Inflation Rates and the EMU Rates

Having looked at convergence or divergence patterns of the EMU countries and of the NMC countries as individual groups, and of the NMC countries as a group towards EMU-related averages, it will now be interesting to examine all 22 countries as one group and see whether

[6] The results for the other time periods are available upon request.

their inflation rates moved as two groups over time or whether there is evidence of convergence clubs between them. Table 3 shows the %R^2 of the first principal components for the total sample of the EMU and the NMC inflation rates. There is clear evidence of independent movements of inflation rates over all time periods considered, with the highest %R^2 being little above 0.4. The results for the five-year moving windows depicted in Fig. 6 confirm that there has been little change over time, even though some of the disintegration in the periods that include the recession carries over from the two individual samples to the whole sample. There are signs of some small divergence between the first and the last five-year moving windows.

Fig. 7 depicts the country weights of the first principal component; the first twelve weights (bars) refer to the EMU countries, the last ten weights refer to the NMC countries. Inspection of the results reveal that the individual country patterns changed rather substantially over time. Examining first the results over the sample period as a whole (panel a, 1997-2007), there is a relatively clear split between the EMU12 and the NMC10 groups, with the exceptions of Greece and Cyprus, which by the sign of their weight move more in line with the respective other country group. This split is removed over time when we divide the whole period into two or three subperiods (panels b, c and d-f). Examining the weights of the seven five-year moving windows (panels b, g-l), we observe that the countries' inflation rates essentially move in the same direction on average over the period that begins with the EMU inception (panel h, 1999-2003), although the individual inflation rates clearly move at different frequencies. Comparing the first and the last periods (panel b and panel l), indicates that over time, the inflation rates disintegrate into groups that are unrelated to the initial split into the EMU and NMC groups. Slovakia and the three countries that have by now joined EMU move more closely in line with most countries of the 'periphery' EMU countries than with most countries of the ‘core’. Hence there is some evidence for the formation of convergence clubs over time.

3.5 Gradual Convergence Patterns of the Inflation Rates of the New Member Countries’ Rates, the EMU Countries and the Candidate Countries Bulgaria, Romania and Turkey

Finally, we add the three candidate countries Bulgaria, Romania and Turkey (BRT) to our country sample. Due to the lack of earlier data for Bulgaria, this moves the beginning of the sample period to 01/1998. The results for the %R^2s of the first principal components for the various time periods are presented in Table 4 and Fig. 8.

Table 4 shows that the inflation rates of the 22 countries clearly move independently of each other as a group in all sample periods considered. The results also suggest marginal gradual divergence over time. Fig. 8 indicates that between the first and the last five-year moving windows, there has essentially been no change, with a %R^2 of around 0.4 indicating lack of co-movement.

Inspecting the country weights of the first principal component in Fig. 9, we can see that over the period as a whole, 1998-2007 (panel a), there are some signs of a split into two broad groups, EMU versus NMC plus BRT, as assessed by the sign of the weights. However, by this criterion, Finland, Greece and the Netherlands moved more closely in line with the second group on average, while Cyprus and Latvia moved more closely in line with the EMU group. Nonetheless neither group is homogeneous as the differences in the size of the weights indicate that some inflation rates moved much more than the average while others moved much less. Panels b to g show the weights over the moving time windows. As the first window gives a lot of weight to the early EMU years, in line with our earlier results the split into the two broad groups is much more evident here, and each subgroup is more homogeneous than over the period as a whole. In the period that begins with the year of the EMU inception (panel c) we observe, as before, that all inflation rates moved into the same direction, and interestingly the BRT rates are no exception here. Over time however, there is disintegration which removes the split into the two broad groups evident at the beginning of the sample. With respect to the BRT countries, comparison of the first and the last moving windows suggests that Bulgaria has disintegrated from Romania and Turkey, with the latter two being more closely in line with Cyprus, Malta, Slovenia and Slovakia and most of the EMU 'periphery' countries.

4. Conclusion

In this note we have presented an alternative technique of approaching the convergence debate proposed in our earlier research and based on a common factor framework which we implement using principal components analysis. We have shown how this is in many ways a more natural way to consider the problem than those conventionally used. We have applied these ideas to a dataset of monthly harmonised consumer price inflation rates of the EMU countries, the NMC countries and three EU candidate countries over the period 1996-2007. We have considered groups between them, and convergence of the NMC countries to the Euro Area aggregate and to a measure of inflation rates of the three best performing countries in the past twelve months, as a close proxy to the Maastricht convergence criterion.

The main results suggest that EMU inflation rates moved much closer together in the time periods that include the year of the inception of EMU, but little signs of convergence can be detected in the later periods. The NMC inflation rates moved less in line with each other than did the EMU rates in the early EMU years, but the NMC rates moved more in sync with each other than those of EMU in the later years of our sample period. Furthermore, in the earlier years, the NMC inflation rates moved rather independently from an average series of the three best performing countries over the past twelve months. Interestingly, our results indicate that the inflation rates of Slovakia which will join EMU in January 2009 and the three countries which have joined EMU by now, Cyprus, Malta and Slovenia, moved in the same direction as the BPC rate, on average, while the inflation rates of the remaining NMC countries moved in the opposite direction. When examining the EMU and the NMC countries as one group, we find that while there was a split into the EMU versus the NMC group at the beginning of the sample period, there is evidence for convergence clubs across the two groups at the end of the period. Finally, adding three candidate countries to the sample of the EMU and the NMC countries does not substantially change the picture, however the inflation rate of Bulgaria seems to have moved away from those of Romania and Turkey over time, with the latter two being more closely in line with Slovakia, Cyprus, Malta and Slovenia and most of the EMU 'periphery' countries.

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Table 1. Principal components analysis of inflation rates of the 12 EMU member countries ($\%R^2$ of first principal component)

Period	**1997-2007**	**1997-2001**	**2002-07**	**1997-2000**	**2001-04**	**2005-07**
$\%R^2$	0.4758	0.6518	0.3778	0.6260	0.3785	0.4702

Fig. 1. Principal components analysis of inflation rates of the 12 EMU member countries ($\%R^2$ of first principal component, *five-year moving windows*)

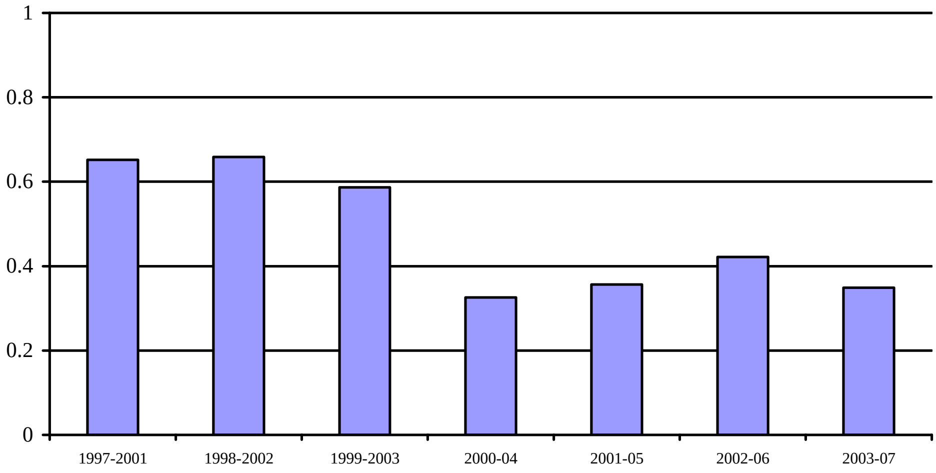


Table 2. Principal components analysis of inflation rates of the 10 New Member Countries ($\%R^2$ of first principal component)
(*Panels a. a'*. NMC inflation rates. *Panels b, b'*. NMC inflation rates as a ratio to the average EMU inflation rate. *Panel c'*. NMC inflation rates as a ratio to the average inflation rate of the three best performing EMU countries over the past twelve months [Beginning of ample period: 1998 for panels a', b', c'].)

	Period	**1997-2007**	**1997-2001**	**2002-07**	**1997-2000**	**2001-04**	**2005-07**
a.	$\%R^2$	0.4795	0.5905	0.4623	0.6318	0.4782	0.5717
b.	$\%R^2$	0.6352	0.6728	0.4936	0.6522	0.4355	0.6063

	Period	**1998-2007**	**1998-2001**	**2002-07**	**1998-2000**	**2001-04**	**2005-07**
a.'	$\%R^2$	0.4163	0.5461	0.4623	0.6197	0.4782	0.5717
b.'	$\%R^2$	0.6089	0.7270	0.4936	0.7241	0.4355	0.6063
c.'	$\%R^2$	0.5639	0.6076	0.4443	0.5051	0.4898	0.5475

Fig. 3. Principal components analysis of inflation rates of the 10 New Member Countries ($\%R^2$ of first principal component, *five-year moving windows*)

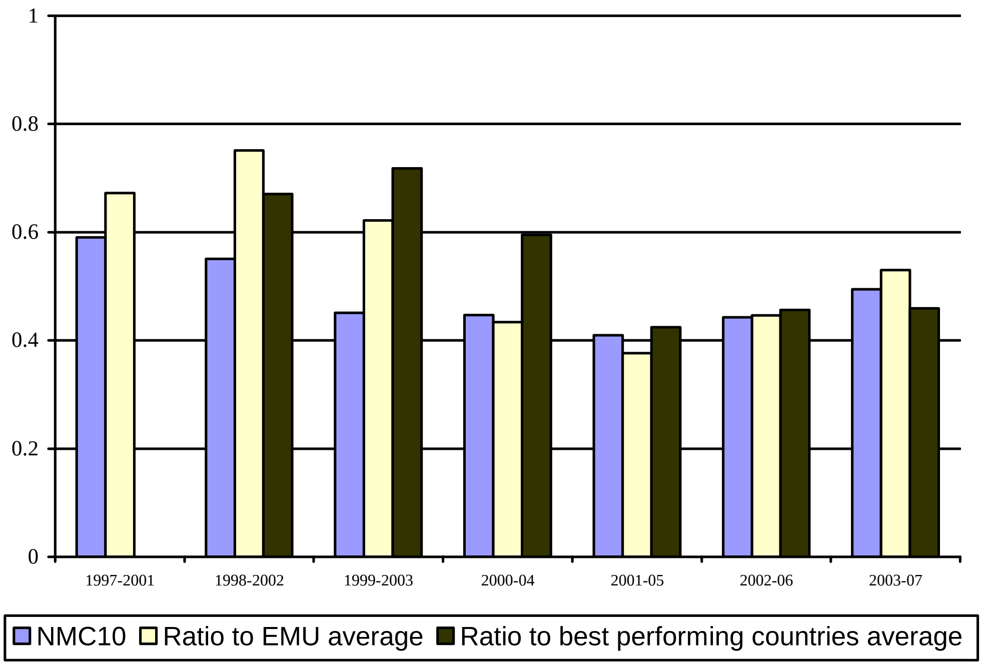


Table 3. Principal components analysis of inflation rates of the 12 EMU member countries and the 10 New Member Countries
($\%R^2$ of first principal component)

Period	**1997-2007**	**1997-2001**	**2002-07**	**1997-2000**	**2001-04**	**2005-07**
$\%R^2$	0.3345	0.4438	0.3648	0.4223	0.3696	0.3808

Fig. 6. Principal components analysis of inflation rates of the 12 EMU member countries and the 10 New Member Countries
($\%R^2$ of first principal component, *five-year moving windows*)

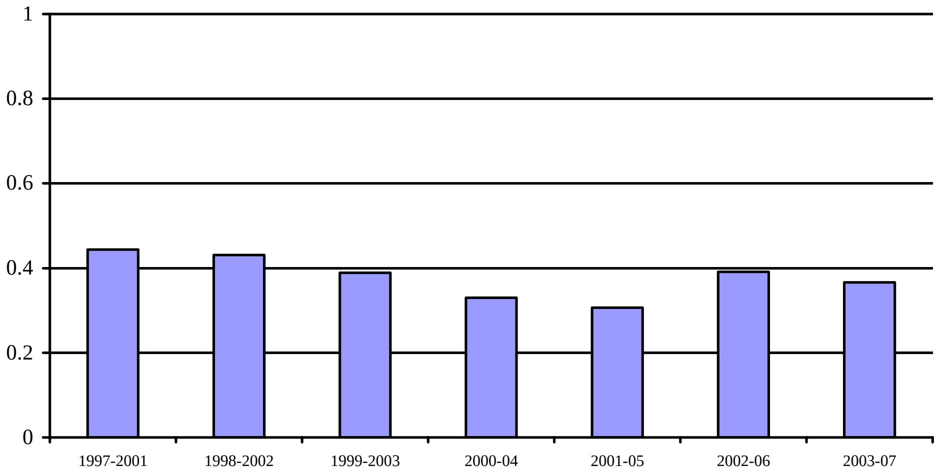


Table 4. Principal components analysis of inflation rates of the 12 EMU member countries and the 10 New Member Countries and 3 candidate countries
($\%R^2$ of first principal component)

Period	**1998-2007**	**1998-2001**	**2002-07**	**1998-2000**	**2001-04**	**2005-07**
$\%R^2$	0.3085	0.4266	0.3815	0.4416	0.3918	0.3611

Fig. 8. Principal components analysis of inflation rates of the 12 EMU member countries and the 10 New Member Countries and 3 candidate countries
($\%R^2$ of first principal component, *five-year moving windows*)

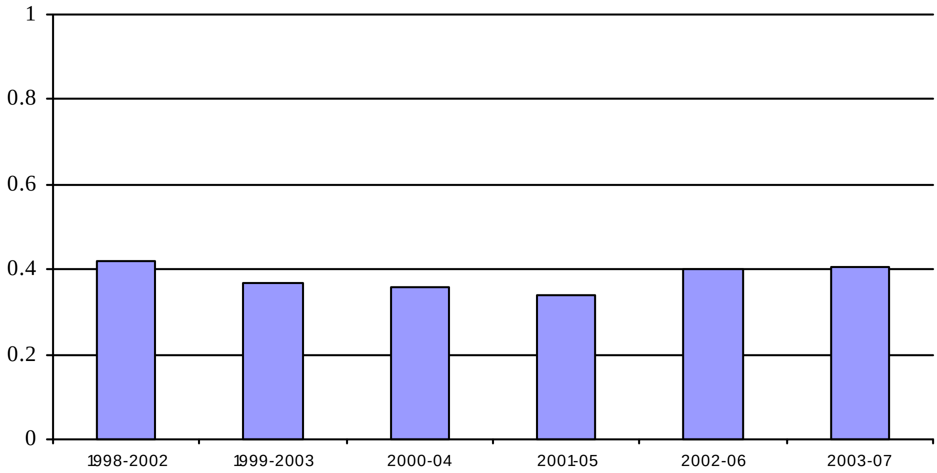


Fig. 5. Country-specific weights of first principal component, 10 New Member Countries as a ratio to the average of the best performing countries over the past twelve months

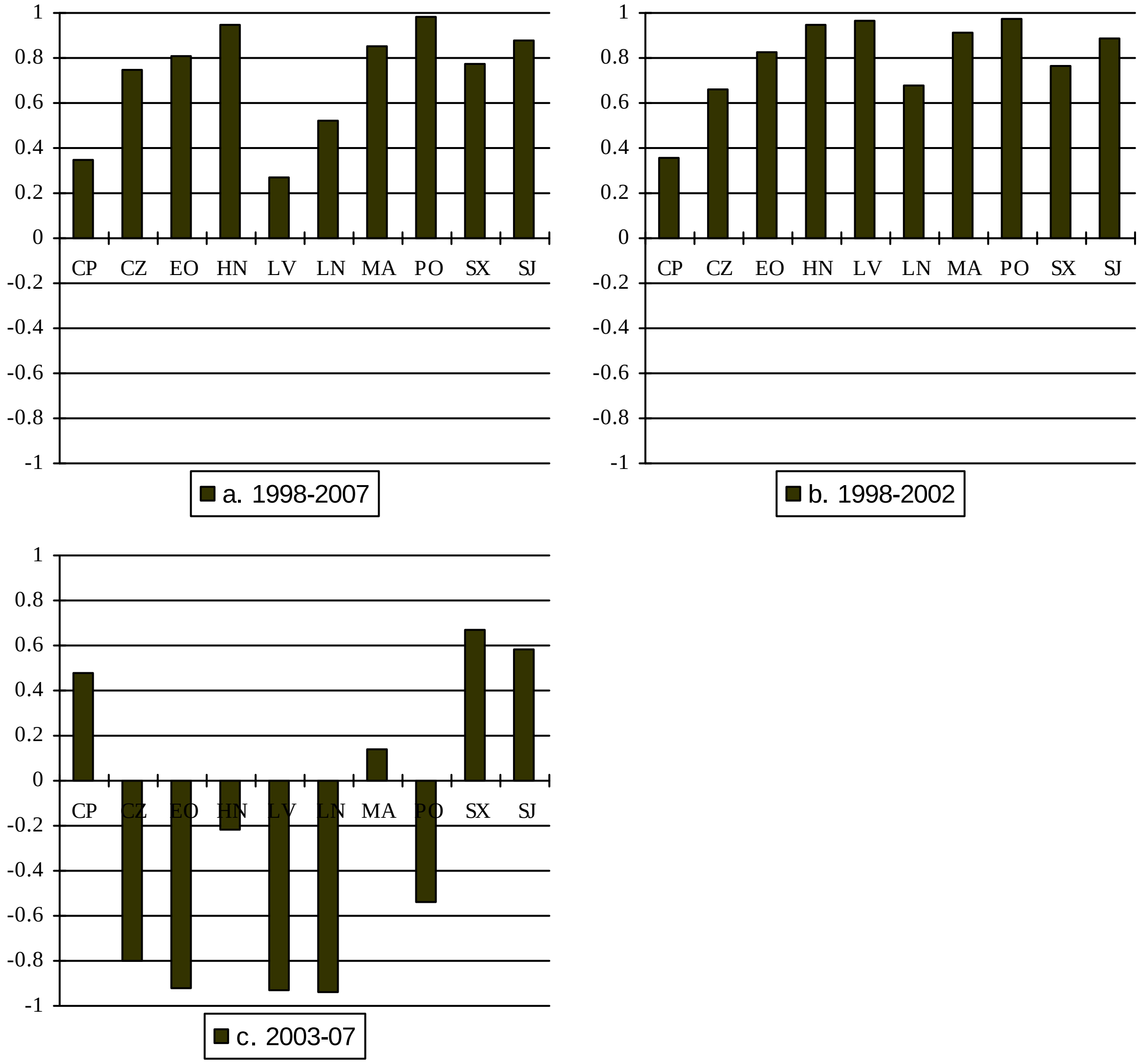


Fig. 2. Country-specific weights of first principal component, 12 EMU countries (*panel a:* total period, *panels b, c:* consecutive periods, *panels b, d-i:* moving windows)

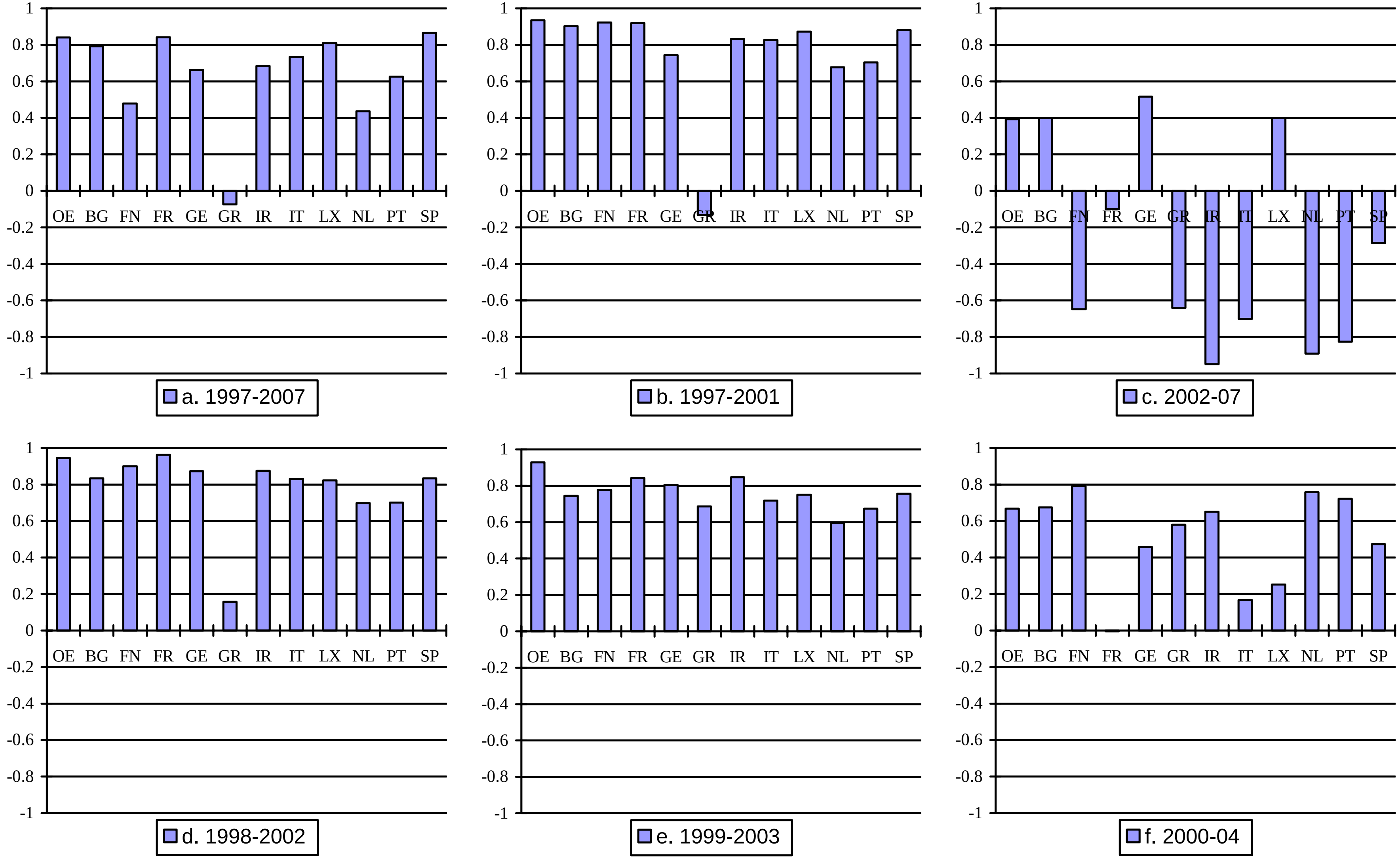
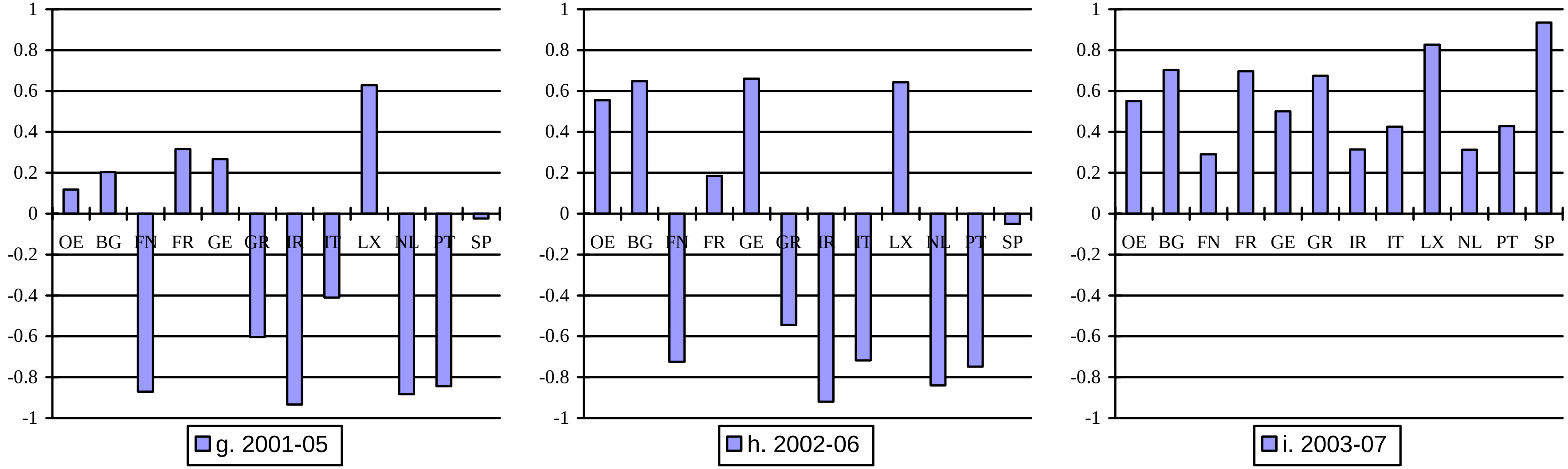


Fig. 2 cont.



Note: The abbreviations used are: OE (Austria), BG (Belgium), FN (Finland), FR (France), GE (Germany), GR (Greece), IR (Ireland), IT (Italy), LX (Luxembourg), NL (Netherlands), PT (Portugal), SP (Spain).

Fig. 4. Country-specific weights of first principal component, 10 New Member Countries (*panel a:* total period, *panels b, c:* consecutive periods, *panels b, d-i:* moving windows)

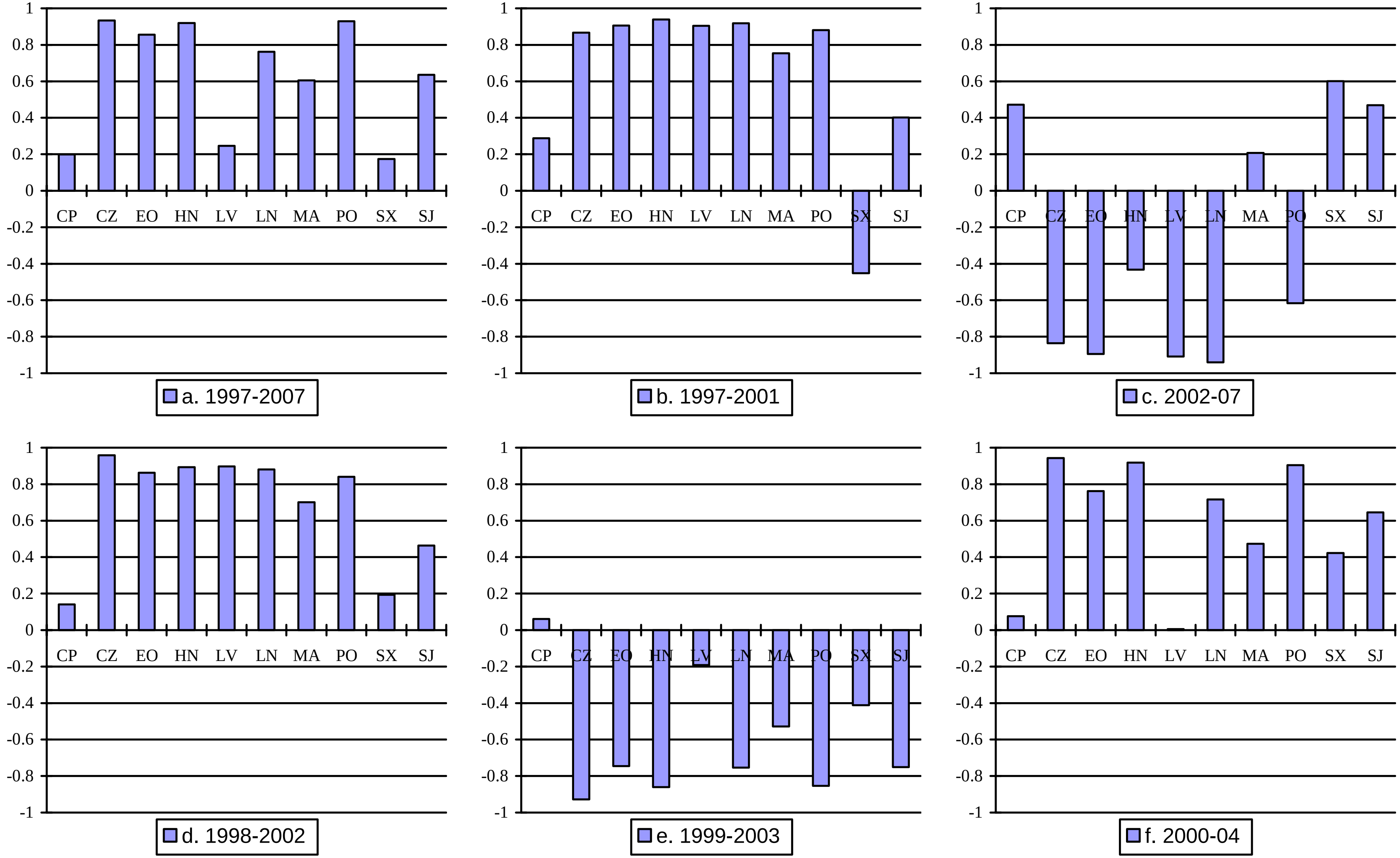
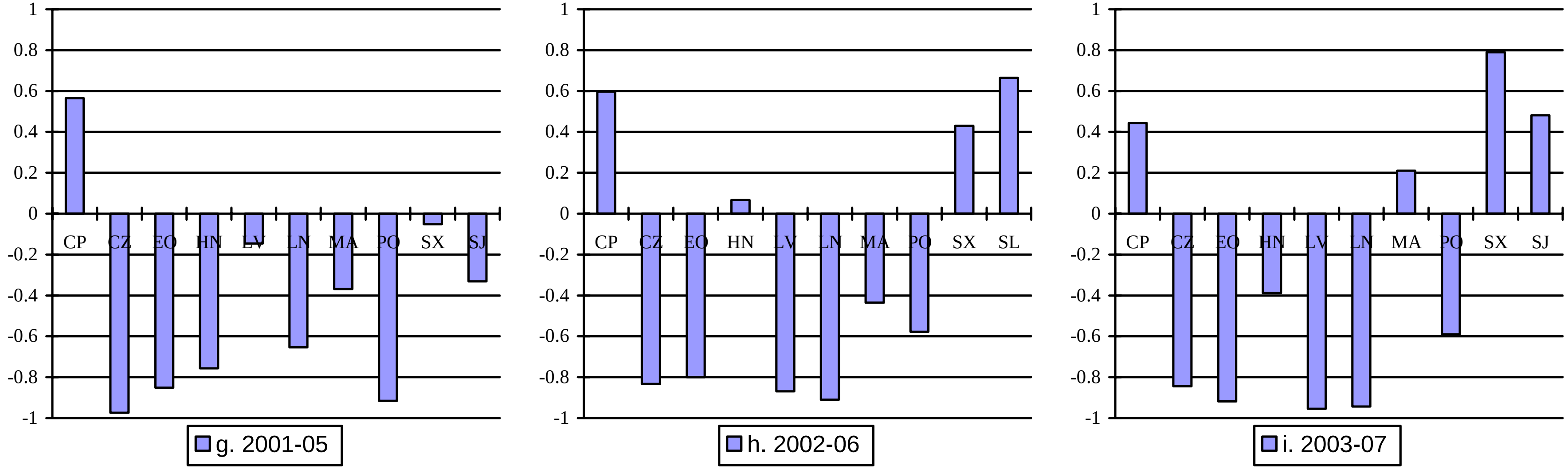


Fig. 4 cont.



Note: The countries are denoted CP (Cyprus), CZ (Czech Republic), EO (Estonia), HN (Hungary), LV (Latvia), LN (Lithuania), MA (Malta), PO (Poland), SX (Slovakia), SJ (Slovenia).

Fig. 7. Country-specific weights of first principal component, 12 EMU member countries plus 10 New Member Countries (*panel a:* total period, *panels b-f:* consecutive periods, *panels b, g-l:* moving windows)

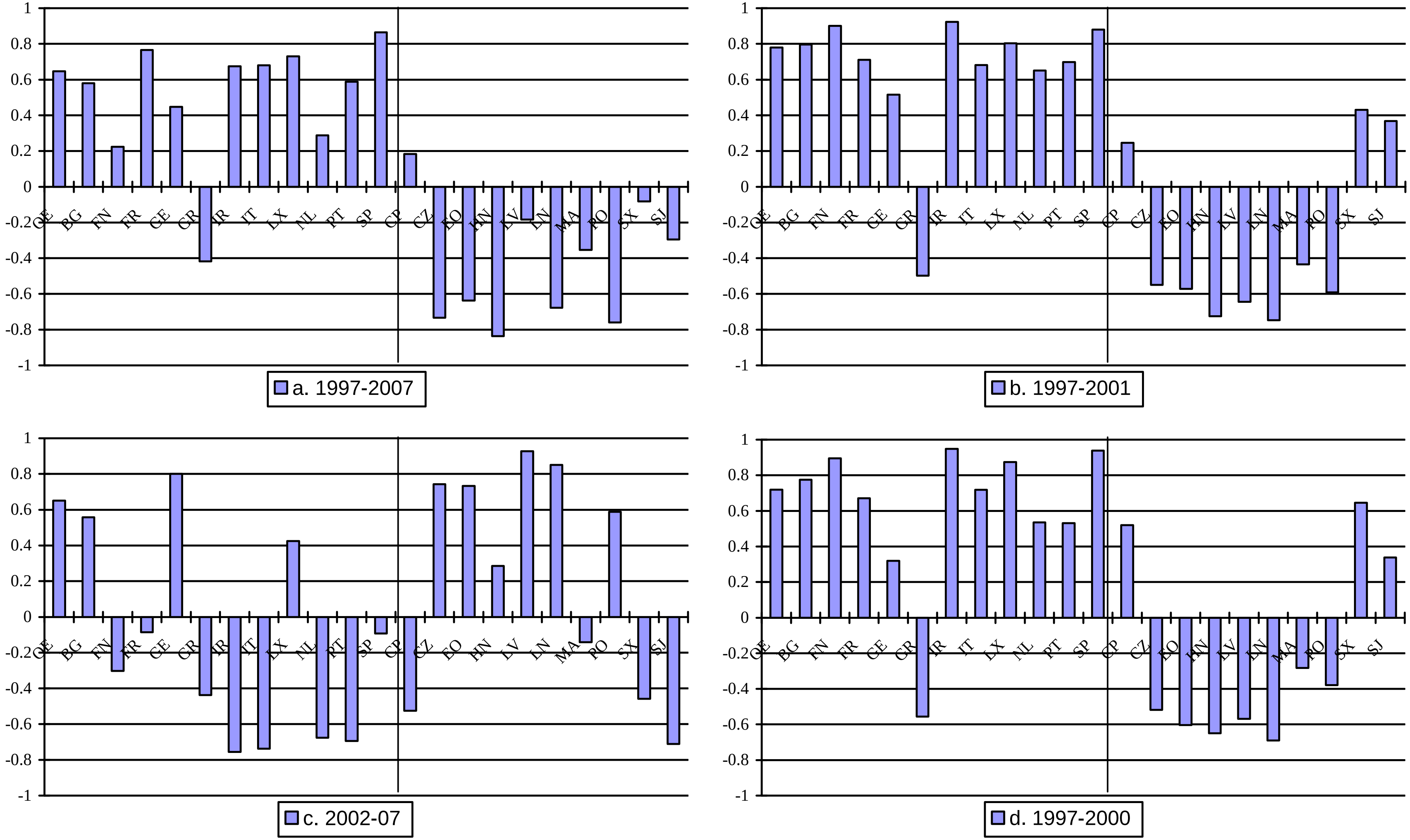
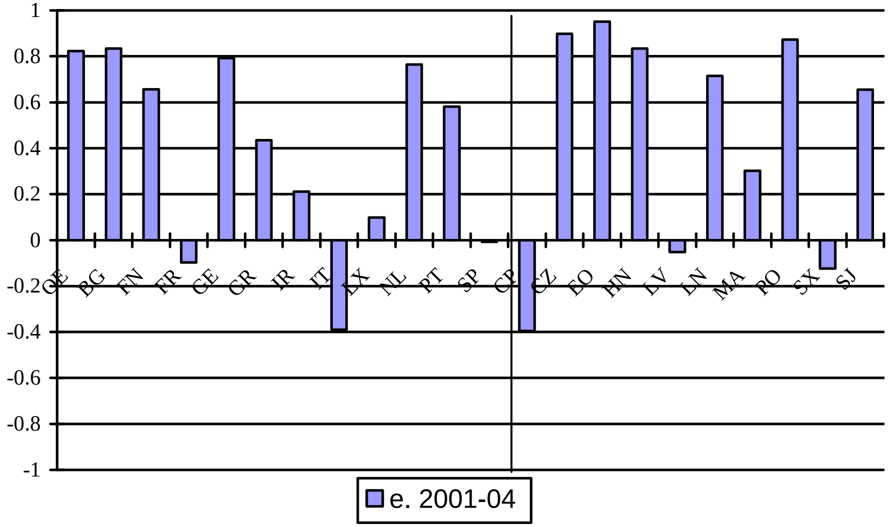
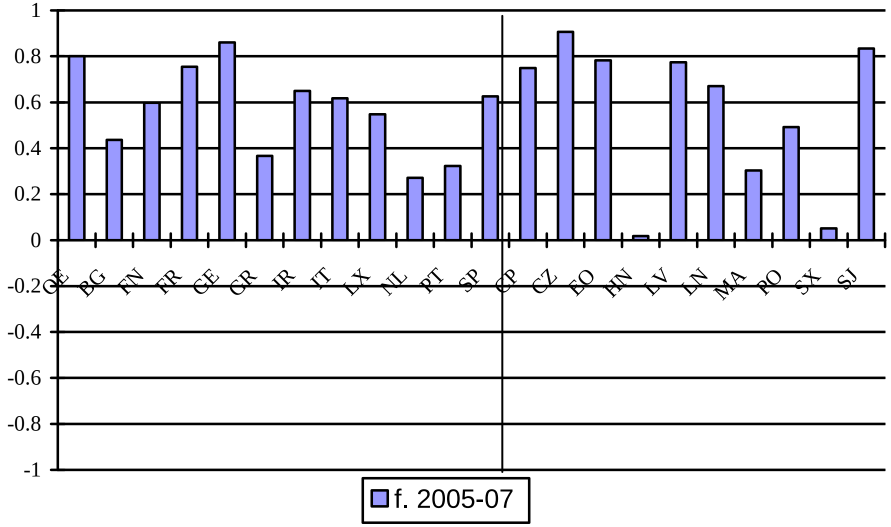
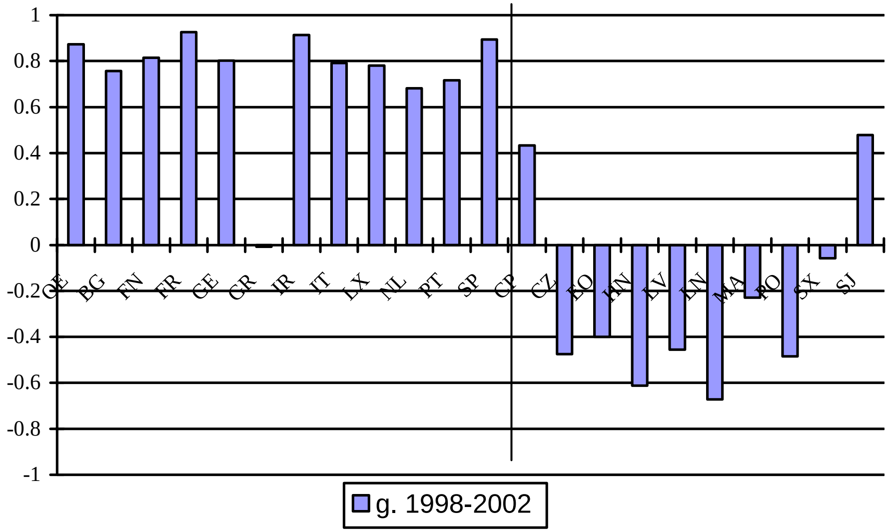


Fig. 7 cont.







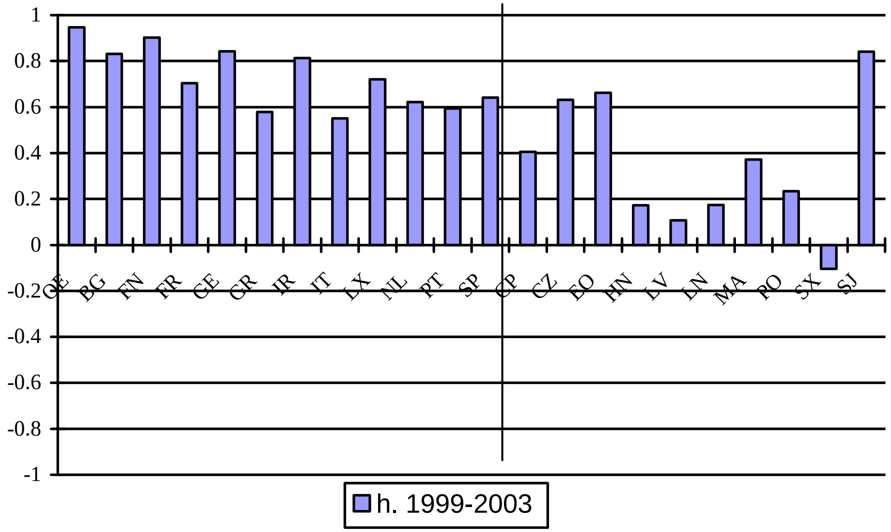


Fig. 7 cont.

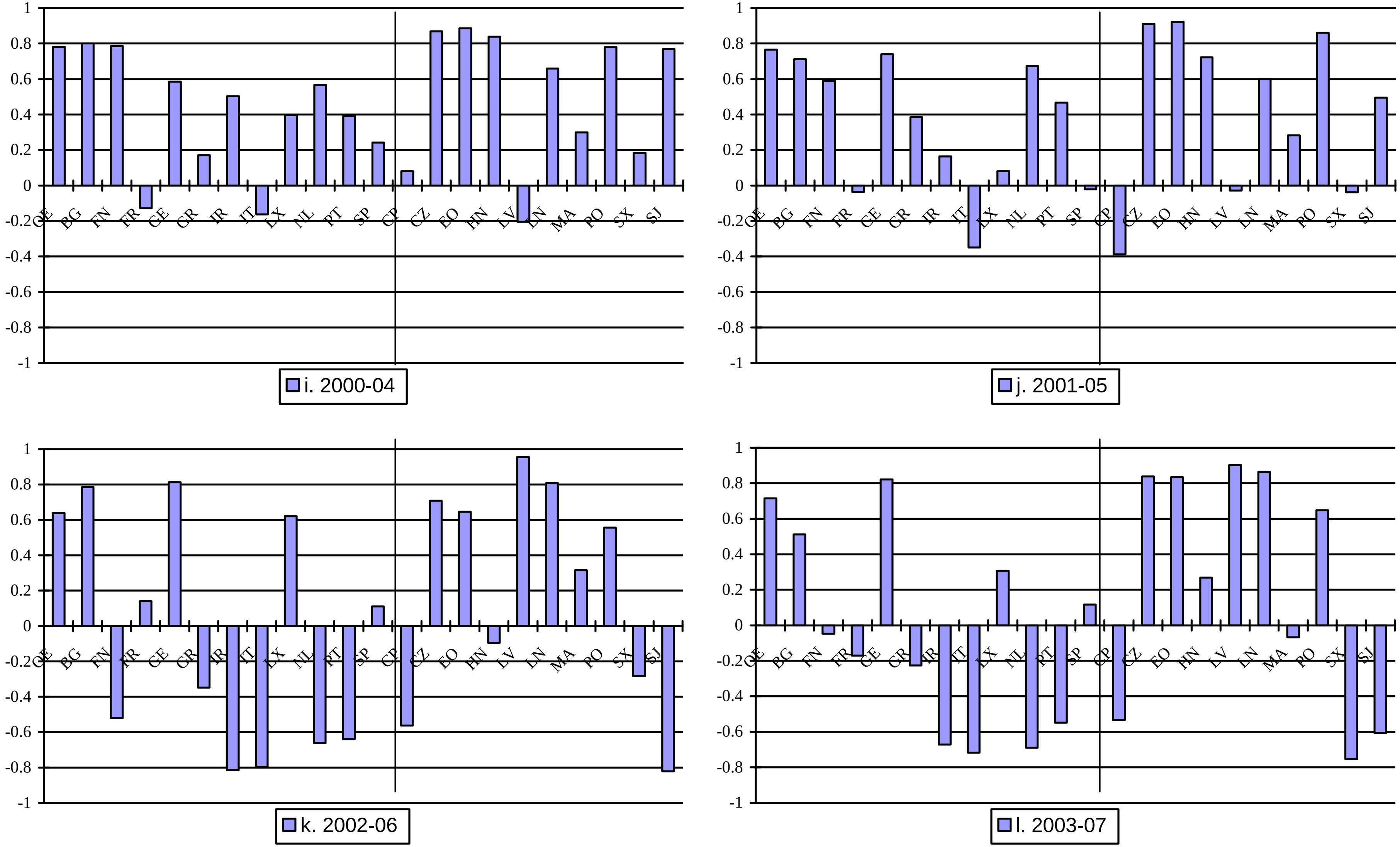
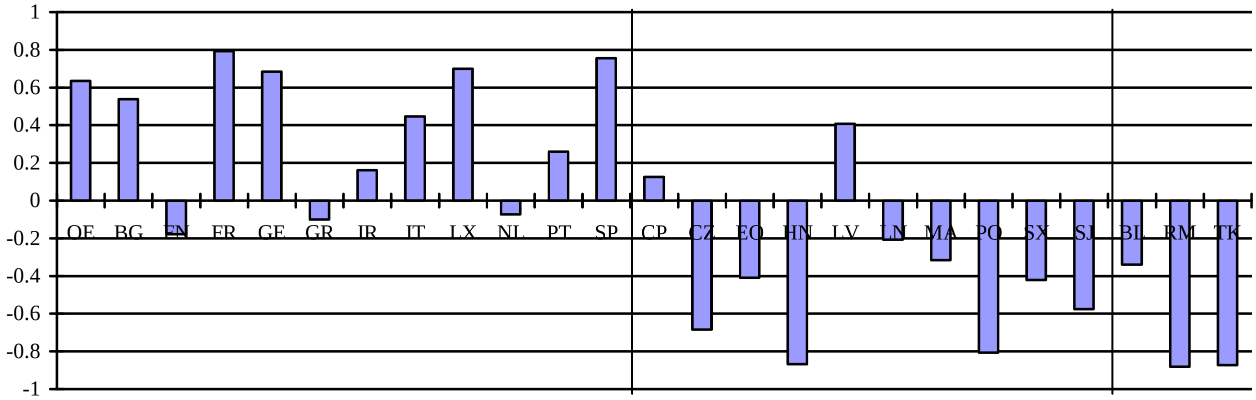
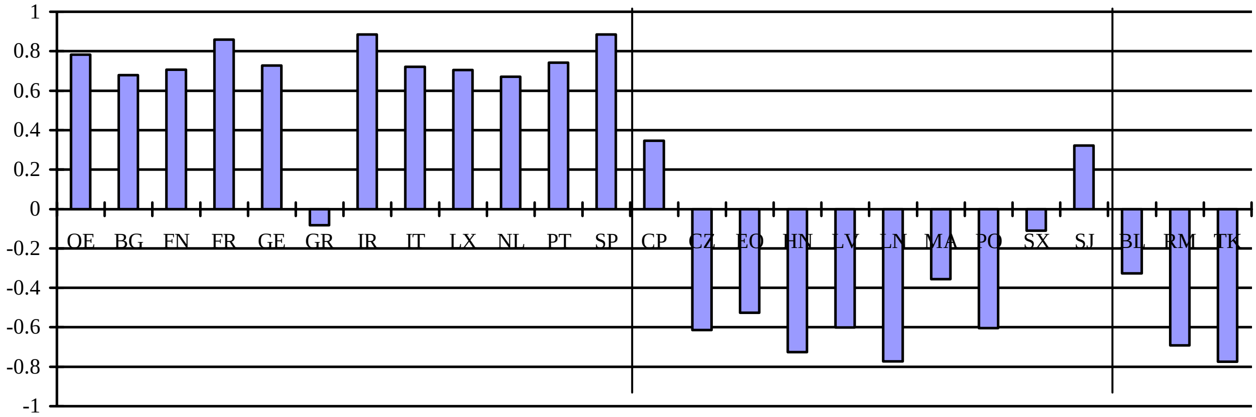


Fig. 9. Country-specific weights of first principal component, 12 EMU member countries and 10 New Member Countries and 3 candidate countries Bulgaria (BL), Romania (RM) and Turkey (TK).
(Panel a: whole period. *Panels b-g:* Five-year moving windows*)*

a. 1998-2007



b. 1998-2002



c. 1999-2003

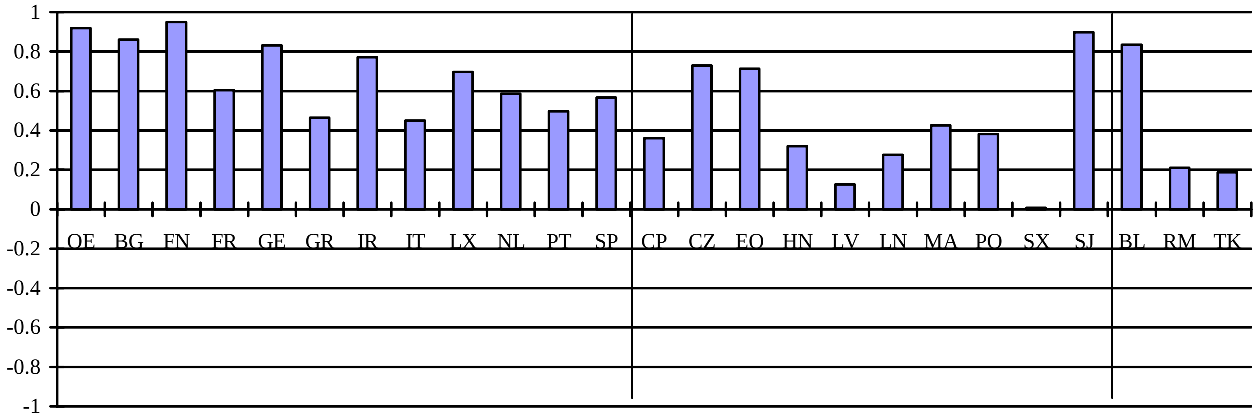
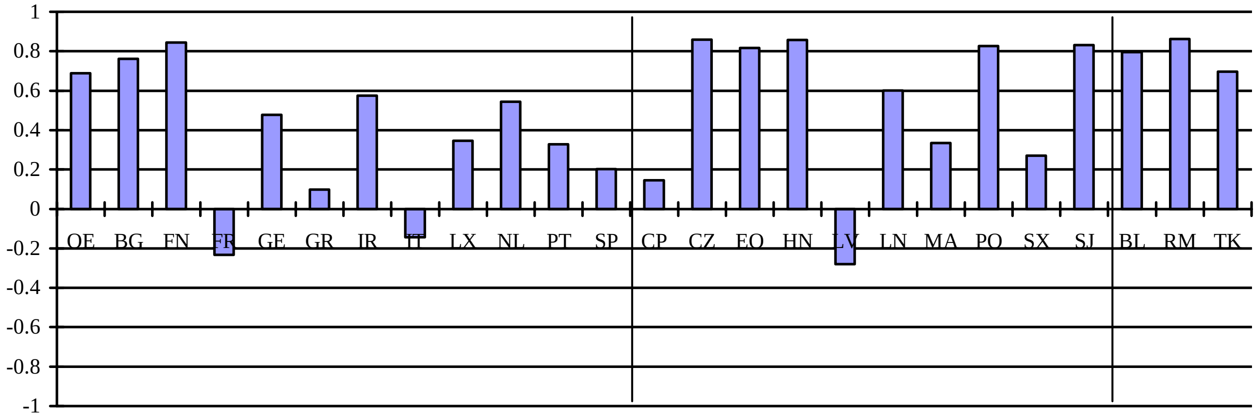
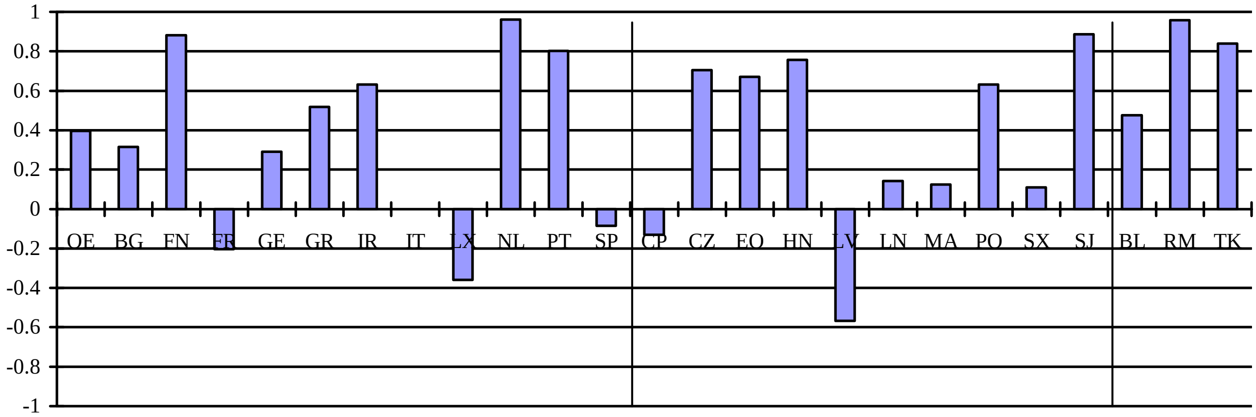


Fig. 9 cont.

d. 2000-04



e. 2001-05



f. 2002-06

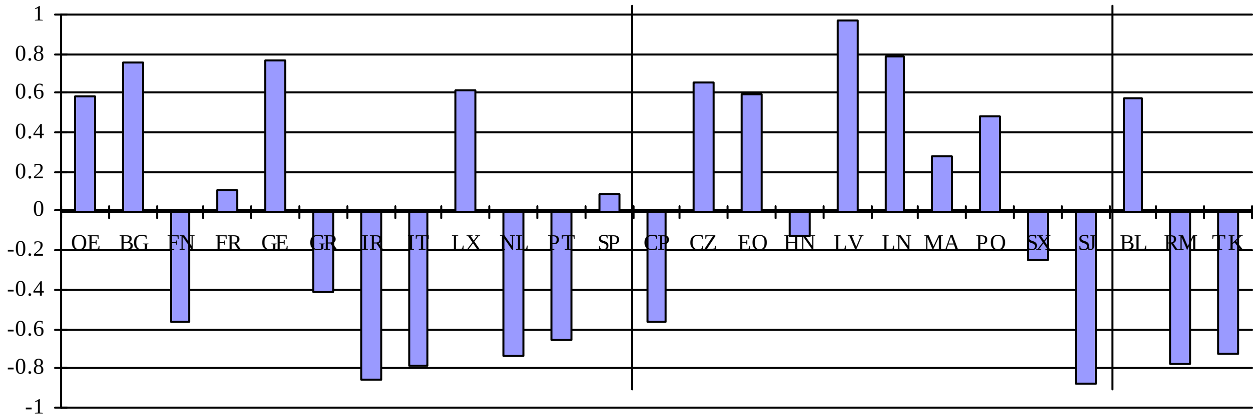


Fig. 9 cont.

g. 2003-07