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A MULTI-CRITERION CLUSTER ANALYSIS**

Delphine Irac and Jimmy Lopez

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**Euro area structural convergence?**

**A multi-criterion cluster analysis**

*Delphine IRAC and Jimmy LOPEZ*

## Résumé

Notre étude propose une classification des 12 plus vieux pays membres de l'Union Monétaire Européenne selon leurs caractéristiques structurelles grâce à une approche de partitionnement hiérarchique permettant de mobiliser un grand nombre de variables. La convergence structurelle de ces pays entre 1995 et 2007 est ensuite analysée à partir d'une métrique cohérente avec cette approche.

Les deux groupes de pays distincts identifiés en 1995 sont toujours les mêmes en 2007. Ce regroupement distingue les pays du Sud, soit l'Espagne, la Grèce, l'Italie et le Portugal, des autres pays membres. La métrique de convergence que nous proposons conduit à trois principales conclusions : (i) la dispersion entre les groupes s'est accrue, (ii) il y a une forme de convergence dans les pays du Sud mais qui prend la forme de d'une généralisation de la dualité des marchés du travail, et (iii) les dynamiques démographiques et les efforts d'innovation divergent entre les autres pays membres de l'Union Monétaire Européenne.

Mots clés : classification hiérarchique, Union Monétaire Européenne, Politiques structurelles

## Abstract

This paper proposes a classification of the old member countries of the euro area in a structural data rich environment and run a convergence analysis using the same framework. First, we use a clustering approach and identify two structurally distinct groups of countries that are not modified between 1995 and 2007: the South Countries Group (SCG) – composed of Greece, Italy, Portugal and Spain – and the Other Countries Group (OCG). Second, we propose a convergence metrics and reach three key findings: (i) increase over time of the between-group dispersion; (ii) diverging demographics and innovation performance into the OCG, and (iii) an unfortunate convergence towards high labour market duality in the SCG.

Keywords: Cluster Analysis, European Monetary Union, Structural Policies

JEL: C38, E02, F33

## Introduction

As was often pointed out at the time of its inception, the euro area did not meet all the requirements of an optimal currency area, particularly it lacked of labour mobility between member countries. Consequently, homogeneity and convergence have always been central concerns in the euro area construction process. Long-term productivity convergence (and other macroeconomic performances) requires structural convergence. For instance, according to Conway and Nicoletti (2007) empirical investigation, anticompetitive Product Market Regulations (PMR) prevent technological catch-up and, thus, cross-country differences in PMR can explain the observed divergence of labour productivity in OECD since the 1990.

An optimistic point of view is that joining a common currency would actually precipitate structural reforms and convergence. There are at least two theoretical arguments supporting this view: (i) a single currency is supposed to reduce the protection of firms and insider workers by enhancing price transparency and fostering trade (see Rose 2000); (ii) since member countries can no longer engage in competitive devaluations, there is greater incentive for the liberalization of labour and product markets. However, according to Alesina, Ardagna and Galasso (2008), while the adoption of the euro has been associated with an acceleration of the pace of structural reforms in product markets, there has not been any corresponding acceleration at the level of employment protection legislation and of unemployment insurance.

Another argument is that the adoption of the euro was accompanied by different political and administrative tools designed to encourage structural reforms and to promote long term growth in a coordinated way. Indeed, the “Europe 2020” strategy, which follows the Lisbon strategy, defines a series of common structural reform objectives: convergence of employment rates of the 20-64 year age group to levels above 75%, increase in the share of R&D in GDP (to 3%), reductions in the school drop-out rate, the poverty rate and greenhouse gas emissions. However, several economists and politicians (see Wyplosz 2010, Tabellini and Wyplosz 2004, 2006) have warned that these convergence strategies - essentially based on peer pressure - may not be adequate since the underlying catching-up process has itself come to a halt.

There is empirical evidence supporting labour productivity convergence in the euro area during the 1990s, mainly driven by convergence in capital intensity. Unfortunately, there is no such evidence for the last decade<sup>1</sup>. Moreover, the crisis has rekindled the question of the risks associated with the persistence of structural heterogeneities within the euro area. There are few papers on this topic of structural convergence. Alesina, Ardagna and Galasso (2008) use the ordinary-least-squares method to evaluate the changes of product and labour market policies before and after the European monetary union implementation in 1999 but they do not analyse convergence. This paper proposes to re-examine the structural dissimilarities into the euro area and their evolution over 1995-2007 in a structural data-rich environment.

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<sup>1</sup> See, for instance, the EU KLEMS Growth and Productivity Account for data on labour productivity and Timmer, O'Mahony and van Ark 2007 for an overview of this database as well as a brief analysis of the major trends.

Heterogeneity across countries has often been tackled through sigma-convergence (see Barro and Sala I Martin 1995 and Sala I Martin 1996) approaches, which try to detect whether some activity variables (e.g. per capita income) tend to converge towards a mean. There is  $\sigma$ -convergence when the dispersion of real per-capita income across a group of economies diminishes over time. Using a similar framework, Quah (1996) analyses the cross-sectional distribution of economies on the basis of per-capita income and shows that this distribution tends to polarize into “twin peaks” at the end of its sample. He interprets this finding as evidence of the existence of convergence clubs. However, limiting his analysis to the European regions, Quah concludes to a tightening unimodal distribution of per-capita income over time (period 1980-1989). 2

In line with the theoretical prediction of the Solow-Swan model, the hypothesis of conditional convergence posits that the convergence process occurs only within groups of countries with similar structural characteristics. For instance, according to Wolff (2000), convergence in labour productivity levels among OECD countries corresponds to their convergence in schooling levels. However, it is difficult to robustly identify the key structural characteristics that could delineate the boundaries of clusters of countries exhibiting convergence. A first option consists in relating structural factors to some variable reflecting economic performance (measured by growth, unemployment, external balance, public deficit, etc). This approach is close to the empirical analysis in the literature on economic growth, in which “robust” relations between growth and a set of theoretically relevant variables are identified:

$$g = \alpha + \sum_{i=1}^n \beta_i x_i + \epsilon$$

Where  $g$  is a measure of long-term economic performance, and  $x_i$  represents a set of explanatory variables. As underscored by Sala-i-Martin, this approach presents numerous caveats. First, the true model of long-term economic performance is not known and, even if it was, the choice of the relevant empirical variables is not obvious. For instance, the level of technology depends both on the capacity to imitate and to innovate. Innovation can be captured by different proxies (R&D, triadic patents, exports of high-technology goods etc.) none of which are capable of fully capturing the different dimensions of innovation. Similarly, a number of proxies are available for measuring human capital or the capacity of labour market institutions to induce higher activity rates. Given the loose predictions of economic theory and the wide variety of structural proxies, economists generally try different combinations of structural factors and estimate their relationship to economic performances using a multivariate framework, in the spirit of the equation above. However it seems

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2 Two other concepts, analogous to sigma-convergence, should be mentioned: the beta-convergence and Phillips and Sul (2007) convergence tests. The beta-convergence focuses on the partial correlation between income growth over time and its initial level:  $\beta$ -convergence is established when this correlation becomes negative. It is easy to show that  $\sigma$ -convergence implies  $\beta$ -convergence but there can be  $\sigma$ -convergence without  $\beta$ -convergence (see Young, Higgins and Levy 2004). Economies can be  $\beta$ -converging towards one another while at the same time being separated by random shocks. The Phillips and Sul (2007) convergence test uses a non-linear and time-varying factor model allowing a distinction between common and individual specific components. There is convergence between individuals, according to this test, when the idiosyncratic components converge over time to a constant.

that the degree of significativity of a given structural factor of interest depends to a large extent on the set of variables that are introduced in the regression (see Levine and Renelt 1992 and Sala-i-Martin 1997). Empirical works fail to provide a general ranking of structural factors based on their degrees of impact on growth or to provide a general one-size-fits-all answer to the question: if one euro has to be spent on structural reforms, which reforms should be targeted in priority.

Another concern with this approach relates to identification of economic performance. Growth is a good option, but the recent economic crisis illustrates that growth indicators can be misleading, particularly in cases where specific sectors are affected by bubbles (e.g. the construction sector in Spain). Employment performance is another option; but this indicator can be biased for instance by excessive labour market duality with the possibility of strong reversal in the case of economic downturn. Yet another option would be to propose some kind of ratings/rankings of economies in line with Cantor and Packer (1996)<sup>3</sup> or with the Global Competitiveness Report (2012). In both cases the aim is, by construction, to provide a unique rating/ranking of a given country, by synthesizing a broad set of medium-term indicators.

We chose an approach that enables classification of countries in a “data-rich” environment without trying to reduce the information into a synthetic structural indicator. In terms of output, we favor a classification formalized with an unordered tree rather than a general ranking of the countries in the spirit of a rating. Since the cluster analysis enables determination of some natural groupings of observations by detecting similarities, it seems particularly appropriate to our purpose.

The paper is organized as follows. In the next section we present the data. We then present the clustering methodology and define our measure of convergence of overall structural indicators (section III). Next, we present the clustering results (section IV) and the convergence analysis (section V) for the period 1995-2007. Finally, we continue the analysis on the post-crisis period (section VI). A few reflections on open issues and directions for future research conclude the paper (section VII).

## I. Data

We analyse three fields of structural factors that are usually identified as key determinants of macroeconomic performance: (i) regulations and quality of institutions; (ii) knowledge and (iii) labour mobilization. Among the factors with major potential for economic impact – according to international discussions on growth-related topics (G20, Lisbon agenda, etc.) – we focus on the variables that are the most likely to differ between euro area countries. This relatively small number of indicators (23) allows a general but parsimonious view of the main differences between euro area countries. For instance, business R&D expenses are preferred to public R&D expenses and we include the employment rates at the two extremes of the age distribution in our analysis, leaving aside the

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<sup>3</sup> The seminal paper by Cantor and Packer (1996) shows that ratings agencies are likely to use quantitative models that identify a “perceived” risk of default of a given country with a set of relevant macro-economic variables, some of which are structural.

medium-age employment rate, as most of the differences between country employment rates concern the younger and older age groups.<sup>4</sup>

Our observation sample covers the 12 countries having joined the euro area before 2007 (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain). To analyze the impact of the monetary union on structural policy convergence, our sample starts before the official launch of the euro area on 1 January 1999. Indeed, countries could have anticipated the strong competition that would result from the union (and the loss of the possibility to devalue) and implemented structural reforms beforehand. However, the sample does not start in 1993 with the Maastricht treaty but in 1995, to avoid the important consequences of German reunification and the 1993 crisis in some of the euro area countries (France particularly). Finally, the sample is split into two periods, 1995-2007 and 2007-2010, in order to obtain a sense of the specific impact of the crisis.

The data comes from various sources: OECD, EUROSTAT, the World Bank (WB) and the Institute for Management and Development (IMD). Twenty-three indicators are mobilized on the 1995-2007 period (when the data availability period is shorter, the resulting period is indicated in brackets):<sup>5</sup>

Field 1: Regulations and quality of institutions:

- regulations: transaction cost of purchasing properties in % of property value (2009); strictness of employment protection on regular contracts; anti-competitive regulations on product markets (1998-2008). Indicators of strictness of employment protection and of anti-competitive regulations are scaled between 0 and 6, with 0 for the most pro-competitive regulations
- quality of institutions (with two indicators for each subject): underground economy (1995-2007 and an estimate averaged over 1999-2003); justice (1996-2007 and 1997-2007); corruption (1996-2007 and 1997-2007). All the indicators are based on subjective assessments by managers, except the estimate of the size of the underground economy as a % of GDP. The subjective indicators have different sources and different scales, but the value of each indicator decreases with the degree of constraint it exercises on the economy

Field 2: Knowledge:

public educational expenses as a % of GDP; average scores measuring educational attainment of 15 year-old students (PISA 2000-2006); % share of populations with some form of college education among the 25-34 and 25-64 years old (2000-2007); business R&D expenses as a % of GDP; number of triadic patent families per habitant; % share of innovating firms in total sales (1998-2006)

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<sup>4</sup> Of course, we fully acknowledge that this variable selection procedure is somewhat arbitrary, but we have endeavored to derive as objectively as possible from the most influential institutional reports. However, note that the 1995 values of our indicators are highly correlated with GDP per capita growth between 1995 and 2007 and/or with average current accounts over the 1999-2007 period. These correlations being of little help to conclude on causality between the structural variables and macroeconomic performances, we don't go into details on this point.

<sup>5</sup> See appendix A for a more detailed presentation of the indicators.



Field 3: Labour mobilization:

Employment rates for the 15-24 and 55-64 age groups; ratio of female employment to male employment; proportion of temporary employment in total employment; proportion of long-term unemployed (unemployment spells of 1 year and over) among all unemployed; shares of under 15 and over 65 years old on the whole population.

Some of the variables are updated annually; others more rarely and most are updated with a lag of a few years. Consequently, there is only limited data available for the post-crisis period. These limits are detailed in the post-financial crisis section.

## II. Empirical method

Our approach relies on an agglomerative hierarchical method: at each step, the algorithm joins two groups of countries; these groups are chosen in order to minimize the resulting increase in the sum of within-group dissimilarity. We implement Ward's method that uses the variance as a dissimilarity metrics. So the Ward method minimizes at each step the sum of within-group contributions to the overall variance  $\sum_x W(x^t)$ :

$$\sum_x W(x^t) \equiv \sum_x \frac{1}{n_{\cdot}} \cdot \sum_i \sum_j (x_{ij}^t - x_{\cdot j}^t)^2 = \sum_x \sum_j \frac{n_j}{n_{\cdot}} \cdot \text{Var}_j(x^t)$$

$W$  is the within-group contribution to the overall variance of a given indicator  $x$ ;  $t$  is the year;  $i$  is the country and  $j$  is the group

Note that minimizing the within-group distribution is equivalent to maximizing the between-group contribution:

$$\sum_x B(x^t) \equiv \sum_x \sum_j \frac{n_j}{n_{\cdot}} \cdot (x_{\cdot j}^t - x_{\cdot \cdot}^t)^2$$

A major issue when using clustering methods is to determine the weight of each variable in the dissimilarity measure. As commonly suggested, we have standardized the variables, i.e. we divide the variables' values by their standard deviation. So each variable has a variance equal to one and thus an equal importance to form the clusters. In order to be able to measure overall convergence/divergence, we divide the 2007 and 1995 values by the same 1995 standard deviation. However, the evolution of the dispersion could also be influenced by trends, so the values are also detrended (i.e. the values are divided by their current mean) before standardization. All in all, a given indicator  $y$  is therefore rescaled in  $x$  using the following formula:

$$x_{ij}^t = \frac{y_{ij}^t / y_{\cdot \cdot}^t}{\sqrt{\text{Var}(y^{95} / y_{\cdot \cdot}^{95})}}$$

Another issue concerning variable weights is that different proxies reflecting the same structural pattern can be used at the same time. In our analysis, the difficulty of measuring the 'quality of institutions' is mitigated by using two sets of indicators to represent the field. This use of two

different sources may reduce the uncertainty. To not overweight the 3 corresponding subjects, the 6 indicators are divided by  $\sqrt{2}$  to get a variance of 0.5. Finally, the adjusted weights of the three different fields are almost the same (respectively 7, 7 and 6 for knowledge, labour mobilization and regulations/institution quality). These weights are inevitably arbitrary and a sensibility analysis is implemented, notably using the correlations of the indicators with some macroeconomic performances.

A main purpose of our analysis is to give quantitative insights on the overall structural convergence in the euro area. For this purpose, we define a measure of overall convergence as the ratio of variance of the 'detrended' variables:

$$\frac{1}{m} \sum_x \frac{Var(x^{t2})}{Var(x^{t1})}$$

with a1 and a2 the first and last year of the analyzed period.

As the rescaled indicators  $x$  have a variance equal to one in 1995 by definition, it is worth noting that the convergence on the 1995-2007 period could be rewritten as:

$$\frac{1}{m} \sum_x \frac{Var(x^{07})}{Var(x^{95})} = \frac{1}{m} \cdot \sum_x (W(x^{07}) - W(x^{95})) + \frac{1}{m} \cdot \sum_x (B(x^{07}) - B(x^{95}))$$

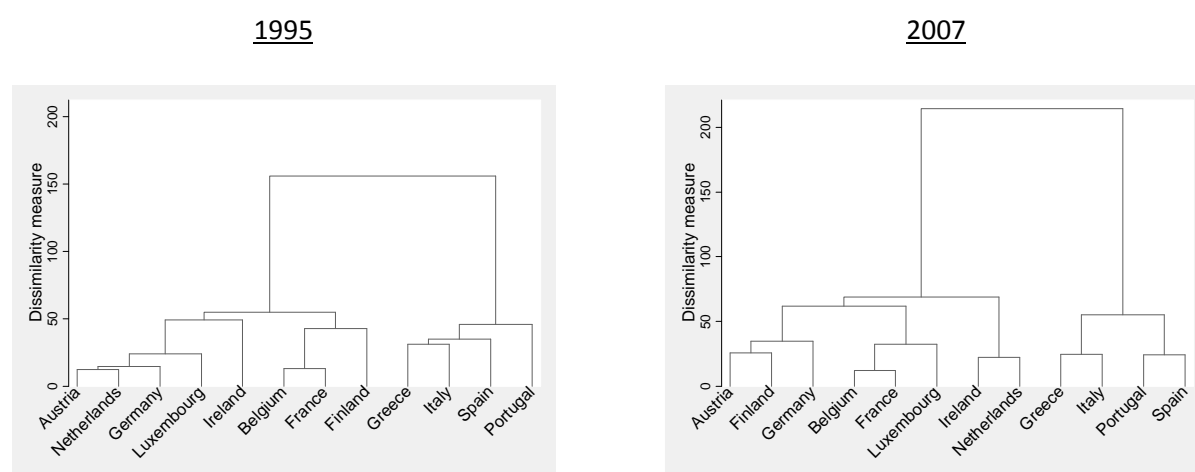
Indeed, the first term of the right part of the equation compares the values of the objective functions of the clustering process in 1995 and 2007. The second term corresponds to the evolution of the objective function of the dual problem, i.e. the evolution of the intra-group contributions.

Thus, our overall convergence measure presents two advantages: (i) consistency with the dissimilarity measure used for the clustering method; (ii) the possibility to break down this measure into between- and within-group contributions.

### III. Clustering results

Dendrogram 1 presents the clustering analysis results for the years 1995 and 2007. Note that the cumulative length of the vertical segments can be viewed as the distance between two groups. According to this representation, two very different groups emerge: the South Countries Group (SCG) - with Greece, Italy, Portugal and Spain - and the Other Countries Group (OCG). Interestingly, this partition holds both in 1995 and 2007 and is confirmed by the results of the optimal rules indicated in table 1, the Calinski/Harabasz and Duda/Hart rules, which enable an identification of the optimal number of clusters. These two rules are based on measures of the within-group dissimilarity increase resulting from joining two groups of countries. For the Calinski/Harabasz pseudo-F and  $Je(2)/Je(1)$  statistics, larger values indicate important dissimilarity increase, whereas it's the opposite for the pseudo-T-squared values. The maximum value of the Calinski-Harabasz pseudo-F is for 2 groups and the Duda-Hart pseudo-T maximum increase is when the two groups are merged.

## Dendrogram 1: Results of the clustering analysis



*Dendrograms produces by the authors from the Ward clustering method*

*The vertical lines indicate the dissimilarity between the two clustered groups*

Table 1: Optimal rules results

Number of s	1995			2007		
	Calinski/Harabasz pseudo-F	Duda/Hart		Calinski/Harabasz pseudo-F	Duda/Hart	
		Je(2)/Je(1)	pseudo T-sq		Je(2)/Je(1)	pseudo T-sq
1	-	0.67	4.82	-	0.63	5.89
2	4.82	0.74	2.11	5.89	0.73	2.18
3	3.53	0.51	2.89	4.33	0.63	2.34
4	3.16	0.59	1.38	3.96	0.47	2.26
5	3.08	0.24	3.21	3.95	0.43	1.34
6	3.20	0.47	1.12	3.67	0.28	2.63

*The results for more than 6 clusters are not presented as the stopping rules become less informative as the number of elements in the groups diminishes. These rules are no longer relevant for such small groups*

The clustering holds when restricting to various subsets of the variables. For instance, the clustering results remains unchanged when the correlations of the indicators' values in 1995 with the 1995-2007 GDP per capita growth are used as weights in the clustering process. The clustering is also robust to the withdrawal of any variable. More interestingly, the groups are very similar if we concentrate on only one of the fields:

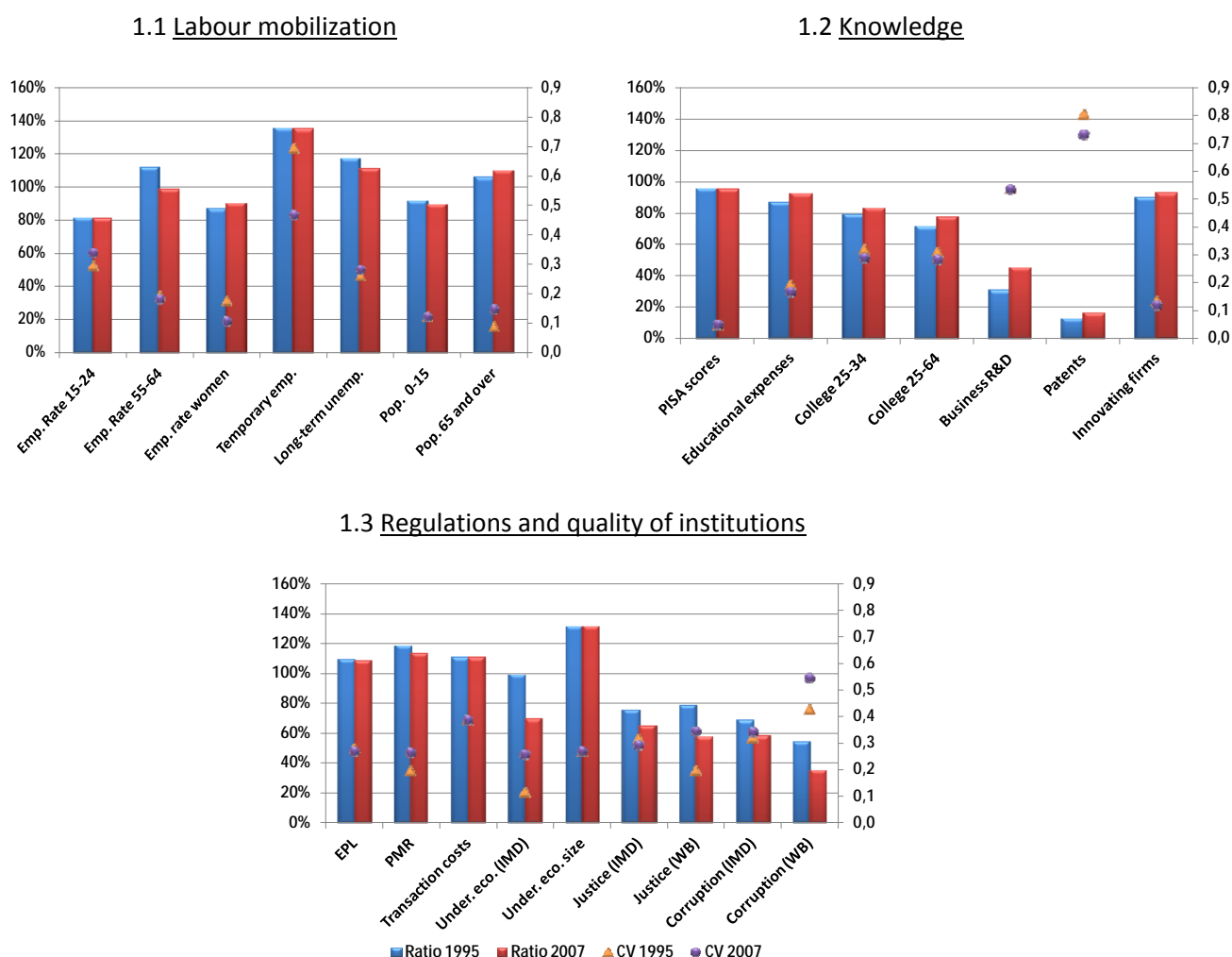
- using only 'labour mobilization' indicators, the groups remain unchanged
- using only 'knowledge' indicators, the only change in the result is Luxembourg switching to the south countries group
- using only 'regulations and quality of institutions' indicators, only Belgium switches

Chart 1 presents, for each variable, the ratio of the South Group average to the euro area average for the years 1995 and 2007 (left axis) as well as the coefficient of variations in the euro area (right axis). According to chart 1, the SCG is lagging behind along various dimensions. The SCG never appears to be sensibly and persistently better than the other countries, but they are sensibly worse for many of the indicators. The largest differences are on the innovation indicators (business R&D expenses and patents per habitant), but there are significant differences for many other indicators: employment

rates of the 15-24 age group, use of temporary workers, working population with some college education, estimated size of underground economy and most of the subjective indicators of the quality of institutions. All these differences are persistent over-time.

Chart 1: Ratio of South Group to euro area average and coefficient of variations

The values of the ratios are on the left axis and the coefficient of variations (CV, the ratio of the standard deviation to the mean) on the right axis



The OECD indicators EPL (Employment Protection Legislation) and PMR (Product Market Regulations) are growing with the importance of economic constraints, whereas the IMD (Institute for Management and Development) and WB (World Bank) indicators are decreasing with the constraints

#### IV. Overall convergence analysis

At first sight, the ratio of the SCG average to the euro area average in 1995 and 2007 suggests a significant persistence of structural differences between the two groups of countries. In particular, chart 1 shows that the differences have worsened for the subjective indicators regarding the quality of institutions, whereas they have only substantially reduced for business R&D expenses, which remain very large. Chart 1 also presents the coefficients of variations on the euro area for the years

1995 and 2007 (right axis). These coefficients of variations have not changed substantially for a significant number of the indicators, and no overall convergence or divergence seems apparent.

To give quantitative insights on the issue of the overall convergence in the euro area and on the convergence between the 2 groups of countries, we extend our analysis to the joint evolution of 22 indicators altogether.<sup>6</sup> To do so, we compute the overall euro area convergence measure:

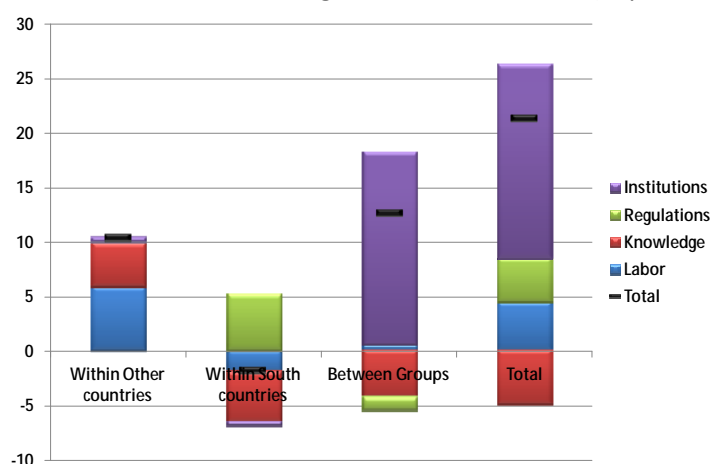
$$\frac{1}{m} \sum_x \frac{Var^{07}(x)}{Var^{95}(x)}.$$

A main advantage of this intuitive measure is its coherence with the dissimilarity measure used for the clustering method. Another advantage is that it is decomposable into between-group and within-group contributions (see the last section)<sup>7</sup>. Table 2 presents the overall euro area dispersion measure taking into account the 22 indicators as well as the between-group and within-group contributions. The contributions of the different fields of indicators to the evolution of the dispersion are shown in chart 2.

Table 2: Within- and between-groups' contributions to the euro area dispersion in 1995 and 2007

	1995	2007	Growth 1995-2007	Contribution to the total evolution
Other countries	0,428	0,532	24,3%	10,4%
South countries	0,232	0,214	-7,54%	-1,7%
Between group	0,340	0,468	37,4%	12,7%
Total	1,000	1,214	21,4%	21,4%

Chart 2: Fields' contributions to euro area divergence over 1995-2007 (in points of percentage)



6 The indicator on transaction costs of purchasing properties is time invariant, so it is not included in the convergence analysis.

7 Note that all the information needed to compute the overall convergence measure is the group means and coefficient of variations presented in Chart 1 (see appendix B).

According to Table 2 results, there is a significant divergence in the euro area – a 21.4% increase of the dispersion – generated by an increase in the dispersion in the Other Countries Group and by divergence between groups. Changes in institutional quality indicators lead to the between-group divergence. When these indicators are excluded from the analysis, the two groups converge and so the overall divergence is much smaller (a 4.2% increase of the dispersion). The ‘knowledge’ indicators tend to converge between countries but the initial differences were so large in 1995 that they are still very high in 2007, as already shown in Chart 1.<sup>8</sup> To conclude, according to these results on the pre-crisis period:

- focusing on the overall dispersion, the divergence is dependent on subjective indicators, but the absence of strong convergence is obvious
- focusing on the between-group dispersion, the major concern is regarding the quality of institutions: the underground economy, justice and corruption. Chart 1 shows that the situation has deteriorated for the south countries relatively to the other countries for each of these indicators

The evolutions of within-group dispersions are smaller than those of the between-group dispersions. However, Chart 3 on the indicators’ contributions shows that some particular indicators explain most of the within-groups’ divergence/convergence in each field: ageing population, temporary employment, business R&D expenses and product market regulations. As these variables could have strong economic and social impacts, it is interesting to analyze their changes. Chart 4 shows the 1995 and 2007 values of these variables for each euro area country. We observe that:

- the ageing population explains most of the divergence between the countries of the Other Group. Indeed, for Germany and Italy, two of the older countries in the euro area in 1995, the proportion of people older than 65 greatly increased over the period
- within the SCG, countries do not necessarily converge in the “right” direction. For instance, the important convergence in temporary employment between the countries of the South Group is caused by a simultaneous significant increase both in Portugal and in Italy
- the divergence in business R&D expenses in the Other Group could be a main concern for the outdistanced countries. Indeed, the great increase in Austria, Germany and Ireland give them an important advantage in the euro area (and global) competition
- in compliance with the requirements of the European single market, all the members of the euro monetary union, except Luxembourg, implemented a trend of reforms during the 1995-2007 period in order to reduce the level of anti-competitive regulations in their product markets. However, this evolution was less pronounced in Greece than in the other countries, maintaining a very high level of constraints, thus increasing the dispersion relative to the other countries of the South Group.

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<sup>8</sup> We could also note the stability of between groups’ dispersions in terms of ‘labour mobilization’ indicators. It will be different after the 2008 financial crisis.

Chart 3: Indicators' contributions to the within-groups' convergence (in percentage points)

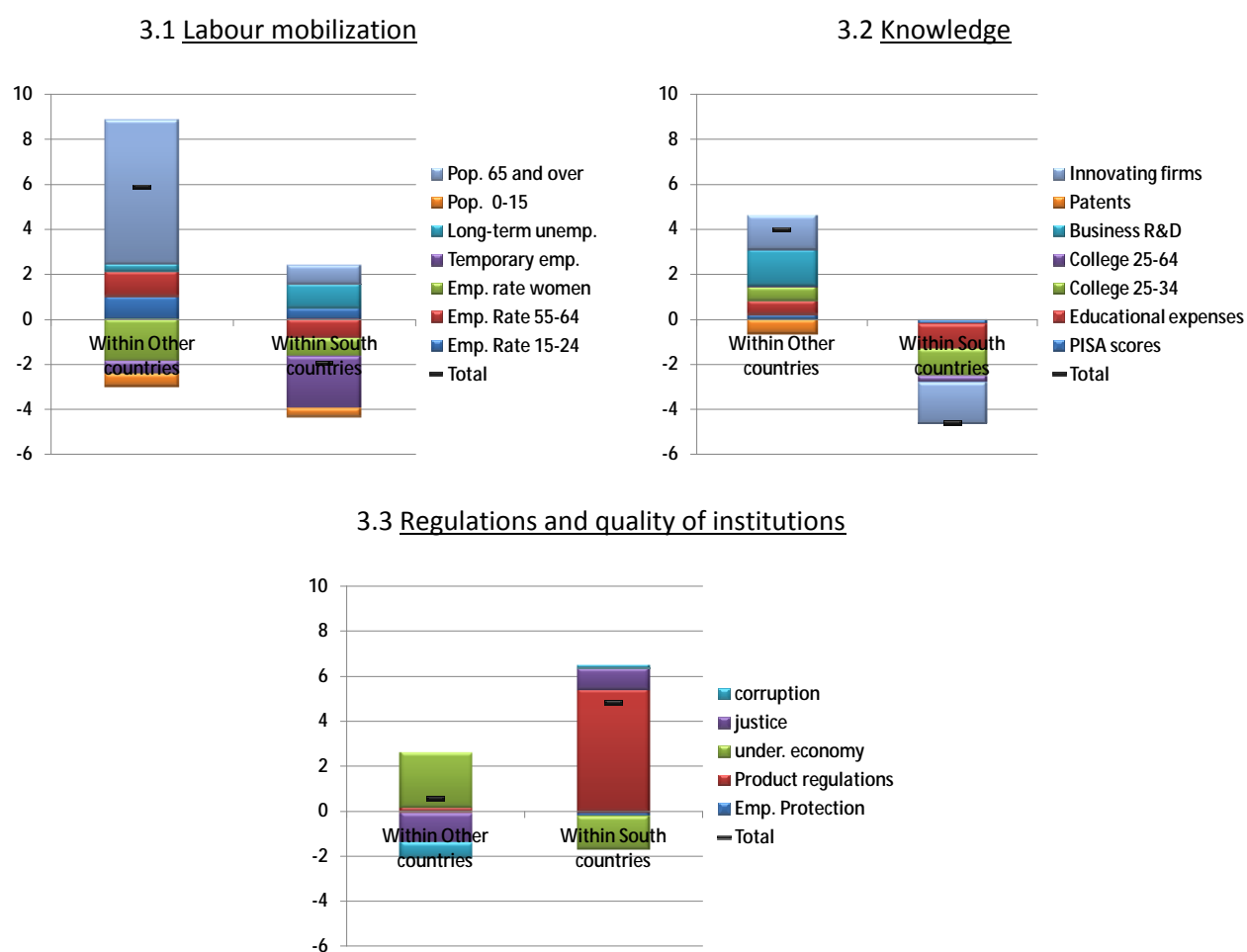
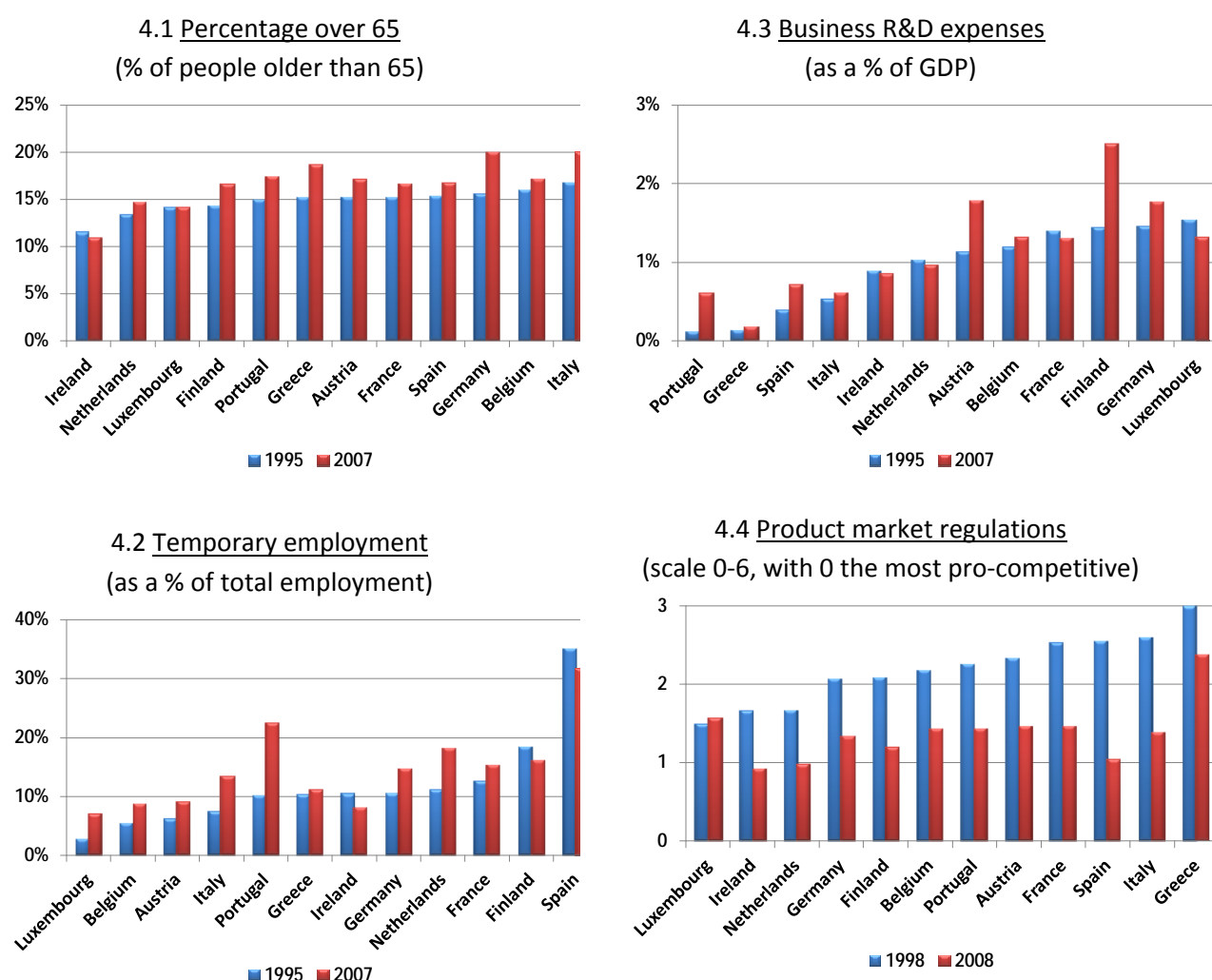


Chart 4: Major contributors to the within-group dispersion



## V. Post-crisis analysis

The economic crisis has brought about renewed incentives to implement major structural reforms and thus plant the seeds of long-term growth. This section provides an overview of recent post-crisis evolutions.

Several arguments support the view that structural reforms are more likely to be initiated in times of economic crisis. According to the “back against the wall” theory, governments make major fiscal adjustments or introduce measures to stabilize inflation when they face an emergency in the decision-making process such as a runaway deficit. In effect, crises unmask the weaknesses and/or the unsustainability of existing policies, which were hidden by cyclical buoyancy. Drazen and Grilli (1993) show that crises can be welfare-enhancing: they accelerate agreement over the distribution of the cost-burden of reforms, thereby accelerating the pace of reforms. A crisis fosters reform because it “convinces” one specific group to bare a larger share of its cost. This argument is mitigated by the possible risk of reform reversals or changes in political conditions (Dewatripont and Roland 1995, Gehlbach and Malesky 2010, Campos *et al.* 2010).



Because of the lack of available data, the analyses focus on the 2007-2010 period and only on the knowledge and labour fields. Moreover, the investigated period is reduced for the PISA scores (2009) and patents, whereas indicators on educational expenses and the proportion of innovating firms are missing. A comparison of dendrograms 1 and 2 for the year 2007 shows that the clustering is very robust to the exclusion of the variable unavailable after 2007. Indeed, the groups are mostly the same at each step of the clustering. Moreover, the optimal number of groups is still 2 according to the Calinski-Harabasz and Duda-Hart rules (see table 3).

Dendrogram 2: Results of the cluster analysis for the 2007-2010 period

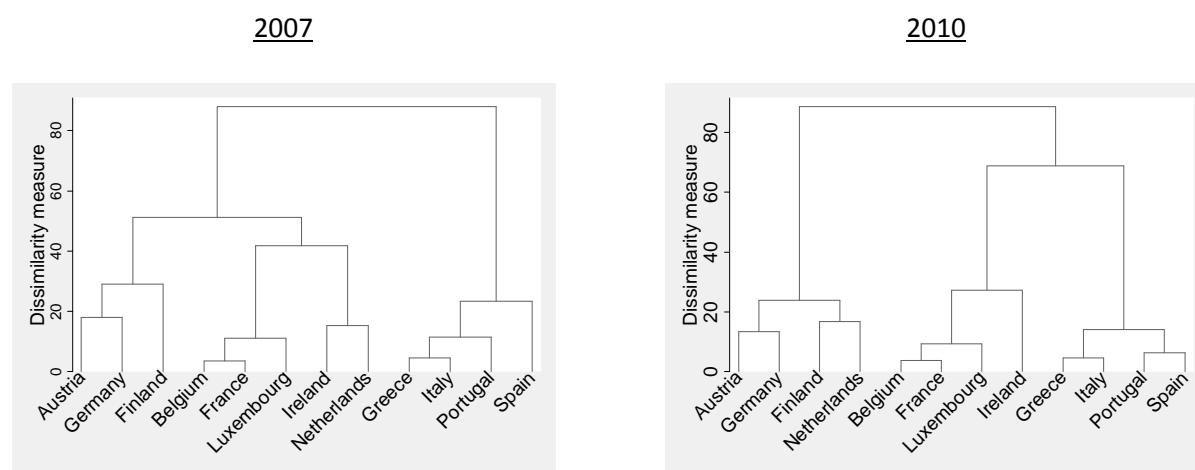


Table 3: Optimal rules results

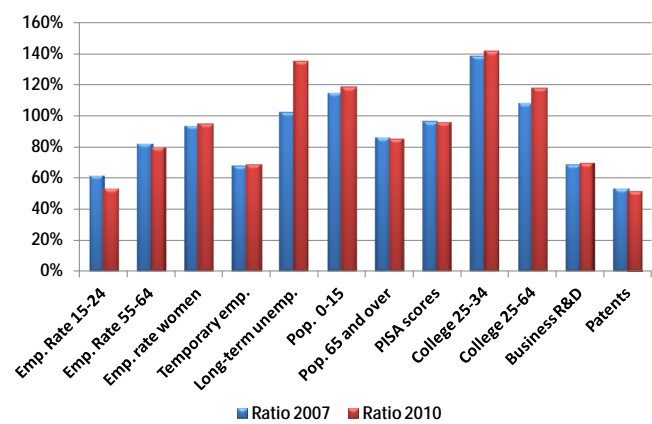
Results on the sub-sample of variables available for 2007-2010

Number of clusters	2007			2010		
	Calinski/Harabasz pseudo-F	Duda/Hart		Calinski/Harabasz pseudo-F	Duda/Hart	
		Je(2)/Je(1)	pseudo T-sq		Je(2)/Je(1)	pseudo T-sq
1	-	0.70	4.21	-	0.68	4.72
2	4.21	0.70	2.59	4.72	0.49	6.36
3	3.96	0.42	4.19	5.96	0.32	4.22
4	4.15	0.38	1.62	5.38	0.56	1.58

Concerning the clustering changes between 2007 and 2010, a brief view of the dendrograms seems to conclude to a split of the OCG. A group including Belgium, France, Luxembourg and Ireland exit the OCG (and move closer to the SCG). This split into three groups is supported by the Calinski-Harabasz rule, but the Duda-Hart rule concludes to 4 groups. However, the split into three groups should be taken with caution. First, note that the three groups mostly already existed in 2007; only the Netherlands changed from one group to the other. Therefore the conclusion of a split from two to three groups is mainly based on arbitrary rules. Moreover, Chart 5 shows that the percentage of long-term unemployment among all unemployed is the only significant divergence between the two ‘new groups’.<sup>9</sup>

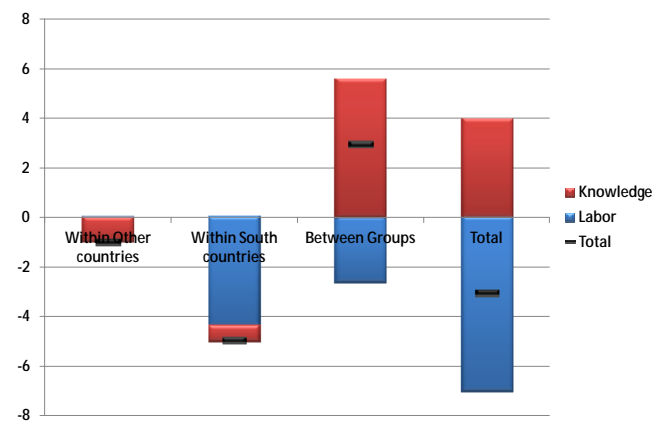
<sup>9</sup> The divergence between the two ‘new groups’ in the percentage of long-term unemployment among all unemployed results from the decrease of this percentage in Germany and Netherlands, whereas it increased in Ireland and remained mostly unchanged for the other OCG countries.

Chart 5: Ratio of French to German group averages



Because of the reservations regarding the split into three groups and to make easier the comparison with the previous sections, we continue the analysis of the post-crisis period by breaking down the contributions to the convergence for only the SCG and OCG. Chart 6 presents the results. The most significant changes are the between-group divergence in the knowledge field and the within-group convergence for the SCG in the labour field. The knowledge divergence comes mainly from the proportion of people with college studies that has continued to increase for both groups but more strongly for the OCG. Unfortunately, the within-group convergence of the SCG was generated by two substantial changes in Spain: (i) the decrease of the employment rate of young workers (from 43% to 27%) and; (ii) the increase of the percentage of long-term unemployment (from 28% to 45%).

Chart 6: Fields’ contributions to the euro area divergence on 2007-2010 (in percentage points)



## VI. Conclusions

This paper revisits the empirical convergence literature by adopting a multivariate analytical framework that allows dealing with a data-rich environment. Whereas the clustering approach is traditionally used to group individual over a given time period, we adapt the methodology to make diachronic comparison and propose metrics of convergence. We identify two clusters of countries in the original 12-country euro area, i.e. the South Country Group (Greece, Italy, Portugal and Spain) and the Other Country Group. This classification is robust to many sensibility analyses concerning the weights of indicators and the withdrawal of variables. These groups are well-known when observing the macroeconomic performances, but our analysis suggests that structural differences explain these performances. Perhaps more significantly, the between-group dispersion expanded over the 1995-2007 period, a worrying factor for European integration. The lack of available data is a barrier for the post-crisis analysis, but the little data available suggests a deterioration of the situation.

The quality of institutions and the level of business R&D expenses are underscored as important determinants of euro area dispersion evolutions. The former explains most of the between-group divergence, whereas the dispersion of the latter has substantially increased over time within the OCG. Detailed analyses of the convergence of these variables are complementary to our analysis, but are few in number. The cluster methodology could be applied to such analyses, but the sigma-method could well be more relevant (as well as other analogous methods, see note 1).

In order to provide a parsimonious view of the main differences between euro area countries (and subsequently further insights) our analysis focuses on a relatively small number of very relevant indicators. However, the cluster analysis approach allows taking large databases into account. Research using these large databases would be useful to confirm or reject our results. Moreover, our analysis is restricted to the 12 initial members of the euro area. These are the most relevant countries for an analysis of long-term euro area integration. Investigating structural convergence in the euro area of 17 countries (or among all the members of the European Union) would be very interesting but would require other data sources than ours, because of the lack of available data.

## References

- Alesina, A., Ardagna, S., and Galasso, V., 2010, "The Euro and Structural Reforms", National Bureau of Economic Research Chapters, in: Europe and the Euro, pages 57-93.
- Barro, R. J., and Sala-i-Martin, X., 1995, "Economic Growth", New York: W. W. Norton.
- Bassanini, A., Nunziata, L., and Venn, D., 2009, "Job protection legislation and productivity growth in OECD countries", Economic Policy, vol. 24(4), pages 349-402.
- Cantor, R. M., and Packer, F., 1996, "Determinants and Impact of Sovereign Credit Ratings", Economic Policy Review, vol. 2(2) .
- Campos, N., Hsiao, C., and Nugent, J., 2010, "Crises, what crises? New evidence on the relative roles of political and economic crises in begetting reforms", Journal of Development Studies, vol. 46(10), pages 1670-1691.
- Conway, P., and Nicoletti, G., 2007, "Product Market Regulation and Productivity Convergence: OECD Evidence and Implications for Canada", International Productivity Monitor, vol. 15.
- Dewatripont, M., and Roland, G., 1995, "The Design of Reform Packages under Uncertainty", American Economic Review, American Economic Association, vol. 85(5), pages 1207-23.
- Drazen, A., and Grilli, V., 1993, "The benefit of crises for economic reforms", American Economic Review, vol. 83(3), pages 598-607.
- Gehlbach, S., and Malesky, E., 2010, "The Contribution of Veto Players to Economic Reform", Journal of Politics, Forthcoming.
- Levine, R. and Renelt, D., 1992, "A Sensitivity Analysis of Cross-Country Growth Regressions", The American Economic Review, vol. 82(4), pages 942-963.
- Phillips, P., and Sul, D., 2007, "Transition Modelling and Econometric Convergence Tests", Econometrica, vol. 75(6), pages 1771-1855.
- Quah, D., 1996, "Twin Peaks: Growth and Convergence in Models of Distribution Dynamics", The Economic Journal, vol. 106(437), pages 1045-1055.
- Rose, A., 2000, "One money, one market: the effect of common currencies on trade", Economic Policy, vol. 23, pages 9-45.
- Sala-i-Martin, X., 1997, "I Just Ran Two Million Regressions", American Economic Review, American Economic Association, vol. 87(2), pages 178-83.
- Sala-i-Martin, X., 1996, "The Classical Approach to Convergence Analysis", Economic Journal, Royal Economic Society, vol. 106(437), pages 1019-36.

Schneider F., 2004, "The Size of the Shadow Economies of 145 Countries all over the World", IZA Discussion Paper, vol. 1431.

Tabellini, G., and Wyplosz, C., 2004, " Réformes structurelles et coordination en Europe ", Conseil d'Analyse Economique, Rapport n° 51.

Timmer, M. P., O'Mahony, M., and van Ark, B., 2007, "EU KLEMS Growth and Productivity Accounts: An Overview", International Productivity Monitor, vol. 14.

Wolff, E., 2000, "Human Capital Investment and Economic Growth: Exploring the Cross-Country Evidence ", Structural Change and Economic Dynamics, vol. 11, pages 433-472.

Wyplosz, C., 2010, "The Eurozone in the Current Crisis", ADBI Working Papers 207, Asian Development Bank Institute. Young, Higgins and Levy 2004.

Global Competitiveness Report, World Economic Forum (2012)

# APPENDIX

## Appendix A: Data definitions and sources

The cluster analysis mobilizes 23 indicators, presented briefly in section II, mostly provided by the OECD. This appendix provides more detailed definitions, the sources of these indicators (when not provided by the OECD) and their correlations with GDP per capita growth (see Table A).

### **Knowledge field indicators**

Educational expenses: Total public expenditures on education as % of GDP, for all levels of education.  
Source: Eurostat

PISA scores: PISA is the OECD Program for International Student Assessment. It evaluates 15-year-old's skills in reading, mathematics and the sciences. We use the simple average of the three tests. Only the reading tests are available since 2000; for the other skills, when data were not available, we imputed the value of the closest year available

College studies: we use the percentages of people who have received some college level education among the 25-34 and the 25-64 year-old age brackets. Indeed, higher education in these two different age brackets groups could have different impacts, particularly concerning the use of Internet and communications technology. (Source: Eurostat).

Business R&D: Research and Development expenses declared by businesses, as a % of GDP.

Patents: number of triadic patent families per million of population. Triadic patents are filed simultaneously at the European Patent Office, the United States Patent office, the Trademark Office and the Japan Patent Office.

Innovating firms: percentage of revenue generated by innovating firms in total revenue. An innovating firm is an enterprise that has introduced new or improved products or services to the market or new or improved processes. Firms can have innovative activities without introducing any innovation to the market (it may either have been unsuccessful or as yet not completed innovative projects). Source: Eurostat.

### **Labour mobilization field indicators**

Employment rates by age group: employment rates among the 15-24 and 55-64 year-old age brackets, which account for most of the employment differences between countries.

Female employment: female employment as a % of male employment.

Temporary employment: number of workers with temporary contracts as their main job (fixed-term or temporary agency contracts) as a % of workers with permanent contracts.

Source: OECD

Long-term unemployment: number of long-term unemployed as a % of total unemployment in the 15-64 age bracket. Long-term unemployment is defined as periods of 1 year and over without employment.

Population age: the cluster analysis includes the proportion of young people (under 15) in the whole population and the proportion of older people (65 and over).

### Regulations and quality of institutions field indicators

Strictness of Employment Protection Legislation (EPL): the OECD provide indicators of employment protection measuring the procedures and costs involved in dismissing workers and the procedures involved in hiring workers on fixed-term or temporary agency contracts. The cluster analysis only mobilizes the indicator on permanent contracts, thus focusing on dismissals, following the empirical literature underlining the impact of this indicator (see Bassanini, Nunziata and Venn (2009)).

Product Market Regulations (PMR): the product market regulation indicator measures, at the economy-wide level, the extent to which policy settings promote or inhibit competition in areas where competition is viable. The indicator's scale is from 0 to 6, with 0 for the most pro-competitive regulation. Source: OECD.

Transaction costs: the average transaction cost (for buyers and sellers) of purchasing properties as a % of value of the property. The estimates do not take into account the various tax breaks that exist in countries for certain dwellings implying that the estimated cost may overestimate the actual cost in some countries (for example in Italy) where such tax breaks are frequent. In addition, VAT when applied to certain costs is not included due to data limitations.

Because of the major difficulties in measuring the quality of institutions associated with the underground economy, justice and corruption, we use two different sources for each of these indicators in order to mitigate uncertainty.

#### Underground economy:

- Subjective indicator built from managers' ranking of the statement "Parallel economy does not impair economic development". On a scale from 0 to 10, with 10 indicating the least significant constraints on economic activities. Source: International Institute for Management Development (IMD).
- Estimates of the size of the underground economy, as a % of GDP on average over the 1999-2003 period. Source : Schneider (2004).

#### Justice :

- Subjective indicator build from managers' ranking of the statement "Justice is fairly administered". On a scale from 0 to 10, with 10 indicating the most fairly administered societies. Source : IMD.
- Subjective indictor build from different sources of information and measuring the abuses of public power for private benefit. The scale of the indicator is from -2.5 to +2.5, with -2,5 for major abuses. Source: World Bank Governance Indicators (WBGi).

## Corruption

- Subjective indicator build from managers' ranking of the statement "Bribing and corruption do not exist". On a scale from 0 to 10, with 10 indicating the most serious cases of bribery and corruption. Source : IMD.
- Subjective indicator build from different sources of information and measuring trust in the rule of law (particularly regarding contract enforcement and respect of private property). On a scale from -2.5 to +2.5, with -2.5 indicating a total lack of trust. Source: WBGI.

## Correlations with GDP per capita growth

Table A presents the correlation of the indicators' values in 1995 with the GDP per capita growth over the 1995-2007 period. We present these linear correlations because we mobilized them for one of the sensibility analyses of our cluster analysis. However, they cannot provide interesting conclusions since the number of observations is small and the risk of bias is high. Some of the presented correlations are weak and four exhibit unexpected sign (educational expenditures, 55-64 employment rate, and strictness of employment protection and transaction costs)

Table A: Correlation of indicators' values in 1995 to GDP per capita growth over the 1995-2007 period

	Correlations
Educational expenses	-0,166
PISA scores	0,211
College 25-34	0,386
College 25-64	0,277
Business R&D	0,010
Patents	-0,169
Innovating firms	-0,166
Employment rate 15-24	-0,074
Employment rate 55-64	0,244
Female employment	-0,142
Temporary employment	0,044
Long-term unemployment	-0,071
Population under 15	0,765
Population over 65	-0,786
EPL	-0,296
PMR	-0,358
Transaction costs	-0,155
Underground economy (size)	-0,438
Underground economy (IMD)	-0,072
Justice (IMD)	0,428
Justice (WBGI)	0,207
Corruption (IMD)	0,452
Corruption (WBGI)	0,219



## Appendix B: Overall convergence measure

The only information required to compute the overall convergence measure over the period 1995-2007 is the group means and the coefficient of variations.

Indeed, we define a measure of overall convergence for the 1995-2007 period as the ratio of variance of the 'detrended' variables. As the rescaled indicators  $x$  have a variance equal to one in 1995 by definition, this convergence could be broken down as follows, underlining the Between (B) and Within (W) dispersions:

$$\frac{1}{m} \sum_x \frac{Var(x^{07})}{Var(x^{95})} = \frac{1}{m} \cdot \sum_x (W(x^{07}) - W(x^{95})) + \frac{1}{m} \cdot \sum_x (B(x^{07}) - B(x^{95}))$$

We note  $x$ , the rescaled indicator, and,  $y$ , the non-rescaled indicator.

Since there are only two identified groups, let us denote them as South and Other, the between-group contribution can be written as:

$$B(x^t) = \frac{n_S}{n_O} \cdot (x_{..S}^t - x_{..}^t)^2$$

With  $n_S = 4$  and  $n_O = 8$ .

By noting that:  $x_{..O}^t - x_{..}^t = n_S/n_O \cdot (x_{..}^t - x_{..S}^t)$ , it is straightforward to check that the differences to the mean - in terms of  $x$  and in terms of  $y$  - are related by:

$$x_{..S}^t - x_{..}^t = \frac{1}{cv(y^{95})} \cdot \left( \frac{y_{..S}^t}{y_{..}^t} - 1 \right)$$

With  $cv(y^{95})$  the coefficient of variation of  $y$  in 1995

Finally we obtain:

$$B(x^{07}) - B(x^{95}) = \frac{1}{2 \cdot (cv(y^{95}))^2} \cdot \left( \left( \frac{y_{..S}^{07}}{y_{..}^{07}} - 1 \right)^2 - \left( \frac{y_{..S}^{95}}{y_{..}^{95}} - 1 \right)^2 \right)$$

In the same way, let us note also that the within-group contributions to the overall change of the dispersion are given by:

$$W(x^{07}) - W(x^{95}) = \frac{1}{(cv(y^{95}))^2} \cdot \sum_j \frac{n_j}{n_{..}} \cdot (cv_j(y^{07}) - cv_j(y^{95}))$$

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