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Regional Innovation Index

Regional champions within national Innovation Systems

Alberto Bramanti and Stefano Tarantola

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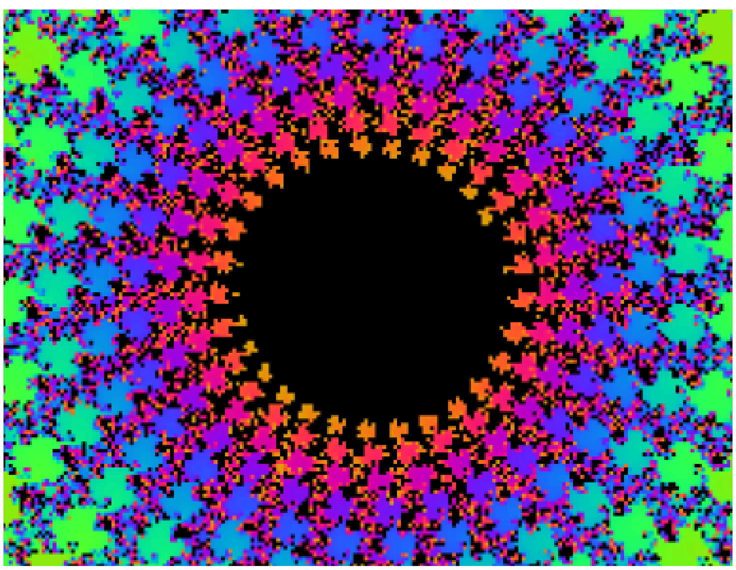

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One of the authors – Alberto Bramanti – worked at the project during his sabbatical leave from Bocconi University – Milan (IT). *«I had the opportunity to spend eight months in such a rich, stimulating and friendly scientific milieu that is the JRC–IPSC. Many thanks to the Unit Head Andrea Saltelli for his warm welcome and to all the staff for supporting me during my staying.»*

We take full responsibility for the research product. All the residual mistakes, or inaccuracies are our only faults.

«... L'esperienza più bella che possiamo provare è il senso del mistero. È l'emozione fondamentale che accompagna la nascita dell'arte autentica e della vera scienza. Colui che non la conosce, colui che non può più provare stupore e meraviglia è come morto, ed i suoi occhi sono incapaci di vedere.»

Albert Einstein

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Executive Summary

Preamble

The present Report is rooted in the previous *Regional Innovation Scoreboard 2009* (PROINNO Europe, 2010) exercise, using its published data of Annex 4 (*the normalized data per indicator by region for 2004 and 2006*). We add other data publicly available from the Eurostat database, and compute the average between the two points in time 2004 and 2006, calling it the '2005 data-set'. Then we estimated the missing values (see Chapter 2) and ended out with a complete matrix – of 35 regions and 17 indicators – on which we work defining a new composite indicator: the *Regional Innovation Composite Indicator* (RICI), (see Chapter 3).

Main objectives of the Report

There are basically two main objectives in this Report, which is articulated in two PARTS and ten Chapters.

In the **FIRST PART** of the Report we **look at composites from the point of view of researchers and practitioners**, and we develop the methodological discussion and the operative construction of a new one. Our focus is on the most innovative regions in Europe with the aim of detecting and describing the distinguishing features of their innovation profiles, and to reach a workable synthesis of such a multi-faceted phenomenon called innovation. Composite indicators (OECD–JRC, 2008) seem to be the natural candidates for this job as they ideally measure multi-dimensional concepts which cannot be captured by a single variable. The main results of the FIRST PART of the Report is, therefore, **the robustness testing and the sensitivity analysis of the computed composite indicator**. In a nutshell, the Report starts with the rigorous construction of a composite indicator, comprehensively discussing how all the workable hypothesis will be tested. The construction process follows the well known and structured procedure, developed by JRC on composite indicators (OECD–JRC, 2008; PROINNO Europe, 2009; 2010) and carries it out at a very detailed level. The Report **explores a large basket of possible meaningful alternatives and tests robustness as well as sensitivity both in a deterministic, as well as in a probabilistic setting**.

The **SECOND PART** of the Report is written by one of the authors. **In this part the author looks at composites from the point of view of the policy-making process.** The overall picture, as well as the narrative, are therefore completely different. The second goal of the Report is, therefore, more ambitious and, to some extent, less defined: it looks at the national dimension (the NISs contribution to regional innovation) and the relationship indicators–policy models. Policy makers in Europe, and especially after the deep and painful financial, economic, and social crisis, **are re-framing policy goals within the Europe 2020 strategy**, looking at effectiveness of measures, surviving and growth of existing firms and job creation process. The attention on innovation, which is still very high, **is moving from the simple 'fostering innovation' objectives, towards the more complex and interdependent goals of 'gaining value from knowledge'.** The declination of this new attention has been on **entrepreneurship and human capital** – and policy makers see these assets as the most important ones on which converge public and private investments – **instead of simply raising R&D expenditures and patent applications.** At the end of the Report it will emerge **the need for new, fresh regional data**. The author signaled the main deficiencies of the existing data sets, especially in their territorial coverage (NUTS2 level), and attention to 'soft' innovation.

Main messages and recommendations

1. The main result of the **First Part** is **a 'robust' ranking of innovative regions which delivers a precise map of 'strong regions' in Europe** – with German Länder and Swedish regions outperforming – beyond any reasonable doubt.
2. The main results of the **Second Part** are: *firstly,* **a new centrality of a sound, reliable, updated 'information system'** – of which composite indicators are a fundamental ingredient – where the relationship between indicators and the policy model is read according to a 'discoursive-interpretative model'; *secondly,* the need for a regional (NUTS2) innovation system of indicators that records also more 'soft aspects' of the innovative process, and gives the greatest attention to human capital measurements. **Micro-data, collected with innovation surveys, and possibly longitudinal data (supported by sound panels of firms), seem to be mandatory for this purpose.**
3. We are convinced that composite indicators – even if their construction falls far short of being an exact or agreed science – **have the merit to speak 'loud and clear'**. They call for the greatest attention from regions in order to identify their weaknesses and look for improvements, from National Statistical Offices and from Eurostat, in order to collect data at a finer territorial grain on 'soft innovation' and on relational dimensions of the innovation process.
4. The innovation-oriented policy agenda calls for **an effective monitoring system, rooted in sound, reliable, timely set of indicators**, allowing policy makers to plan, implement, and re-frame a more 'evidence-based policy'.
5. The utilization, among others, of the *Data Envelopment Analysis* (DEA) methodology, as a suitable weighting procedure, shows the large number of regions which are actually using their inputs efficiently. **The final ranking of the 35 regions offers a clear-cut list** without doubts on their relative performance (see Chapter 5).

   Recommendation 1 — *the weighting scheme is by far one of the most important sources of uncertainty. The proper choice of the weights is therefore a strong priority.*
6. We test different aggregation choices including partially compensatory ones; **less performing regions have to improve in all the Pillars** in order to gain position in the ranking of innovative regions (see Chapter 6).

   Recommendation 2 — *regions could fast improve their ranking position by first addressing their less favorable factors.*

   Recommendation 3 — *in the aggregation of indicators apply also partially compensatory procedures. Full compensatory approaches have different* *shortcomings; the more the indicators are unbalanced, the more expensive compensability could be.*

7. Comparing forty discrete scenarios (to simulate different hypothesis in the construction of the composite indicator) **we can distinguish three different groups of regions which are well separated from each other** (see Chapter 7).

   Recommendation 4 — *the more the factors we allow to vary, the greater the uncertainty to be expected in the composite scores. Therefore, carefully identify a neighborhood of alternative assumptions 'wide enough to be credible'. and test, via uncertainty analysis, whether the corresponding interval of inferences is 'narrow enough to be useful'.*

   Recommendation 5 — *even when we cannot reach a complete ranking of all the regions, we should be satisfied to have clearly identified some clusters.*

8. In the probabilistic setting the imputed values are considered as normally distributed variables having the mean equal to the nominal imputed value and the standard deviation set according to the assumed error for the imputation procedure (see Chapter 8).
9. **We discuss the role of the different determinants of the overall regional innovation performance** (see Chapter 9). While the first three Pillars (in their original form) are not meaningful in explaining regional innovative performance, the picture becomes clearer when we replace Pillars with Factors (resulting from applying factor analysis to the original dataset).
10. The availability of the new SII (*Summary Innovation Index*) for the years from 2006 to 2010 enables us to highlight **the strong persistence of the national ranking among the 10 Countries analysed**. A direct implication is that the 'RICI 2005' proposed in this study remains appropriate in studying regional innovative performance.

    Recommendation 6 — *it is necessary to study the dynamics of the indicators. When they show stability over time (as in the SII case) also 'older data' (such as the RICI 2005) should be trustworthy.*

11. It is important to address and interpret the link between indicators and policy-models. **The 'discoursive-interpretative' model is the most appropriate and rewarding for policymaking** (see Chapter 10). A distinction between 'use' and 'influence' of indicators should be made: **it seems more fruitful to think about the role of indicators as the 'influence' they can exert on policy makers.**
12. *What are composite indicators useful for?* They offer an answer to policy makers on the strengths and weaknesses of the regional innovation systems. They guide policy-makers towards more 'evidence-based' policies. They convince statistical offices to devote greater efforts in collecting sound, comparable, timely, regional data (see Chapter 10).

1. Introduction

The dynamics and the geography of innovation are extraordinary important issues in understanding the direction and the pace of growth in knowledge-based economies. There is large agreement at the policy level that innovation (in its broader meaning) is a key to the future achieving sustainable long-term economic recovery, as advocated by the European Strategy (Europe, 2020) and its Innovation Union Flagship Initiative (COM, 2010-546).

The recovery out of the global crisis for developed Countries – beyond public finance control and monetary stability – is substantially expected from increasing productivity (Expert Group Report, 2009; European Union, 2010); productivity is first and foremost a better use of inputs, thanks to the strong support offered by process and organizational innovations, as well as by a more intense use of immaterial resources (Bessant and Venables, 2007), mainly brainware and creativity (Hollanders and van Cruysen, 2009; Villalba, 2008). Moreover, new products are the only ones on which developed Countries can compete against BRICs and, also from this point of view, product innovation is on top of the agenda of policy makers and entrepreneurs.

1.1 The re-emerging role of regions

Despite the fact that information is quite widespread and we frequently deal with an increasing overflow of information, knowledge is all but a free and costless commodity. On the contrary, knowledge is subject to a strong 'path dependency'[1], that is economic agents try to search close to the knowledge they already have (Magnusson and Ottosson, 2009). As a consequence, also the final result of the whole process – the endless spiral 'information, knowledge, know how, creativity' that is, innovation in all its multi-faceted dimensions (see further on Figure 3.1) – is spatially concentrated and strongly supported by a specific, many times idiosyncratic, systemic context which scholars are used to call 'National/Regional Innovation Systems' (Braczyk, Cooke and Heidenreich, 1998; de la Mothe and Paquet, 1998; Etzkowitz, 2008; Niosi, 2010). It is not so surprising, therefore, that regions are becoming more and more important nodes of economic and technological organization in the new age of global, knowledge-intensive capitalism (Rutten and Boekema, 2007; Eurochambres, 2008).

The present section (§ 1.1) aims at exposing, and presenting in brief, issues surrounding the policy agenda: the long-term sustainability of our model of growth (Jones and Romer, 2010), and the role of innovation in guiding societal and market answers to the epocal questions on development and quality of life (Stiglitz *et al.,* 2008). The short-term competitiveness issue, and the role of firms in creating 'good jobs', are likely to be, to a large extent, an expected outcome of innovation efforts (Niosi, 2010; Storz and Schäfer, 2011).

[1] According to David (2000) *path dependence* is a dynamic property of allocation processes that are limited by their past states. Initial conditions matter and many factors contribute to rigidify the original path (knowledge, sunken costs, initial technical choices, contracts and regulations, etc.).

Firms, on average, are smaller in Europe compared with their American counterparts and, therefore, they often need to cluster, to fully benefit from technological spillovers. But clusters – even if they should remain to a large extent 'spontaneous' and market driven – calls always for a proper governance, and for well functioning territorial organizations and institutions, which are mostly important in framing a sound *Regional System of Innovation* (RIS) (Niosi, 2010; Wintjes and Hollanders, 2010).

The awareness of all these themes – and of their centrality in shaping competitiveness, societal quality, and well-being – dates back in Europe to early '80s and before. As time went on, the EU has substantially improved its efforts towards innovation. For the period 1989-1993 the 4% of Structural Funds were dedicated to innovation (2 billion € out of 50); from 1994 to 1999, the 7% (4.6 billion € out of 110); from 2000 to 2006, the 11% (20 billion € out of 195); and finally for the current period 2007-2013, the 25% of structural funds were dedicated to innovation (86 billion € out of 345). In addition, Member States have devoted a total of 86 billion € of EU regional funds to research and innovation in their 246 National or Regional Operational Programmes.

Further on, the 'unexpected' financial crisis has risen more deep-rooted questions beyond the recovery process, questions related to long term sustainability of our model of growth. Given current technologies, these challenges seem to be out of the reach in terms of emissions, natural resources exploitation, food production, and access to water (Expert Group Report, 2009; Soete, 2009). As a consequence the themes of innovation strategies (at all the different territorial levels, global, European, national and regional ones), of Community research policy, of the balance (never gained once and for all) between competition and coordination in national/regional allocation of scarce resources, are all challenging questions on the table (Halkier *et al.*, 2010).

Microeconomic competitiveness of firms comes back in the light as a major test of survival of the productive systems and of the capacity to create jobs and wider prosperity. Looking at the British economy, NESTA research shows that the 6 per cent of UK businesses with the highest growth rate generated half of the new jobs, created by existing businesses between 2002 and 2008.

«Although these companies came from across the country and from all sectors of the economy, they had one important factor in common: they were far more likely to be innovative, and the research shows that their innovation was the source of growth. This has important implications for the Government (...). It shows that an approach of backing excellence and innovation is not an elitist policy: rather, it is the best way of generating employment and opportunities.» (NESTA, 2009: 3).

Clusters[2] are a very widespread phenomenon all around the world (Borras and Tsagdis, 2008) and show an extraordinary strong statistical regularity whatever the production – goods, services, ideas, etc. – under scrutiny would be. As innovation is mainly an interactive process, it appears to be a strongly clustered phenomenon: with important regional and city poles, with a clear-defined net-like

[2]The cluster term has intrinsically a 'fuzzy' character. *«While classical explanations refer to Marshall's ideas of agglomeration externalities like common regional labour pool, specialized suppliers, a shared infrastructure and knowledge spillovers, some additional factors beneficial for geographically concentrated firms have been identified in the past two decades. Besides others they include the access to networks, to a local science base and/or to local knowledge in general, but also 'buzz' in the sense of a diffuse and pervasive sharing of information, the co-ordination of complex tasks, local competition, supportive institutions and the characteristics of regional cultures.»* (Fornahl, Henn and Menzel, 2010: 1).

structure and fundamental feedbacks, loops, and look-ins governing all growth, fluctuation and decay processes (Malerba and Vonortas, 2009). Regional clusters are therefore regarded as a tool that could be used to improve regional growth and to prevent the delocalization of productions outside the region[3].

At least to some extent this positive role derives from the 'proximity issue'. If the relevant actors are close to each other, the spreading of all kind of information is facilitated; proximity enhances the role that cluster networks play in innovative activities, the combination of new solutions is eased up if information about components is at hand[4] (Malecki and Hospers, 2007; Blien and Maier, 2008).

It is therefore quite understandable that the research agenda would be full of many questions on the role of 'distances' in shaping innovative performances (Boschma, 2005; de Jong and Freel, 2010) and spillover effects (Maier and Sadlacek, 2005; Trippl and Maier, 2010). In particular, the notion of 'knowledge spillover agents' becomes central to the debate:

«[It] reflects the view and growing insight that these individuals promote the spilling over and the circulation of their top-level knowledge and expertise between organizations, regions and nations by means of their movements and through various forms of knowledge transfer activities.» (Trippl and Maier, 2010: 229).

Governance and leadership are very important in order to foster successful world-class clusters and transnational collaborations. A Triple Helix (Leydesdorff and Etzkowitz, 1998) based management, which puts together leading representatives from the business sector, academia and public sector, seems to be useful – and to some extent necessary.

As a matter of fact organizations and institutions play a growing and decisive role in framing regional systems of innovation in which collective agents matter (Braczyk, Cooke and Heidenreich, 1998; Niosi, 2010) and make the difference, not only because innovation is shaped by a variety of institutional routines, and social conventions, but also because they play the fundamental role of gateways. They contribute in putting the regional innovation system in contact with the global economy as a key channel to renovate and to augment the local knowledge base and to mitigate the potential risks of lock-in.

The rapidly increasing global competition urges larger critical mass, new cross sectoral combination of knowledge and resources of a size that regions might have difficulties to provide alone. Supporting the international mobility of cluster actors may be a role successfully played by institutional actors interested in creating stronger linkages between clusters in different locations, which offer complementary strengths, providing access to the most advanced technologies and know how.

There is much research in support of the idea that differences in economic performance and specialization across regions can be explained by the institutional endowments (Ostrom, 2005; Molle and Djarova, 2009). Such endowments –

[3]The Region of Knowledge is a fully flagged program under FP7 with a budget of EUR 126 million over seven years. The program aims at promoting regional economic development by boosting cooperation, across Europe, between at least three mature regional research-driven clusters. Fifteen projects were selected in 2008 in the field of reducing CO_2 emissions; mine projects were funded in 2009 on sustainable use of natural resources.

[4]There are two main agglomeration economies which link together clustering of activities and innovation paths. The first is related to a market for specialized labour, the establishment of a local pool of skilled labour known since Alfred Marshall wrote on the advantages of being located in an industrial district. The second is connected to localized learning and knowledge spillover in a local milieu stimulating processes of interactive learning.

sometimes called *localized capabilities* (Malmberg and Maskell, 2006) – include rules, routines, habits and traditions.

«Localized capabilities construct the environment for creation of localized knowledge in a region, meaning that the knowledge created in not ubiquitous, but has the characteristics of tacit knowledge. The creation of tacit knowledge reinforces the institutional endowments and local competitiveness.» (Lagerholm and Malmberg, 2009:100).

As earlier noted, the innovation-oriented policy agenda, contains a huge number of relevant issues. They all call for an effective monitoring system, rooted in sound, reliable, timely set of indicators, allowing policy makers to plan, implement, and continuously re-frame an 'evidence-based policy'.

Next section will present a comprehensive detail of the entire Report.

1.2 Presentation of the Report

The present Report is directly rooted in the previous *Regional Innovation Scoreboard 2009*[5] (PROINNO Europe, 2010) exercise, using its published data of Annex 4 (*normalized data per indicator by region*). It is organized in two Parts and ten Chapters which are here presented.

FIRST PART — We perfectly know – and share the opinion – that the construction of composite indicators falls far short of being an exact or agreed science[6]. And the picture is even worse due to media propensity to absorb 'quick and dirty' comparative measures of regional performance. We are also aware that the RICI is not the 'best representation' of the innovation phenomenon even in a compact subset of European innovative regions. But, anyway, as the Nobel-laureate Amarthia Sen wrote, after a harsh debate, on the Human Development Index (HDI):

«the crude index spoke loud and clear and received intelligent attention and through that vehicle the complex reality contained in the rest of the Report also found an interested audience» (United Nations, 1999: 23).

We surely can say the same thing: the RICI speaks 'loud and clear'; it calls for the greatest attention from regions in order to identify their weaknesses and look for improvements, from National statistical offices and from Eurostat, in order to collect data at a finer territorial grain on 'soft innovation' and on relational dimensions of the innovation process. There are evidences that the growing disparity between successful and lagging regions in the EU is reflective of the difference between innovation–prone regions, where there is strong policy support for innovative firms, and innovation–averse regions, where relevant policy support is much less developed or backward (Rodriguez-Pose, 1999; Bristow, 2010; Wire 2010). In view of all the methodological and interpretative problems, the FIRST PART articulates in seven Chapters the construction of the composite.

[5]RIS (*Regional Innovation Scoreboard*) is a Report prepared by Hugo Hollanders from MERIT (the Netherlands) and Stefano Tarantola and Alexander Loschky from JRC–IPSC (Italy) with the aim to provide a comparative assessment of innovation performance across the NUTS 2 regions of the European Union (PROINNO Europe, 2010).

[6]We are aware of the long lasting debate between 'aggregators' and 'non-aggregators' scholars (Sharpe, 2004; Saltelli *et al.,* 2006), and we will deal with the issue of usefulness later on (see § 1.3). We can just anticipate that composite indicators are not the 'one best way' to represent complex systems, but certainly a possible solution with *pros and cons*, subjective in nature and depending on value judgement and policy preferences.

Second Part — A sort of estrangement and dissatisfaction has been growing along the First Part of the Report due to the problems arising from lack of good data and reasoning of the innovation model that implicitly sustains a too exclusive attention to 'hard' measures of innovation (such as inputs indicators).

«The presence of advanced sectors and advanced functions like R&D and higher education are special features of only some of the possible innovation paths and, though relevant, cannot be considered as necessary or sufficient preconditions for innovation. Furthermore, emphasizing the stock of human capital, advanced functions and sectors may risk overlooking the interactive process between the different actors of knowledge development, which is increasingly seen as the crucial element in knowledge creation and evolution.» (Camagni and Capello, 2009: 148-149).

Starting from a central point which remains an unanswered question – *«does the R&D goose really lay golden eggs?»* – we introduce the debate on 'evidence based policy', signaling the new centrality of the 'discoursive-interpretative' policy model (Boulanger, 2007; Gudmundsson, 2009).

1.1.1 The single Chapters' contents

Chapter 1 — The Report opens stressing the role of innovation in fostering competitiveness and sustainable growth in the medium– long–term period. Looking at this issue, a central role of regions and RISs will emerge. Central actors are here institutions[7] and organizations playing a fundamental function in enhancing knowledge accumulation and transfer. The Chapter closes rising the main question on composite indicators' usefulness, a largely controversial issue to be addressed. That is why we shall deal with it again in the last Chapter (see Chapter 10).

Chapter 2 — The first task of the Report is to identify an appropriate selection of innovative regions. We opted for a two-step procedure. Firstly we choose 10 Countries, all the 'five big' (German, France, Italy, Spain, and UK) and five small but innovative Countries (Austria, Belgium, Finland, the Netherlands, and Sweden). Within this selection, we picked up the four most innovative regions of the 'big five' and the three most innovative regions of the other five Countries, for a total number of 35 regions (see Table 2.1).

Chapter 3 — Secondly, we looked at the raw data (emphasising on missing values and the imputation procedure) and commented on the differences in absolute values. Even the European Innovation scoreboard (EIS), aimed at measuring innovation performance at country level since 2000, has been the object of constructive critics by Hollanders and van Cruysen, 2008 and Schibany and Streicher, 2008. The main problem affecting the EIS is the 'omission' issue, *i.e.* the fact that the EIS does not capture all relevant dimensions of innovation and does not take into account structural differences between countries. Obviously, these critics are even more severe if we look at the regional level: here the emerging shortcomings mixed with a lower availability and accuracy of data, at NUTS2 level, make the evaluation task more difficult and in this Chapter we shall be devoting attention to some major critics (see § 3.1). Chapter 3 portrays a detailed presentation of data, distinguishing, within the Pillars, indicators belonging to four different categories:

[7] A widespread and rising literature insists on the role of institutions in shaping different innovative behaviours and therefore affecting economic performance. This is not to deny that factors such as demand, competition, and geography matter, but it is worth stressing the quality of institutions.

input, process, output, and outcome measures. The main novelty introduced with respect to the RIS 2009 exercise, is the emphasis on a fourth Pillar with the aim of distinguishing market results (sales) derived from innovation, and not mixing this last with the measures relative to innovative outputs.

CHAPTER 4 —The procedure to construct a robust, meaningful, and understandable composite indicator – the main aim of the fourth Chapter – is valued, from the point of view of regional competitiveness. Despite the fact that the competitiveness issue is still largely elusive (Bristow, 2010), it is doubtless that innovation matters at the regional level and that innovation index is an important proxy of the health state of the different territorial economies.

Chapter 4 contains a key point relating to the aggregation phase and the compensability debate, before introducing and commenting on the new RICI indicator and its ranking outcome. The next two Chapters will be devoted to weighting choices and aggregation.

CHAPTER 5 — This Chapter is devoted to the weighting choices. In addition to the standard solution (equal weighing) we shall be exploring the DEA (*Data Envelopment Analysis*) methodology, and a specific version that is the *cross efficiency DEA*. The cross efficiency scores, are derived from cross efficiency matrix; when a region shows a high cross efficiency score on average, we can assume it is actually using its inputs efficiently. The frequencies matrix of the BoD weights (see Table 5.7), offers a clear-cut ranking of the 35 regions without much doubts on their relative performance.

CHAPTER 6 — In the present Chapter, the emphasis rather remains on aggregation choices, exploring the OWA (*Ordered Weighted Averaging*) operators for aggregation purposes. The most important result of different aggregation choices (not fully compensative) is that regions have to improve all the Pillars in order to gain position in the ranking of innovative regions, and have to start from worse scores.

CHAPTER 7 — This Chapter analyses robustness and compares forty alternative scenarios deriving from the combination of different methodological choices. A glimpse of the regions' performance is offered by two scatterplots (see Figures 7.3, 7.4) comparing RICI scores and ranks. The Chapter goes on testing differences in means with the *Wilcoxon non parametric test* and completing the uncertainty analysis. The main result is that we can distinguish three different blocks of regions well separated from each other (see Figure 7.3), while within the blocks regions overlap according to different scenarios. This is a direct consequence of the application of DEA or OWA weighting schemes, which are both 'extreme' solutions.

CHAPTER 8 — The present Chapter develops the analysis in a probabilistic setting. Instead of dealing with discrete choices, we explore the space of alternatives by generating a considerably large number of scenarios using the Monte Carlo method. In particular – coherently with the previously recalled criticisms – we focus on uncertainty in the indicators scores and in the weights used for their aggregation. Any score that is the outcome of an imputation routine is replaced with a normally distributed variable, having the mean equal to the nominal imputed value and the standard deviation that is set according to the assumed error for the imputation procedure. Concerning the weights for the individual indicators, we consider the *baseline* equal weights scenario with normal distribution of weights.

These two additional sources of uncertainty produce an infinite number of combinations (with the power of the continuum) from which a Monte Carlo sample of size 50,000 is generated[8]. The main results here confirm what has already been stressed in the previous Chapter. As far as robustness is concerned we find out the main three well distinct blocks of regions: for instance, the first three regions always rank in the first three positions, while overlap in the blocks. According to sensitivity, the weighting scheme is the most important source of uncertainty and therefore, is the first thing on which experts would agree.

Chapter 9 — In this Chapter we analyze the innovative path as a precondition for regional performance and, contextually, we up-date country level data to 2010, thanks to the recent availability of the IUS (*Innovation Union Scoreboard*) 2010. The main results are the following.

Notwithstanding the presence of a convergence path among European Countries, the absolute levels reached deliver a very clear-cut hierarchy of innovative nations. Sweden, Finland and Germany are strongly ahead, leading the global competitive race of a European Union rooted on knowledge and innovation. Not surprisingly the final ranking of European Countries in 2010 is almost a copy of the previous one computed in 2005 (RICI) or 2006 (SII).

To explain firms' innovative performance (captured by Pillar 4) we developed some regression exercises showing that NISs do not seem to affect at any level firms' performance, while firms' characteristics are rather the most relevant factor.

The two previous results support the RICI 2005 composite as a meaningful synthesis of the relative position of innovative regions.

Chapter 10 — While the rhetoric on innovation is rather widespread, policy makers have changed the questions to be addressed: these are now relating to the need for 'getting value from knowledge' (final outcomes and societal results, instead of simply resting on output indicators), and the 'quest on R&D' which is no more seen as a sufficient condition for success.

Chapter 10 goes on addressing the relationship indicator–policy model and identifying the 'discoursive-interpretative' model as the most rewarding for policymaking. The need for coherent information systems is the strong implication of re-framing policy goals and, in this view, innovation indicators become relevant from a theoretical, practical, ideological and political point of view.

A new political awareness, sharpened by the recent crisis, has contributed to a renewed attention for entrepreneurship and human capital (and young innovative firms are a central outcome of the union of these two factors).

After having presented and discussed two alternative measures of innovation and human capital – High Level Panel Group (High Level Panel, 2010) and Lisbon Council (LC, Ederer *et al.,* 2011) – the Chapter comes back to the regional data, making a point for rich and well designed innovation surveys, possibly longitudinal, but certainly territorial stratified, for analysing regional (NUTS2) level.

[8]This high number of sample points is necessary to explore the space of the uncertainties as much as possible.

1.3 Are composite indicators definitely useful?

We close this introduction anticipating a final consideration about the frequently reported objection of using composite indicators to 'name and shame' individual objects (regions, countries, hospitals, universities, teachers, and so on). No one – and policy makers less than others – would like to be pointed out as a laggard element in a benchmark process. Comparisons among different top performing European innovative regions – apart for the problem of data availability and comparability – implies that those regions follow the same development path and innovation trajectories. And we know that there are different regional models to innovate. There is no 'one best way' but certainly great importance could have a balanced mix among the access to knowledge, the absorptive capacity – which enables the metabolization of what is coming from the outside – and the local capability for diffusion an re-combination of knowledge and technology.

There is a wide strand of literature, supported by sound empirical analysis, which shows the extent and the relevance of country-specific, as well as sector specific (Breschi and Malerba, 1997; Breschi, 2000; Malerba and Vonortas, 2009), different paths to innovation (Carricazeaux and Gaschet, 2006). All that highly depends on the fact that the dynamics of the regional innovation system is not only determined by the regional governance structure but also by the sectoral patterns of innovation:

«The regional performance is thus no more a question of optimal governance structure but rather of coherence between industrial structure and the knowledge creation and diffusion setup.» (Carricazeaux and Gaschet, 2006: 13).

A strong implication may even be a questioning about 'composite indicators', as they naturally address a benchmarking approach. Once again, 'aggregators' think that composite indicators can provide a 'bottom line' to the phenomenon under scrutiny and this, in turn, may rise the attention of media, citizens, and policy makers. Moreover, it seems finally accepted that the quality of a composite (fitness for purpose) strongly depends on the existence of a community of practice (be individuals, regions, intermediate institutions, etc.) who will accept the indicator as a common language to frame the problems, sharing a degree of understanding of the issue at hand.

The right question therefore – provided that the correct procedures have been applied – is not the 'why' but rather the 'what' one: *«what are they (composite indicators) useful for»?* We offer some possible answers in the final Chapter of the report.

The FIRST PART of the Report is devoted to the computation of the RICI on a sub-set of 35 regions among the most innovative in Europe – while the SECOND PART discusses the 'what' question, among other important points.

All the reasoning on composite indicators has certainly two fundamental by-products. The *first* is related to policy makers' awareness of a number of implications of their choices. To construct a composite implies answering various questions: *i)* the goals to be pursued; *ii)* the model of innovation (the cause–effect relations); *iii)* the bearing structure of the composite; *iv)* the weighting scheme (the differential role of the 'ingredients').

The *second* by-product is a clearer indication of the needed data. Notwithstanding the great efforts lavished in recent years by Eurostat and OECD – the two main international Institutions systematically gathering data on innovation, – we are still in a 'waste-land'. We have meaningful data – with a wide coverage of different topics – only at Country-level, but insufficient information at the regional (NUTS2) ones: incomplete, old, disomogenous data. We have many data related to inputs (such as R&D, human capital, high-tech sectors, etc.) and output results (such as patents, publications, export, etc.), but we have much less information on 'soft' innovation (such as tacit knowledge, interrelationships, lifelong learning, etc.) and final outcomes (such as revenues, profitability, employability, quality of life, etc.).

The problem is clear: a sound knowledge of soft innovation, final outcomes, and societal improvements, may be gathered only through direct surveys. Europe has already worked in this direction (CIS analysis on firms' innovative behaviours, and Eurobarometers on different citizens' perceptions), but the margins for substantial improvements are still very large.

First Part

Composite indicators
from the point of view of researchers and practitioners

by Alberto Bramanti and Stefano Tarantola

2. Selecting regions

We are interested in 'strong innovative regions' but, at the same time, we will scrutinize the possible intervening 'national effect' affecting regional performances. For this reason we choose to consider a not too restricted set of innovative regions within different European Countries (see Tables 2.1 and 2.2).

Table 2.1 – *Strongly innovative regions (year 2005)**

Region	Country code	Population (1.000)	GDP per-capita PPP (Euros)	Structural and cohesion funds per capita expenditures 1994-1999	Typologies multi-modal accessibility potential
Stuttgart	de11	4.003	32.000	131,35	Central
Karlsruhe	de12	2.728	30.900	187,41	Central
Oberbayern	de21	4.211	39.400	119,42	Central
Berlin	de3	3.388	23.400	19,12	Very Central
Pais Vasco	es21	2.103	26.600	59,13	Intermediate
Navarra	es22	581	26.300	320,69	Peripheral
Madrid	es3	5.821	27.300	12,17	Intermediate
Cataluña	es51	6.784	24.800	4,87	Central
Île de France	fr1	11.442	42.500	18,04	Very Central
Est	fr4	5.282	23.800	334,22	Intermediate
Sud-Ouest	fr6	6.559	24.500	535,64	Intermediate/Central
Centre-Est	fr7	7.296	26.800	374,52	Intermediate/Central
Piemonte	itc1	4.330	26.900	257,15	Intermediate
Lombardia	itc4	9.393	32.000	435,13	Central
Emilia-Romagna	itd5	4.151	29.700	108,99	Central
Lazio	ite4	5.270	29.500	232,93	Central
East Midlands	ukf	4.309	27.100	305,06	Intermediate
Eastern	ukh	5.537	29.000	25,68	Intermediate/Central
South East	ukj	8.155	32.700	111,86	Intermediate/Central
South West	ukk	5.064	28.000	148,15	Peripheral
Région de Bruxelles	be1	1.007	57.300	102,50	Very Central
Vlaams Gewest	be2	6.043	28.700	132,77	Central
Région Wallonne	be3	3.396	20.800	31,26	Central
Utrecht	nl31	1.171	37.900	65,64	Central
Noord-Holland	nl32	2.599	37.000	54,24	Very Central
Noord-Brabant	nl41	2.411	31.700	30,34	Central
Etelä-Suomi	fi18	2.581	34.600	39,80	Peripheral
Länsi-Suomi	fi19	1.330	26.600	96,27	Peripheral
Pohjois-Suomi	fi1a	632	25.800	33,92	Peripheral
Stockholm	se11	1.873	45.400	57,40	Intermediate
Sydsverige	se22	1.311	29.000	69,68	Central
Västsverige	se23	1.806	31.300	114,13	Intermediate
Ostösterreich	at1	3480	31.200	38,11	Intermediate/Central
Südösterreich	at2	1.756	25.300	32,94	Intermediate
Westösterreich	at3	2.966	30.300	73,91	Intermediate

Notes: *The choice of 2005 makes these structural data comparable with the CIS analysis on innovation. Source: Population and GDP – Eurostat; Total funds and Accessibility – Espon 2006.
For a short presentation of the regions' background see Appendix 1.

Table 2.2 – *Disaggregation of NUTS1 Regions*

Cod	Regions NUTS 1 or 2	Cod	Regions NUTS 2	Population (1,000)	GDP per-capita PPP (Euros)
at1	Ostösterreich	at11	Burgenland	279	18.800
		at12	Niederösterreich	1.576	22.500
		at13	Wien	1.639	37.900
at2	Südösterreich	at21	Kärnten	560	23.600
		at22	Steiermark	1.200	24.100
at3	Westösterreich	at31	Oberösterreich	1.399	27.300
		at32	Salzburg	527	31.100
		at33	Tirol	695	29.100
		at34	Vorarlberg	362	29.000
be1	Région de Bruxelles	be10	Région de Bruxelles	1.013	53.300
be2	Vlaams Gewest	be21	Prov. Antwerpen	1.683	31.900
		be22	Prov. Limburg (B)	812	21.700
		be23	Prov. Oost-Vlaanderen	1.385	23.900
		be24	Prov. Vlaams Brabant	1.041	28.100
		be25	Prov. West-Vlaanderen	1.140	25.000
be3	Région Wallonne	be31	Prov. Brabant Wallon	365	26.100
		be32	Prov. Hainaut	1.288	17.700
		be33	Prov. Liège	1.037	19.700
		be34	Prov. Luxembourg (B)	257	18.400
		be35	Prov. Namur	457	18.600
de11	Stuttgart	de11	Stuttgart	4.003	32.000
de12	Karlsruhe	de12	Karlsruhe	2.728	30.900
de21	Oberbayern	de21	Oberbayern	4.211	39.400
de3	Berlin	de30	Berlin	3.388	23.400
es21	Pais Vasco	es21	Pais Vasco	2.103	26.600
es22	Comunidad Foral de Navarra	es22	Comunidad Foral de Navarra	581	26.300
es3	Comunidad de Madrid	es30	Comunidad de Madrid	5.821	27.300
es51	Cataluña	es51	Cataluña	6.784	24.800
fi18	Etelä-Suomi	fi18	Etelä-Suomi	2.581	34.600
fi19	Länsi-Suomi	fi19	Länsi-Suomi	1.330	26.600
fi1a	Pohjois-Suomi	fi1a	Pohjois-Suomi	632	25.800
fr1	Île de France	fr10	Île de France	11.487	38.600
fr4	Est	fr41	Lorraine	2.334	20.500
		fr42	Alsace	1.809	23.300
		fr43	Franche-Comté	1.148	21.300
fr6	Sud-Ouest	fr61	Aquitaine	3.104	22.400
		fr62	Midi-Pyrénées	2.760	22.500
		fr63	Limousin	729	20.400
fr7	Centre-Est	fr71	Rhône-Alpes	5.993	25.000
		fr72	Auvergne	1.334	20.900
itc1	Piemonte	itc1	Piemonte	4.330	26.900
itc4	Lombardia	itc4	Lombardia	9.393	32.000
itd5	Emilia-Romagna	itd5	Emilia-Romagna	4.151	29.700
ite4	Lazio	ite4	Lazio	5.270	29.500
nl31	Utrecht	nl31	Utrecht	1.171	37.900
nl32	Noord-Holland	nl32	Noord-Holland	2.599	37.000
nl41	Noord-Brabant	nl41	Noord-Brabant	2.411	31.700
se11	Stockholm	se11	Stockholm	1.873	45.400
se22	Sydsverige	se22	Sydsverige	1.311	29.000
se23	Västsverige	se23	Västsverige	1.806	31.300
ukf	East Midlands	ukf1	Derbyshire and Nottinghamshire	2.034	24.400
		ukf2	Leicestershire, Rutland and Northants	1.613	26.800
		ukf3	Lincolnshire	681	19.100
ukh	Eastern	ukh1	East Anglia	2.266	24.900
		ukh2	Bedfordshire, Hertfordshire	1.638	31.100
		ukh3	Essex	1.657	22.700
ukj	South East	ukj1	Berkshire, Bucks and Oxfordshire	2.143	37.600
		ukj2	Surrey, East and West Sussex	2.597	28.400
		ukj3	Hampshire and Isle of Wight	1.818	27.000
		ukj4	Kent	1.624	23.100
ukk	South West	ukk1	Gloucestershire, Wiltshire and North Somerset	2.238	30.500
		ukk2	Dorset and Somerset	1.214	23.100
		ukk3	Cornwall and Isles of Scilly	522	17.100
		ukk4	Devon	1.111	20.800

The ‘big five’ are France, Germany, Italy, Spain and UK, while the small innovative ones are Austria, Belgium, Finland, the Netherlands and Sweden. The chosen 35 regions are reported in the Tables (see Tables 2.1 and 2.2).

It is important from the very beginning to stress that the selected regions are not the 35 top innovative ones in Europe, but they are the most innovative within the selected Countries. In absolute terms they belong to three out of five clusters – ‘high innovators’, ‘medium-high innovators’ and ‘average innovators’ – as highlighed in the previous RIS (2009) exercise.

We are therefore dealing with a sub-set of well or quite-well performing regions. The variance among the selected regions is wide but not as high as the within-Country variance (*i.e.*, the variance among all the regions of the same Country). In the considered list there are neither peripheral nor agricultural regions, but industrial regions as well as ‘capital regions’ (Berlin, Madrid, Paris, and Rome, all the capital regions in the ‘big five’ with the exception of London[9] are included) as well as those ones of the small innovative Countries.

From the point of view of geographic disaggregation, we have to deal with two partially unsatisfactory elements: *i)* the first one is the presence of NUTS 1 and NUTS 2 regions (see Table 2.2); *ii)* the second one is that, due to the non availability of data at NUTS 2 level, some Countries have been considered as a whole and we could not choose the most innovative regions within those Countries (*i.e.*, Austria and Belgium).

In order to have only NUTS 2 regions (their absence is particularly disturbing for France and UK) we should have renounced to very important information, *i.e.,* those reported in the CIS survey[10] available at NUTS1 level.

So, the trade off is quite clear: we align the exercise to the previous RIS (2009), making it more comparable on the larger geographical scale of EU27.

Let us have a better look to Table 2.1. The first two columns report population and GDP per-capita. Population is the main proxy for the dimension of the region: the biggest is Île de France – with the capital metropolis Paris – while the smallest is Pohjiois in Finland resulting 18 times smaller than the greater Paris. We should keep these differences in mind when attempting direct comparisons between such regions.

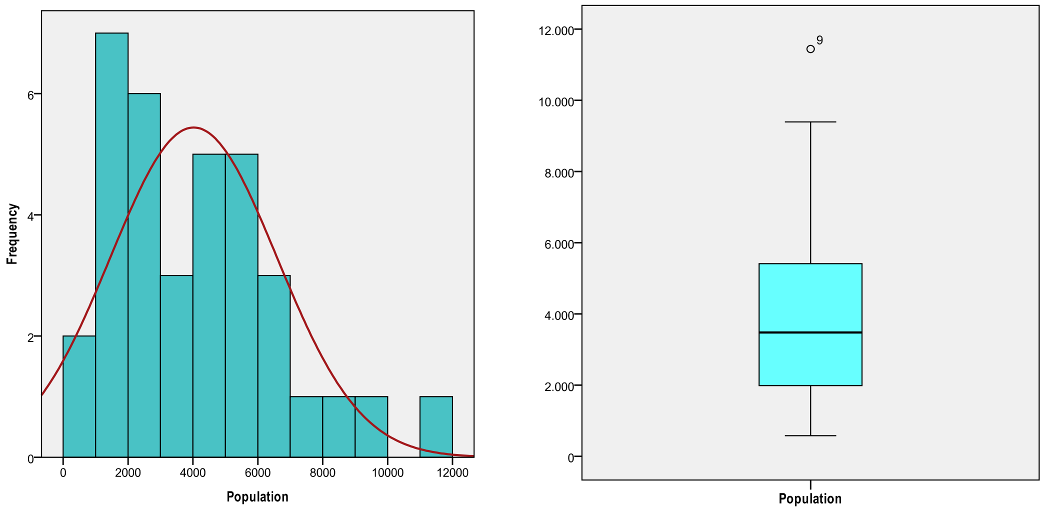
The second column – GDP per-capita – shows a greater homogeneity with only one ‘outlier’: the capital region of Brussels, which is (only) 2.3 times richer than Berlin Länder, probably still affected by the recovery of the former East part.

[9]The exclusion of London may be surprising to some extent. Effectively – according to RIS (2009) analysis – London is not in the top four innovative regions in UK.

Regions	Enablers	Firm activities	Outputs
East Midlands	High	High	High
Eastern	High	High	High
South East	High	High	High
South West	High	High	High
London	High	Mid-low	Mid-high

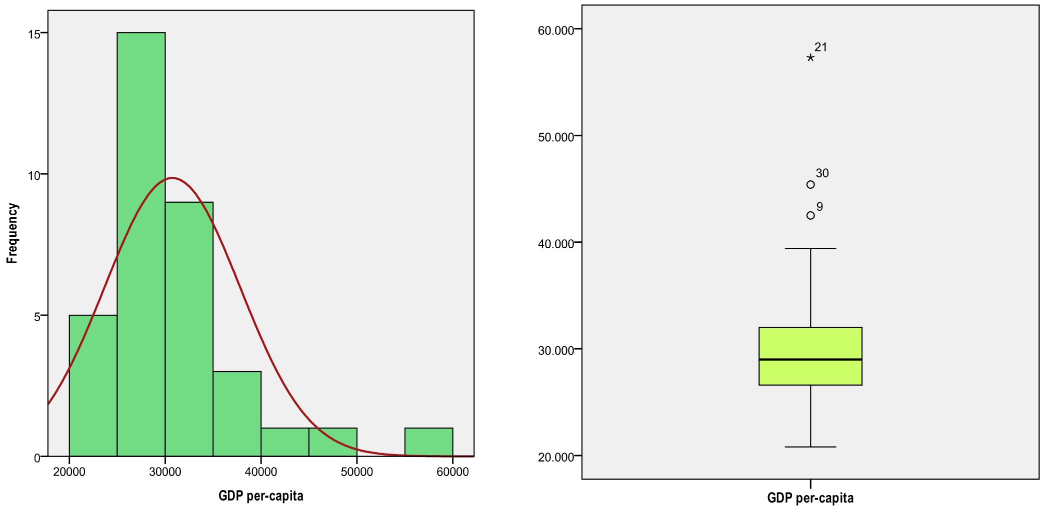
[10]The *Community Innovation Surveys* (CIS) are a series of surveys executed by national statistical offices throughout the European Union and in Norway and Iceland. The harmonized surveys are designed to give information on the innovativity of different sectors and regions. Data from these surveys are used for the annual European Innovation Scoreboard. In this Report we make use of the CIS 2006, for the reference period 2004-2006, while CIS 2008 has been only recently completed and Eurostat has just released the Country-level data (see Chapter 9).

Figure 2.1a – *Frequency distribution and boxplot of population (1,000)*



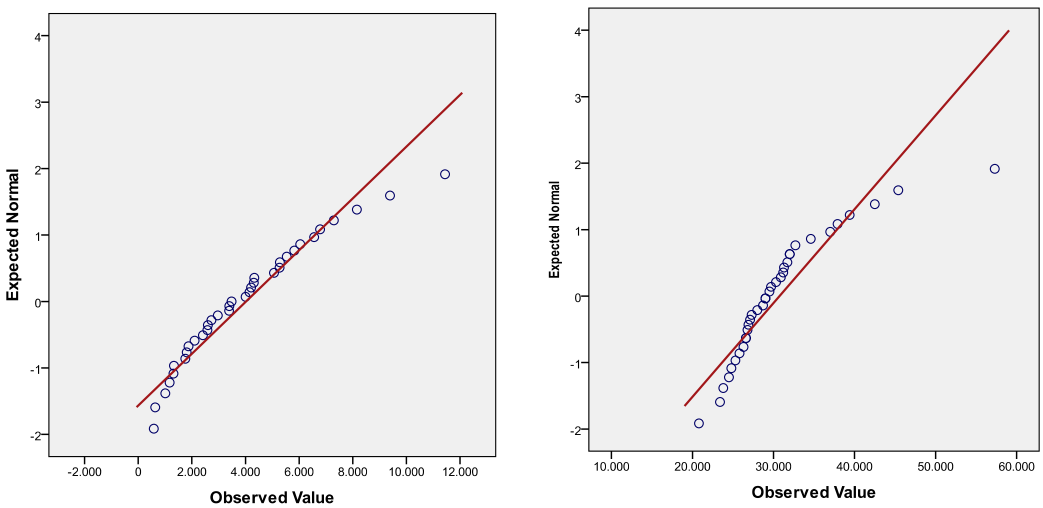
Notes: Mean = 4022; Std.Dev. = 2566; N = 35

Figure 2.1b – *Frequency distribution and boxplot of GDP per-capita (Euros)*



Notes: Mean = 30785; Std.Dev. = 7084; N = 35

Figure 2.1c – *Kolmogorov–Smirnov test for normal distribution: population and GDP*



Notes: Statistics = 0.109; Sig = 0.200* Notes: Statistics = 0.201; Sig = 0.001

Figures 2.1 (from *a* to *c*) report the frequency distribution of these two main dimensions – population and GDP per-capita – distinguishing the regions. While population is normally distributed, even in the presence of an outlier, GDP results unevenly distributed as clearly signaled by the Kolmogorov–Smirnov test[11] (see Figure 2.1c).

The last two columns of Table 2.1 present different and more ‘qualitative’ data. We record – from the Espon project (Espon, 2010) – the overall structural and cohesion funds received by the regions in the previous 1994-1999 programming period. We consider the per-capita figures in order to preserve some sort of comparability. We do however recognize a very strong variance, with a distance of more than 100 times between the most and the least supported region (respectively, Sud-Ouest–FR and Cataluña–ES).

Figure 2.2 – *Scatterplot of GDP per-capita (2005) and European total funds per-capita (1994-1999)*

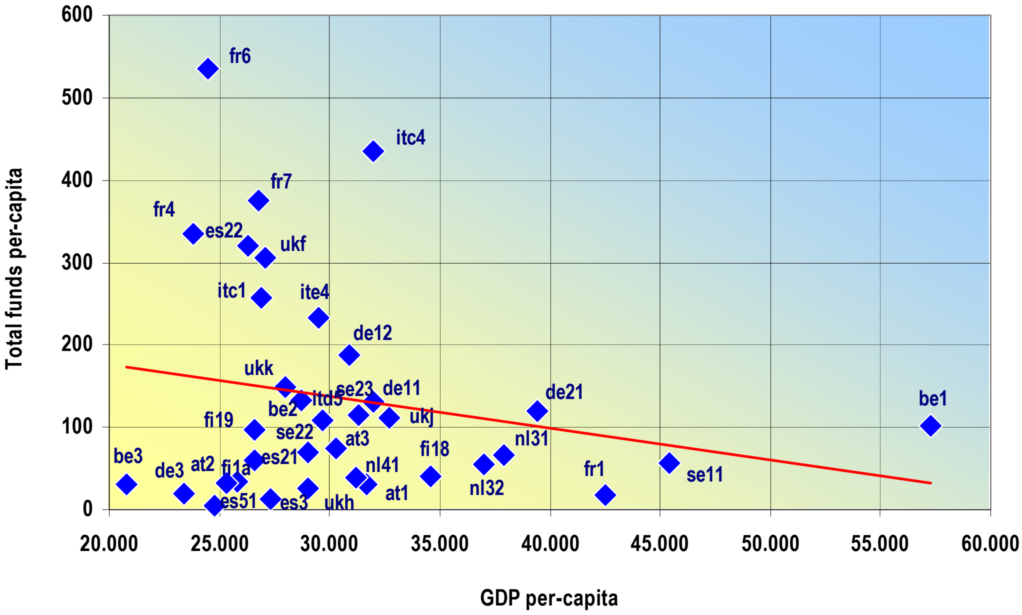


Figure 2.2 puts together total funds and GDP signaling that there is not a clear cut (inverse) relation between the two, as one should have expected: the Pearson’s R = –.206 is not meaningful). So, it is not true that the (relatively) poorer regions have received more money on European overall funds, nor that regions which have more benefited from regional funds have significantly increased their per-capita GDP five years later.

The final column in Table 2.1 offers a qualitative evaluation of potential accessibility which is important in terms of outward relations and belonging to innovation networks: here we have the whole spectrum of situations, ranging from the ‘very central’ capital regions to the ‘peripheric’ Finnish and Spanish (only Navarra) regions.

[11] The K–S test compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation. If the test is significant – that is, $p < 0.05$ – then the distribution in question is significantly different from the normal distribution (*i.e.,* it is non normal).

3. Looking at the data

In a valuable work analysing many of the criticisms raised against European Innovation Scoreboard (EIS) Hollanders and van Cruysen (2008) highlight different fundamental points which deserve the greatest attention even working on innovation scoreboard at the regional level. The main criticisms are related to the following four points[12]:

- lack of innovation model;
- high-tech criticism;
- missing data and timeliness;
- 'more is not always better'.

All the arguments raised are highly pertinent and certainly needs to be carefully scrutinized at the regional level where the importance is even more crucial in the following decreasing order: *i)* missing data; *ii)* high-tech bias; *iii)* lack of model; and *iv)* the more, the better.

We pass rapidly through these points before presenting the simple indicators (see § 3.2).

3.1 Devoting attention to same major criticisms

MISSING DATA — The criticism on missing data – in which we will come back more than once at different points in the analysis – is certainly by and large the major fault on European regional innovation statistics due to the lack of homogeneity on the geographical scale (nation, NUTS1, NUTS2), alignment on time span, unhomogeneity of different sources (CIS-6 regards 2004-2006 and ESPON project results even more dated). A major difficulty is noticed from the estimate procedures of these missing data most of the times re-proportioned on the national value, where we know that national variances are always very high.

Apart from the 'voice' for a more precise, detailed and sharp gathering process of territorial data, we can let the data 'fluctuate' within a reasonable band of variation. We will do so in the 'probabilistic setting' (see Chapter 6), replacing the exact, although estimated, value with its statistical distribution around the mean and investigating the effect in terms of robustness of the composite.

Other procedures may look at appropriate clusters of regions (on the basis of a detailed analysis of many different aspects of innovation) and try to assign the missing values not with respect to the reference Country but, rather, to the belonging of the region to a specific cluster showing a higher degree of homogeneity in innovation behaviours. Even in this case the lack of sound data seems to be the major constraint to the right implementation of the procedure.

[12] We don't consider here two other points related to *i)* multicollinearity (see § 3.3) and *ii)* the use of composite to capture innovation phenomena, which is, evidently, a preliminary very philosophical point and we'll come back further on (see Chapter 10) on the matter.

HIGH-TECH BIAS — A high-tech bias[13] means too much attention paid to R&D, skilled labour, formalized networks with universities and research centres, etc. From the analysis of the European Community Innovation Survey (CIS) it shows that half of the innovative European firms do not perform R&D in-house. This, in turn, affects the share of innovation expenditures other than R&D (sometimes called 'soft innovation') (NESTA, Stoneman, 2009; Stoneman, 2010), with a specific sectorial distribution (Huang, Arundel and Hollanders, 2010). A major implication of this structural feature of European productive systems is that medium–technology SMEs continuously generate tacit knowledge by combining external sources of knowledge and codifies know-how with very specific problem solving attitude. Therefore, even innovation performance shouldn't be measured by using 'standard indicators' such as high-tech industries, patents, R&D expenditures and so on.

In addition, medium-technology industries are not only the dominant sectors for European exports into the global market, but they are still the fastest-growing sector in international trade (Cappellin and Wink, 2009). These sectors, and the firms operating within, are focused on networks, interactive learning process and the development of creative capabilities as standard means to master the process of innovation (Malerba and Vonortas, 2009; Molle and Djarova, 2009).

«The concept of 'territorial knowledge management', which investigates the preconditions that knowledge networks have to meet for successful knowledge generation processes, highlights criteria to measure the existing capabilities and needs within knowledge networks, and offers recommendations for firms and policy-makers in the improvement and steering of their networks.» (Cappellin and Wink, 2009: 5).

We should never forget that R&D is not a goal in itself; it is rather a means of pursuing increase in sales activities. More than R&D, what matters in the long term is well being for the society on the whole, personal income for households, and profitability for enterprises, three goals which are all facilitated by widespread innovation activity.

That is exactly why we have chosen to distinguish a fourth Pillar aiming at specifically recording innovation outcomes in terms of *market*. This is logically separated from innovation in terms of *production,* as we perfectly know that several times new and good products are hardly able to find their own markets. The CIS survey – with a sample of some 15 thousands manufacturing and service firms – has clearly shown that small firms without skilled staff (with tertiary education), and lack of exports, do innovate even without carrying on R&D activities.

THE LACK OF MODEL — In terms of the model of innovation the underlying idea is certainly an 'eclectic vision' of innovation (Bessant and Venables, 2008; Etzkowitz, 2008; Dewatripont *et al.,* 2010) along with the evolutionary economics approach[14] (Malerba and Brusoni, 2007; Boschma and Martin, 2010) representing territorial economies as a complex adaptive system in which input, output and enabling actors (or services) are all necessary to innovate and reinforce each others.

[13]It is still noticeable a sort of elitist conception of knowledge in which scientific knowledge is extolled while 'lower' forms of knowledge (like tacit knowledge and engineering and production know how) are undervalued.

[14]A key focus of evolutionary economics is on the processes and mechanisms by which the economy self-transforms itself from within (Witt, 2006) and *novelty* is the ultimate source of self-transformation.

«An evolutionary perspective (today) is considered essential to a fuller understanding of such issue as the geographies of technological progress, dynamic competitive advantage, economic restructuring and economic growth. In this context, there is a considerable scope and potential for applying and extending the ideas and concepts from evolutionary economics to our analysis of regional and urban development.» (Boschma and Martin, 2010: 3).

Here we would like to stress three major points which look decisive.

The *first* is the need for a dynamically balancing of 'internal synergies' (regional *robustness*) with 'external energies' (regional *openness*) (Bramanti, 1999; Fratesi and Senn, 2009). Any unbalanced solutions lead to a dissolution of the territorial fabric: alternatively to a 'death for entropy' of the system or to its 'disintegration' (Bramanti and Miglierina, 1995);

The *second* deals with the capacity to transform knowledge (and R&D expenditures producing knowledge and know-how) into productive activities (Bramanti and Riggi, 2009). So as not to deny the rising role of codified knowledge and research intensive activities, we have to recognize the full complementarity of both tacit and codified knowledge, and the importance of face-to-face contacts, which have four major properties:

«[Face-to-face] is an efficient communication technology; it allows actors to align commitments and thereby reduces incentive problems; it allows screening of agents; and it motivates effort» (Storper and Venables, 2004: 353).

The *third* point is surely related to the emerging of a (regional) innovation system consisting of elements and relationships that interact in the production, accumulation, diffusion and exchange of new and economically useful knowledge.

«A region endowed with mutual understanding, trust and reciprocity within the collective economic community shows robust system characteristics which, in turn, can channel flows of information to the members of the regional innovation community. Regions have their own 'social filter' in which innovative and conservative components are combined: the fewer the innovative components, the lower the capacity to accomplish high returns from R&D activities. But this social filter may be strongly influenced and shaped by appropriate local innovation institutions.» (Bramanti and Fratesi, 2009:63-64).

This is the idea of a convergence and crossing-over of different actors – researchers, businessmen, and policy makers – which have reached a certain degree of attention through the *triple helix model* (Leydesdorff and Etzkowitz, 1998; Etzkowitz, 2008).

The central idea is that, while R&D still matters, it is only a part of a larger system including education, vocational training, government support and linkages between actors (Malecki and Hospers, 2007; Nesta, Stoneman, 2009).

Conclusively (see Figure 3.1), we have two main dimensions: *i)* openness which measures the capability of the system to stand global competition and to be in contact with different actors and sources of knowledge and innovation (and region's accessibility matters – see Table 2.1); and *ii)* robustness of the territorial milieu which, in turn, is made of stocks (endowments) and flows (relational dimensions).

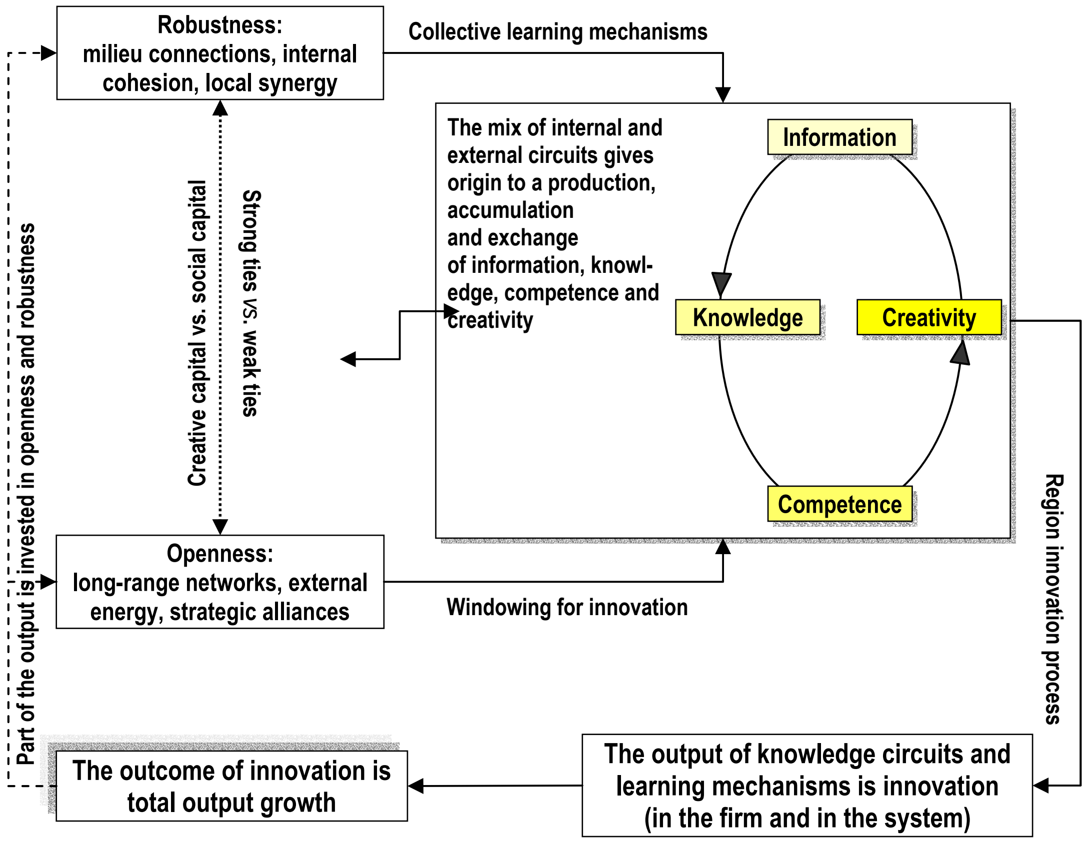
In the evolutionary approach public policy may break (or not) national inefficient path dependencies and this is why we consider that beyond regional performances a 'national effect' is recognizable. National systems of innovation[15]

[15]*«A National system of innovation is the system of interacting private and public firms, universities and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social, and*

(NISs) (Freeman, 1988; Lundwall, 1992; Nelson, 1993) may be considered a way for systematic description and mapping of innovation activities at different territorial scales (nations as well as regions). Within the idea of NISs there is a growing attention to the learning dynamics:

«The capability of individuals, organizations, and local systems to learn to cope with new problems becomes a prerequisite for economic success (...). Innovation and learning are strongly interconnected and the most relevant knowledge cannot be reduced to time- and space-less 'information'. Learning is an interactive, socially embedded, and localized process.» (Lundvall *et al.*, 2007: 214-216).

Figure 3.1 – *A diagrammatic view of regional sustainable 'innovation driven' growth mechanism*



Bramanti and Riggi (2009: 32).

Even if top performing regions, to some extent, may make up for the lack of some specific input, the NISs remain of the greatest importance. It is essential to have this point in mind as the collected data do not contain any information – apart from R&D public expenditures – on a large part of the NISs (research universities and government laboratories as well as the system of incentives for companies to conduct R&D activities).

THE MORE, THE BETTER — All the EIS indicators assume that 'more is better' but this is not probably the case. 'More' is not always better for two different kinds of reasons. First of all, we can assume that some variables have an 'optimal' level that, in turn, may be conditioned by the level reached by other variables and

financial, inasmuch as the goal of the interaction is the development, protection, financing or regulation of new science and technology.» (Niosi, *et al.*, 1993: 212).

may be different across Countries. In some cases physical endowment may reach its threshold of saturation (as is the case of broad band diffusion in Northern Countries).

In addition, dealing with expenditure-related indicators a higher level may reveal suboptimal allocation of scarce resources when, due to pressing budget constraint, 'more' in some specific investment necessarily imply 'less' in other fields of the same sectors of intervention.

Another problem possibly arising with *'the more, the better' approach* is that this logic may distort incentive schemes. Where there are policies and policy makers sensitive to indicator system overemphasizing a specific type of output, this can induce some actors to implement sub-optimal interventions (extending, for example, the specific investment beyond what would be efficient).

Furthermore, and more radically, individual and collective societal well-being do not come only from material wealth or traded goods. To be (or not) the most innovative region in Europe may contribute to, but not exhaust, the well-being of individuals or communities as a whole. Collective responsibility and shared endeavours are fundamental to the reproduction of development (the sustainability issue) while competitiveness is ostensibly economically framed and measures quality of life in only narrowly circumscribed economic measures (Stiglitz *et al.,* 2010).

There is no answer at all to this kind of problems – except the case in which we know the optimal value and measure indicators in terms of distance from the optimal threshold –, so we simply have to apply the greatest caution in the selection of simple indicators.

3.2 The simple indicators: a description

Before going through the selected indicators, it is worthwhile a preliminary step devoted to a methodological introduction to indicators at large.

3.2.1 A general methodological introduction

Generally speaking indicators are measures of some 'level' (stock) of 'visible variation' (flow) registered in the analysed phenomenon. They can be distinguished into four broad categories (OECD, 2009; Chapter 2):

- *input* measures, related to the concept of resources used to produce something (material of immaterial);
- *process* measures, revealing the way in which resources are employed in order to obtain the expected results;
- *output* measures, directly capturing the produced services or goods, on immaterial result of the process;
- *outcome* measures, relating to dimensions expected to change as a consequence of the intervention (policy, programme, or project).

Three further distinctions should still be done. *i)* The first one is the differentiation between stocks and flows. It is important not only in terms of the measurement unit, but also because flows may depend on pre-existing stocks (along a circular accumulation process). *ii)* The second one is on exogeneity (*vs.* endogeneity) of the phenomena considered. Typically, we refer to 'context indicators' to indicate factors occurring outside and behind the control of the regional system. Context indicators provide information on the environment in which regional policies must operate. *iii)* The third, and last one, regards the distinction between 'gross' and 'net' quantities and/or effects (see also § 9.3.2). The latter is particularly important with respect to outcome measures and they nearly always need a counterfactual approach enabling to distinguish the actual result from what would have happened if the intervention had not occurred (European Commission, 2009; 2010).

A good 'information system' should keep attention to some balancing of the different typologies. In the present exercise on innovation we try to match these ex-ante characteristics with the simple indicators already used in the RIS 2009 exercise.

Obviously, the selection of the indicators also depends on the purposes of the monitoring system. If policy makers are attentive to *budget control* they will emphasize inputs indicators; if they focus on *process* – what and how things get done – process measures will receive the greatest attention; if, finally, the policy priorities are on *result* – that is to demonstrate the 'value for money' of the programme – than priority will receive output and outcome measures.

Also the construction of the composite should answer the manifest or hidden goals of the benchmarking exercise. It is quite frequent to have an undervalued presence of outcomes measures; this is in part comprehensible due to the objective difficulties in measuring long-term impact of the policies. But, most times, the real matter is that there are not clear models to read the data: too many intervening factors hide the casual relations among variables and make all the picture opaque.

As the data set used is the same of the RIS 2009 (PROINNO Europe, 2009), in the present Technical Report we use also the same 'Pillars' which are: 'Enablers' (§ 3.2.2), 'Firm activities' (§ 3.2.3) and 'Output' (§ 3.2.4). Differently from the RIS exercise, due to the centrality of some qualitative data regarding the performance of SMEs, we introduce a fourth Pillar (§ 3.2.5) splitting the previous third in two sub-sets, and distinguishing between the firms' output in terms of 'innovation' and 'market'.

The data set is composed of 17 simple indicators gathered into four different Pillars. It is worthwhile to look into them as any further result is rooted on these simple indicators and depends on all their possible deficiencies.

3.2.2 The first PILLAR: enablers

The first Pillar includes four indicators which may be red as input coming from outside the firm and are generally measured as endowments (stocks) – such as *population with tertiary education* (1.1.3), *life-long learning* (1.1.4), or *broadband access* (1.2.4) – but sometimes also as flows (typically *public R&D expenditure* 1.2.1) (see Table 3.1).

Table 3.1 – *Definition and measurement of simple indicators: PILLAR 1*

	Indicators	Numerator	Denominator	Ref. year	Source	Type
1.1.3	Population with tertiary education per 100 population aged 24-64	Number of persons in age class with some form of post secondary education (ISCED 5 and 6)	Population between 25 and 64 years	2007	Eurostat	Input
1.1.4	Participation in life-long learning per 100 population aged 24-64	Number of persons involved in life-long learning. Life-long learning is defined as participation in any type of education or training course during the four weeks prior to the survey	Population between 25 and 64 years	2007 (2006 for SE, UK)	Eurostat	Input

(Table 3.1) continued

1.2.1	Public R&D expenditures (% of GDP)	All R&D expenditures in the government sector (GOVERD) and the higher education sector (HERD). Both GOVERD and HERD according to the Frascati-manual definitions	Gross Domestic Product	2008	Eurostat	Input
1.2.4	Broadband access by firm (% of firms)	Number of enterprises (excluding the financial sector) with 10 or more employees with broadband access	Total number of enterprises (excluding the financial sector) with 10 or more employees	2007	Eurostat	Input

Source: European Innovation Scoreboard (PROINNO Europe, 2009).

Table 3.2 – *Regions ranked for PILLAR 1 indicator and single ranks of the four simple indicators within PILLAR 1*

Regions	Cod	PILLAR 1	1.1.3 Tertiary education	1.1.4 Life-long learning	1.2.1 Public R&D expenditures	1.2.4 Broadband access	Pillar 2	Pillar 3	Pillar 4
Utrecht	nl31	0,719	3	**12**	5	1	0,241	0,358	0,424
South East	ukj	0,677	**14**	3	4	9	0,373	0,452	0,440
Stockholm	se11	0,662	10	4	7	**11**	0,698	0,481	0,593
Pohjois-Suomi	fi1a	0,647	**12**	8	6	4	0,548	0,210	0,328
Sydsverige	se22	0,643	**20**	1	9	7	0,683	0,372	0,556
Etelä-Suomi	fi18	0,628	**15**	7	7	6	0,577	0,285	0,352
Länsi-Suomi	fi19	0,623	4	10	**14**	4	0,611	0,252	0,373
Noord-Holland	nl32	0,595	8	11	20	2	0,216	0,325	0,367
Berlin	de3	0,594	5	17	**1**	19	0,585	0,711	0,858
Västsverige	se23	0,581	22	2	16	7	0,745	0,384	0,550
Eastern	ukh	0,523	25	9	17	12	0,435	0,482	0,430
South West	ukk	0,506	18	5	22	15	0,320	0,391	0,363
East Midlands	ukf	0,486	21	6	26	13	0,330	0,355	0,359
Région de Bruxelles	be1	0,476	**1**	18	23	14	0,262	0,344	0,322
Noord-Brabant	nl41	0,426	19	13	35	3	0,518	0,262	0,333
Karlsruhe	de12	0,412	24	21	**2**	21	0,694	0,722	0,815
Vlaams Gewest	be2	0,402	11	20	21	10	0,457	0,371	0,290
Île de France	fr1	0,391	9	22	11	23	0,309	0,539	0,418
Madrid	es3	0,379	6	29	18	17	0,093	0,225	0,134
Oberbayern	de21	0,347	16	24	10	24	0,795	0,741	0,821
Pais Vasco	es21	0,333	**2**	19	33	26	0,221	0,330	0,497
Ostösterreich	at1	0,332	29	14	13	18	0,399	0,297	0,650
Navarra	es22	0,301	7	25	24	28	0,204	0,268	0,689
Région Wallonne	be3	0,292	13	34	28	16	0,412	0,277	0,434
Cataluña	es51	0,265	17	33	27	19	0,123	0,220	0,524
Sud-Ouest	fr6	0,264	26	31	12	30	0,269	0,210	0,334
Stuttgart	de11	0,249	23	23	29	21	0,782	0,597	0,597
Lazio	ite4	0,245	30	27	**3**	32	0,131	0,316	0,516
Centre-Est	fr7	0,244	27	26	**19**	27	0,233	0,367	0,271
Südösterreich	at2	0,234	31	**16**	**14**	31	0,410	0,212	0,582
Westösterreich	at3	0,205	32	**15**	31	25	0,399	0,296	0,641
Est	fr4	0,191	28	30	25	29	0,228	0,385	0,222
Emilia-Romagna	itd5	0,086	33	28	29	33	0,251	0,243	0,594
Lombardia	itc4	0,049	34	32	34	33	0,261	0,311	0,579
Piemonte	itc1	0,005	35	35	32	35	0,255	0,283	0,444

Notes: In black **bold**, for the first seven best performing regions, we have the position ranking above 10 (the relative worse performances), for the last seven worse performing regions we have the position ranking below 20 (the relative best performances), and in blue **bold** we have the outperforming positions of all the other regions.

A preliminary analysis of the raw data, within the first Pillar, is supported by the following Table 3.2 (the first of a series of four – one for each Pillar – all constructed in the same way). It ranks the 35 regions according to the absolute value of the first Pillar sub-index showing also the ranking position of the single indicators which contribute to the selected Pillar.

So, in Table 3.2 the Utrecht region (NL) is the best performing in Pillar 1 due to the achievements of simple indicators *broadband access* (ranks 1st), *tertiary education* (ranks 3rd), and *public R&D expenditure* (ranks 5th), while *life-long learning* is not so outstanding (ranks 12th).

Table 3.2 shows a strong coherence at the top of Pillar 1 ranking: the first seven regions register a quite strong performance in all the four simple indicators with only one case each (one indicator out of four) with a rank above the 10th (and mainly concentrated on *tertiary education*). Similarly, at the bottom of the Pillar 1 ranking the last seven regions show a very weak performance in all the four simple indicators with only four cases in which the ranks for these regions are below the 25th, and no one better than the 14th position of Südöesterreich in *Public R&D expenditure* (indicator 1.2.1).

The strong emphasis on human capital inputs and the importance of education and skills is surely beyond dispute as the relationship between human capital and economic development has been proved to be positive and effective[16].

However, major problems arise on definition and measurement issues:

«Three matters have proven particularly intractable: quality of education, workforce participation of people with higher education, and links between education and productivity.» (Niosi, 2010: 72).

From a statistical point of view a major problem within this Pillar is represented by the first indicator relating to 'tertiary education' (1.1.3). As a matter of fact considering the whole population (25-64 years) it does not seem so appropriate. While the share of ISCEAD 5 and 6 is rapidly increasing among young people it is still very low – especially in Southern Countries – among aged people, and the indicator moves very slowly according to the generational turnover[17]. In the European Innovation Scoreboard (EIS) more focused indicators concerning human capital are present. The EIS indicator looks at the 20-29 years band (first stage of tertiary education) and 25-34 years band (second stage education). Unfortunately these data are not available at the regional level and we have to use the only two on hands.

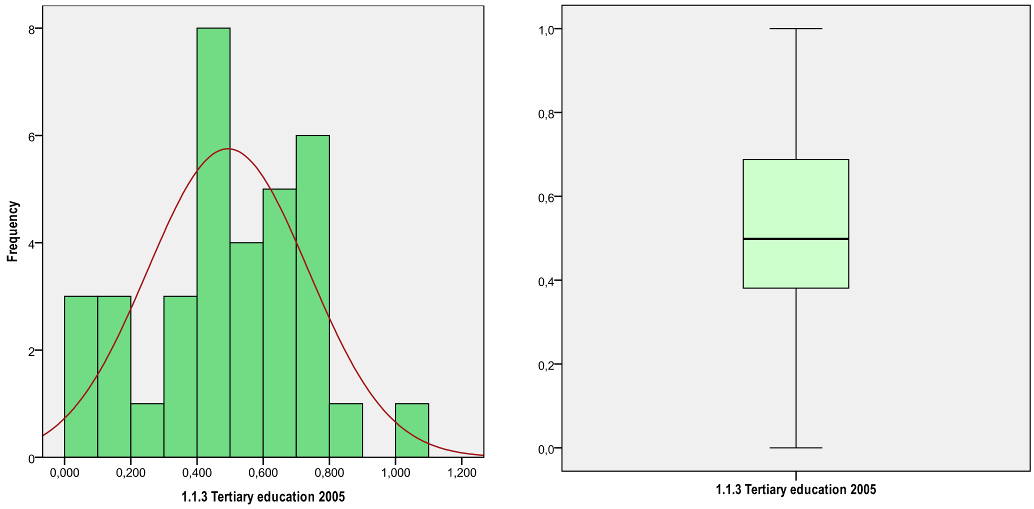
The investment in human capital is typically a field in which national policies matter and make the difference and the experience of the most advanced Countries have shown the importance of balancing supply and demand: when you develop higher education you have simultaneously to stimulate R&D activities[18].

[16]Extensive studies in OECD Countries have shown, for instance, that, on average, each extra year of schooling over ten years raised output per capita by 6 per cent (Temple, 2001), while annual private rate of return for an extra year of education ranged between 5 and 15 per cent. Other benefits, even more difficult to estimate, included greater life expectancy, more social capital (trust), and better quality of life (Niosi, 2010).

[17]Some Countries (Spain, Germany and Scandinavian Countries) have much larger scores. In the case of Spain it is partially the result of a specific program for active population to obtain a degree at university (*cursos senior*) (see also LD, Ederer *et al.*, 2011).

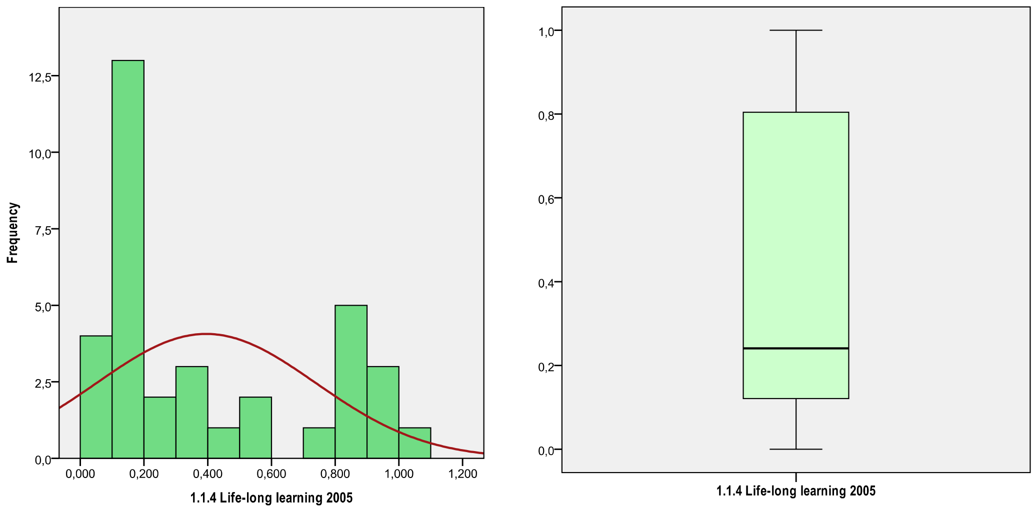
[18]Former communist Countries in Central and Eastern Europe, after the fall of the Berlin Wall, find themselves with educated personnel for which the private sector had no demand because government had not aimed adequate innovative policies at the private sector.

Figure 3.2a – *Frequency distribution and boxplot of indicators 1.1.3: tertiary education*



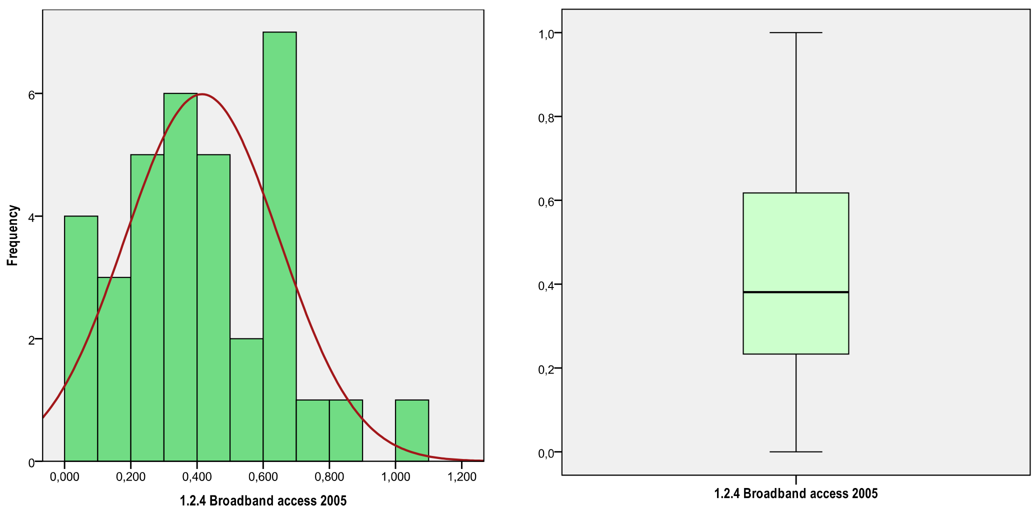
Notes: Mean = 0.49; Std.Dev. = 0.243; N = 35

Figure 3.2b – *Frequency distribution and boxplot of indicators 1.1.4: life-long learning*



Notes: Mean = 0.40; Std.Dev. = 0.344; N = 35

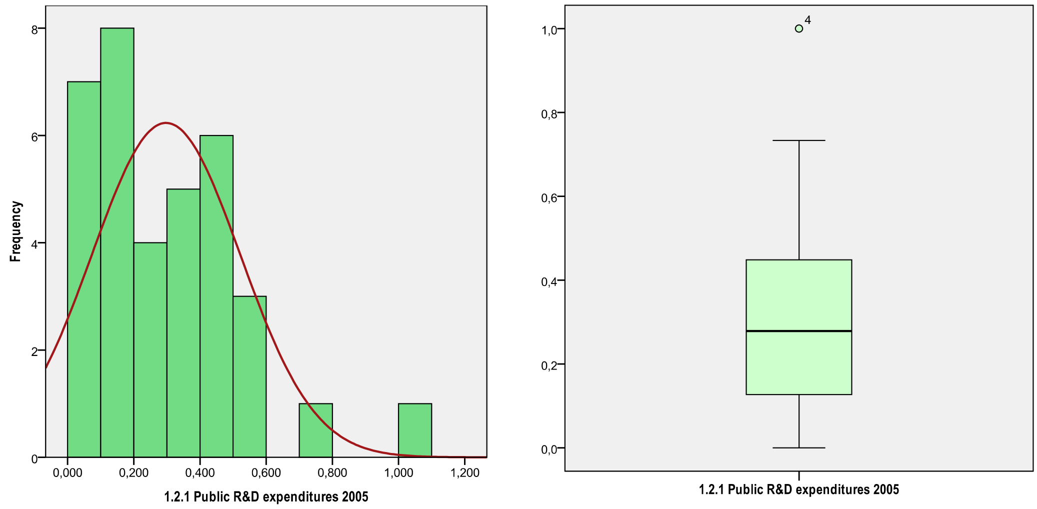
Figure 3.2c – *Frequency distribution and boxplot of indicators 1.2.3: broadband access*



Notes: Mean = 0.42; Std.Dev. = 0.233; N = 35

Figure 3.2d – *Frequency distribution and boxplot of indicators 1.2.1: public R&D expendi-*

tures



Notes: Mean = 0.30; Std.Dev. = 0.224; N = 35

Figures 3.2 (from *a* to *d*) report the frequency distribution of single indicators, we can see a mixed evidence with a higher dispersion for *life-long learning* (see Figure 3.2b) and the smallest variance for *public R&D expenditure* (see Figure 3.2d).

3.2.3 The second PILLAR: firm activities

The second PILLAR includes five indicators capturing innovation efforts undertaken by firms with absolute as well as relative measures (see Table 3.3). Among the first we have *business R&D expenditure* (2.1.1) and *EPO patents* (2.3.1), while three further measures are shares on the reference universe. A main shortage of these data is the absence of availability for German Länder, so we have to impute the data adding a source of uncertainty in the final result.

In Table 3.4 (for the construction refer to the previous Table 3.2) the Oberbayern region (DE) is the best performer in Pillar 2 due to an interesting performance of simple indicators *SMEs innovating in-house* (ranks 2nd), *business R&D expenditure* (ranks 3rd), and *EPO patent* (ranks 3rd).

Table 3.4, as the previous 3.2, shows a strong coherence at the top of Pillar 2 ranking: the first seven regions produce an outstanding performance in all the five simple indicators with no more than one case each with a rank above the 10th (Karlsruhe Länder is borderline with *business R&D expenditures* which ranks 11th and 'Innovative SMEs collaborating' which ranks 14th).

In the same way the coherence is also strong at the bottom of Pillar 2 ranking: the last six regions show a very weak performance in all the five simple indicators with only one case in which the rank for these regions is below the 25th (Cataluña for *SMEs innovating in-house*). In the middle of the ranking we have regions more divaricated in terms of performance in the single indicators. In particular Berlin (DE), and Vlaams Gewest (BE) outperform in *SME innovating in-house* (2.2.1), while Pohjois-Suomi (FI) and Eastern (UK) outperform in *business R&D expenditures* (2.1.1), but in all the cases the weak position in the other indicators does not allow these regions to rank well with respect to Pillar 2.

Table 3.3 – *Definition and measurement of simple indicators: PILLAR 2*

	Indicators	Numerator	Denominator	Ref. year	Source	Type
2.1.1	Business R&D expenditure (% of GDP)	All R&D expenditures in the business sector (BERD), according to the Frascati-manual definition	Gross Domestic Product	2008	Eurostat	Input
2.1.3	Non R&D innovation expenditures (% of turnover)	Sum of total innovation expenditures for enterprises, in national currency and current prices excluding intramural and extramural R&D expenditures	Total turnovers for all enterprises	2006	Eurostat	Input/also process
2.2.1	SMEs innovating in-house (% of SMEs)	Sum of SMEs with in-house innovation activities. Innovative firms are defined as those firms which have introduced new products or processes either 1) in-house or 2) in combination with other firms	Total number of SMEs	2006	Eurostat	Process
2.2.2	Innovative SMEs collaborating with others (% of SMEs)	Sum of SMEs with innovation co-operation activities. Firms with co-operation activities with other enterprises or institutions in the three years of the survey period	Total number of SMEs	2006	Eurostat	Process
2.3.1	EPO patents per million population	Number of patents applied for at the EPO, by year of filing. The national distribution of the patent applications is assigned according to the address of the inventor	Total population	2005	Eurostat	Output

Source: European Innovation Scoreboard (PROINNO Europe, 2009).

Table 3.4 – *Regions ranked for PILLAR 2 indicator and single ranks of the five simple indicators within PILLAR 2*

Regions	Cod	Pillar 1	PILLAR 2	2.1.1 Business R&D expenditures	2.1.3 Non-R&D innovation expenditures	2.2.1 SMEs innovating in-house	2.2.2 Innovative SMEs collaborating with others	2.3.1 EPO patents	Pillar 3	Pillar 4
Oberbayern	de21	0,347	0,795	3	5	2	9	3	0,741	0,821
Stuttgart	de11	0,249	0,782	1	8	4	8	2	0,597	0,597
Västsverige	se23	0,581	0,745	2	3	**11**	3	9	0,384	0,550
Stockholm	se11	0,662	0,698	6	1	7	5	5	0,481	0,593
Karlsruhe	de12	0,412	0,694	**11**	6	3	**14**	4	0,722	0,815
Sydsverige	se22	0,643	0,683	5	2	10	6	6	0,372	0,556
Länsi-Suomi	fi19	0,623	0,611	9	9	**12**	1	8	0,252	0,373
Berlin	de3	0,594	0,585	14	4	**1**	18	13	0,711	0,858
Etelä-Suomi	fi18	0,628	0,577	10	10	15	**2**	7	0,285	0,352
Pohjois-Suomi	fi1a	0,647	0,548	**4**	11	22	**4**	15	0,210	0,328
Noord-Brabant	nl41	0,426	0,518	8	31	31	11	**1**	0,262	0,333
Vlaams Gewest	be2	0,402	0,457	19	18	**5**	7	16	0,371	0,290
Eastern	ukh	0,523	0,435	7	17	16	23	20	0,482	0,430
Région Wallonne	be3	0,292	0,412	21	7	19	20	26	0,277	0,434
Südösterreich	at2	0,234	0,410	13	19	14	12	23	0,212	0,582
Ostösterreich	at1	0,332	0,399	18	12	8	15	17	0,297	0,650
Westösterreich	at3	0,205	0,399	23	14	6	21	11	0,296	0,641
South East	ukj	0,677	0,373	15	13	20	19	21	0,452	0,440
East Midlands	ukf	0,486	0,330	22	21	17	13	31	0,355	0,359
South West	ukk	0,506	0,320	24	20	21	17	29	0,391	0,363
Île de France	fr1	0,391	0,309	12	24	32	16	10	0,539	0,418
Sud-Ouest	fr6	0,264	0,269	17	15	33	22	30	0,210	0,334
Région de Bruxelles	be1	0,476	0,262	33	32	18	10	24	0,344	0,322

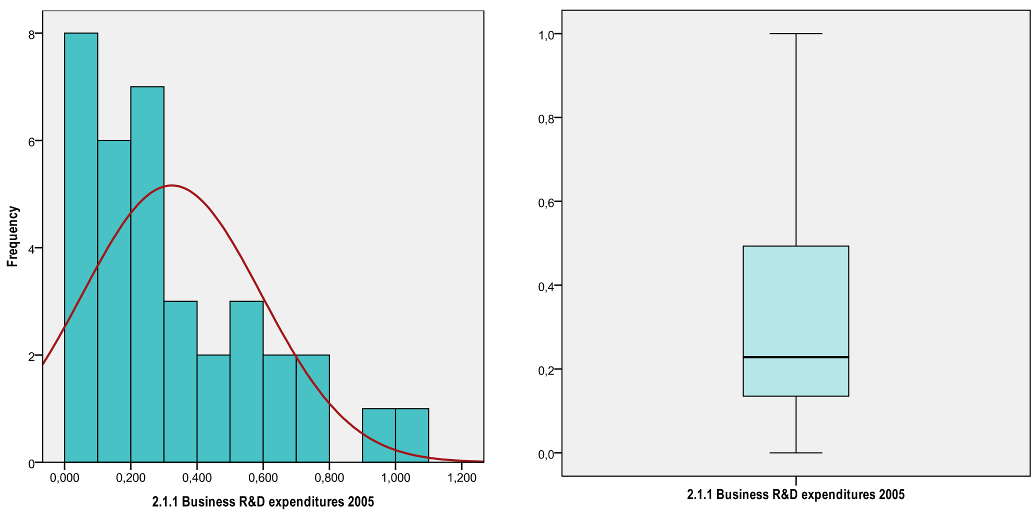
(Table 3.4) continued

Regions	Cod	Pillar 1	PILLAR 2	2.1.1 Business R&D expenditures	2.1.3 Non-R&D innovation expenditures	2.2.1 SMEs innovating in-house	2.2.2 Innovative SMEs collaborating with others	2.3.1 EPO patents	Pillar 3	Pillar 4
Lombardia	itc4	0,049	0,261	30	23	13	31	18	0,311	0,579
Piemonte	itc1	0,005	0,255	20	29	23	30	22	0,283	0,444
Emilia-Romagna	itd5	0,086	0,251	31	22	9	33	14	0,243	0,594
Utrecht	nl31	0,719	0,241	34	26	28	25	19	0,358	0,424
Centre-Est	fr7	0,244	0,233	16	27	35	27	12	0,367	0,271
Est	fr4	0,191	0,228	28	16	34	24	28	0,385	0,222
Pais Vasco	es21	0,333	0,221	25	28	27	29	33	0,330	0,497
Noord-Holland	nl32	0,595	0,216	32	30	29	26	25	0,325	0,367
Navarra	es22	0,301	0,204	26	33	26	28	27	0,268	0,689
Lazio	ite4	0,245	0,131	35	25	25	35	34	0,316	0,516
Cataluña	es51	0,265	0,123	29	34	**24**	32	32	0,220	0,524
Madrid	es3	0,379	0,093	27	35	30	34	35	0,225	0,134

Notes: In black **bold**, for the first seven best performing regions, we have the position greater than 10 (the relative worse performances), for the last six worse performing regions we have the position smaller than 25 (the relative best performances), and in blue **bold** we have the outperforming positions of all the other regions.

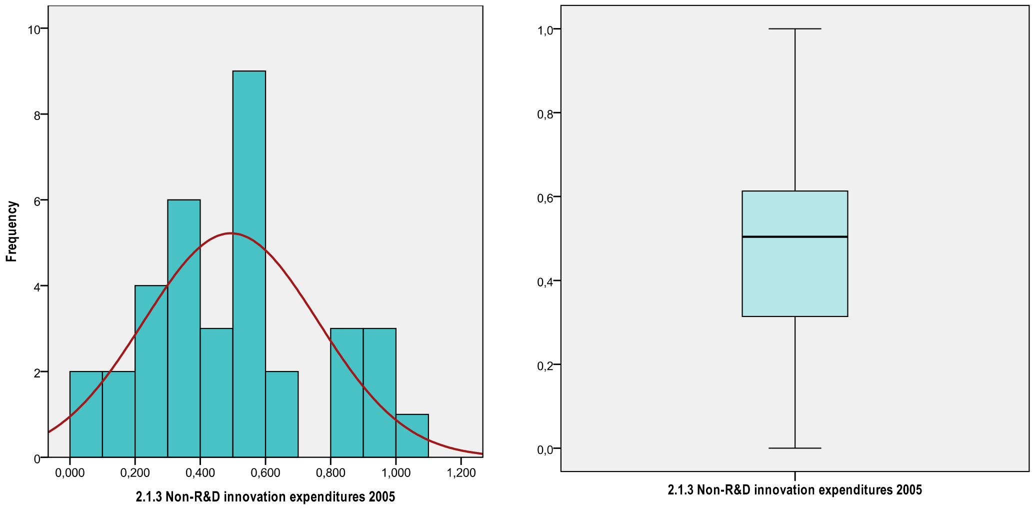
In Pillar 2 one major problem is related to the limited availability of CIS data at regional level (the following considerations are also applicable for Pillar 3 and 4). As clearly evidenced by the methodology of the RIS exercise there are here five limitations to be addressed: *i)* misreporting of regional activities in the CIS for multi-establishment enterprises (main reason of the choice to consider only SMEs where the enterprise/workplace problem is minimized); *ii)* lack of regional stratum in the CIS sample design; *iii)* too small CIS sample size (main cause of the choice to use NUTS 1 regional aggregation for different Countries instead of NUTS 2); *iv)* overrepresentation of CIS indicators at the regional level; *v)* missing data. All these points working together make the regional indicators less meaningful than the national one.

Figure 3.3a – *Frequency distribution and boxplot of indicators 2.1.1: business R&D expenditure*



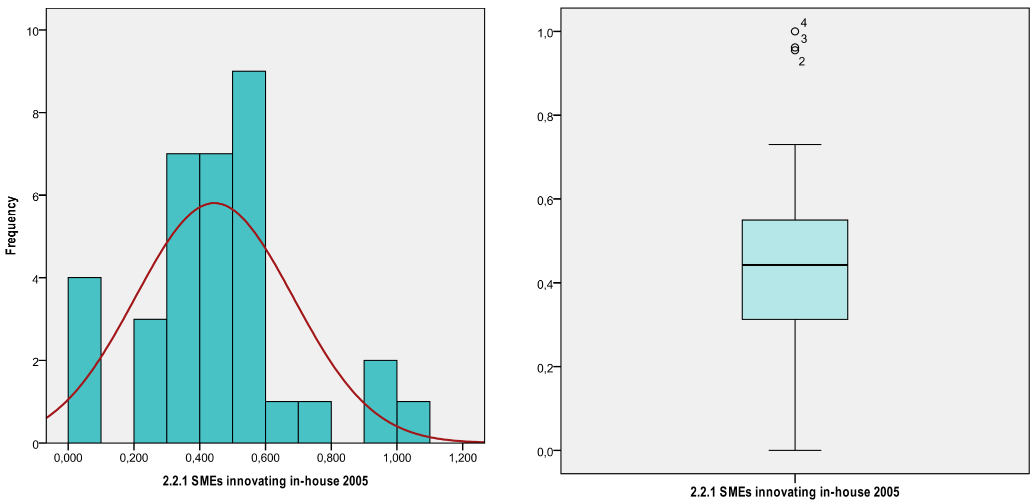
Notes: Mean = 0.32; Std.Dev. = 0.271; N = 35

Figure 3.3b – *Frequency distribution and boxplot of indicators 2.1.3: non R&D innovation expenditure*



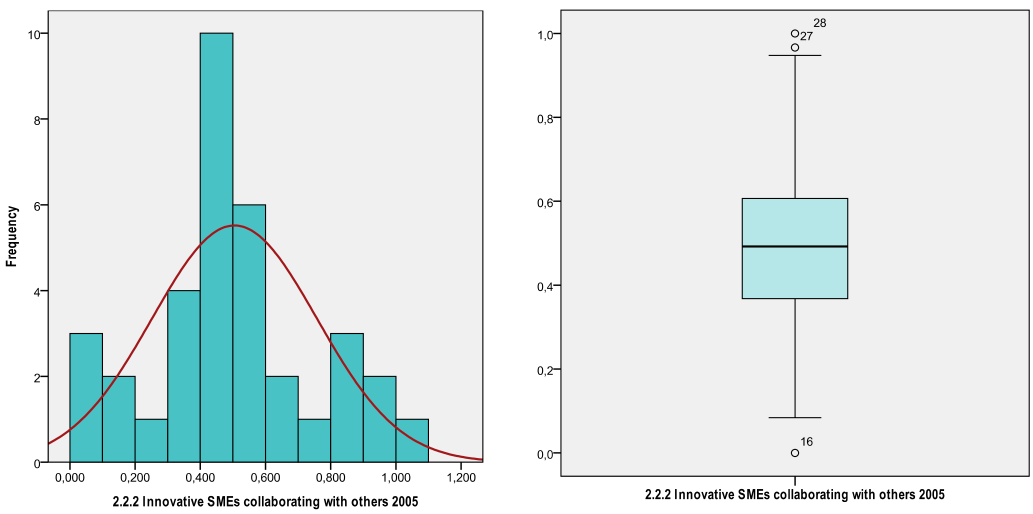
Notes: Mean = 0.49; Std.Dev. = 0.268; N = 35

Figure 3.3c – *Frequency distribution and boxplot of indicators 2.2.1: SMEs innovating in house*



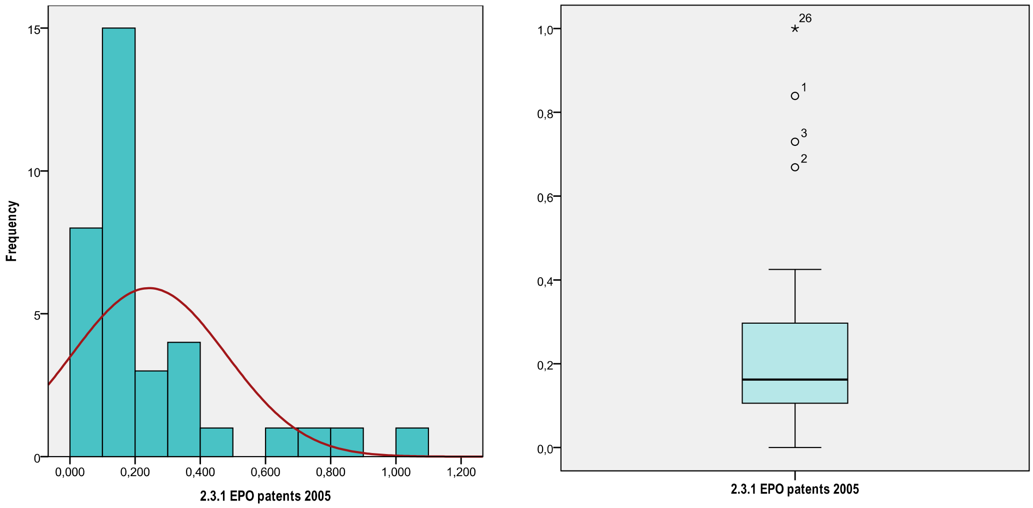
Notes: Mean = 0.44; Std.Dev. = 0.240; N = 35

Figure 3.3d – *Frequency distribution and boxplot of indicators 2.2.2: innovative SMEs collaborating with others*



Notes: Mean = 0.50; Std.Dev. = 0.253; N = 35

Figure 3.3e – *Frequency distribution and boxplot of indicators 2.3.1: EPO patents per million population*



Notes: Mean = 0.24; Std.Dev. = 0.237; N = 35

Figures 3.3 (from *a* to *e*) report the frequency distribution of simple indicators and we can see a more unhomogeneous distribution with respect to Pillar 1: the boxplots are quite small but showing a meaningful number of outliers, specifically: SMEs innovating in-house (see Figure 3.3c) and EPO patents (see Figure 3.3e).

3.2.4 The third PILLAR: outcomes (innovation results)

The third Pillar includes six indicators capturing the outputs (but not only) of firm innovation activities (see Table 3.5).

Table 3.5 – *Definition and measurement of simple indicators: PILLAR 3*

	Indicators	Numerator	Denominator	Ref. year	Source	Type
3.1.1	SMEs introducing product or process innovations (% of SMEs)	Number of SMEs who introduced a new product or a new process to one of their markets	Total number of SMEs	2006	Eurostat	Output
3.1.2	SMEs introducing marketing or organisational innovations (% of SMEs)	Number of SMEs who introduced a new marketing innovation and/or organizational innovation to one of their markets	Total number of SMEs	2006	Eurostat	Output
3.1.3a	Reduced labour costs (% of firms)	Number of innovating firms who replied that their product or process innovation had a highly important effect on reducing labour costs per unit of output	Total number of innovating firms	2006	Eurostat	Process/also output
3.1.3b	Reduced use of materials and energy (% of firms)	Number of innovating firms who replied that their product or process innovation had a highly important effect on reducing materials and energy per unit of output	Total number of innovating firms	2006	Eurostat	Process/also output
3.2.1	Employment in medium-high & high-tech manufacturing (% of workforce)	Number of employed persons in the medium-high and high-tech manufacturing sectors	Total workforce	2007	Eurostat	Input
3.2.2	Employment in knowledge-intensive services (% of workforce)	Number of employed persons in knowledge-intensive services sectors	Total workforce	2007	Eurostat	Input

Source: European Innovation Scoreboard (PROINNO Europe, 2009).

We have chosen to distinguish, within the 'old Pillar 3', this sub-set of indicators which are all referred to the output of the innovation process from the last two simple indicators – here included in the new Pillar 4 – which are differently referred to outcomes in terms of market. To some extent the last two are the ultimate results of the innovation effort of the firm.

Table 3.6 – *Regions ranked for PILLAR 3 indicator and single ranks of the six simple indicators within PILLAR 3*

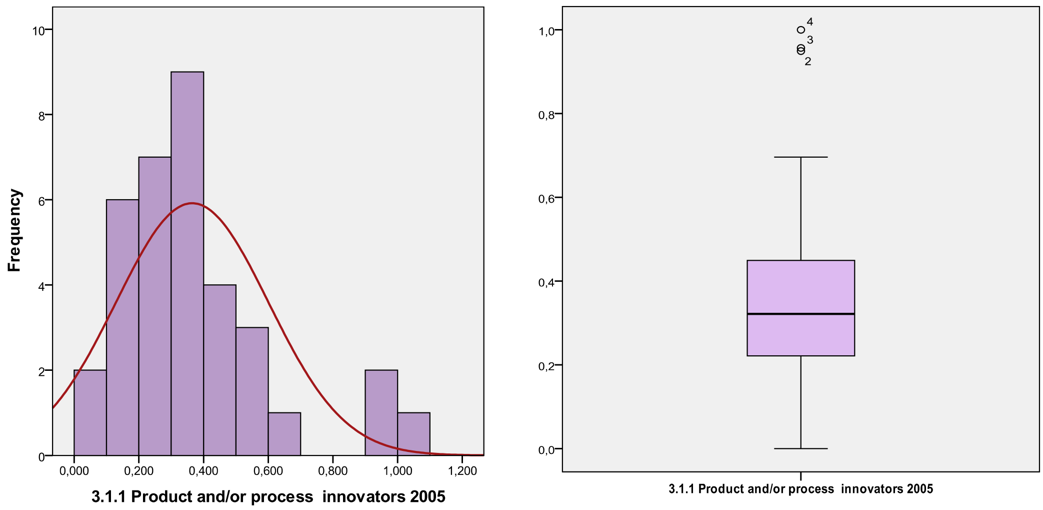
Regions	Cod	Pillar 1	Pillar 2	PILLAR 3	3.1.1 Product and/or process innovators	3.1.2 Marketing and/or organisational innovators	3.1.3a Resource efficiency innovators - Labour	3.1.3b Resource efficiency innovators - Energy	3.2.1 Employment medium-high & high-tech manufacturing	3.2.2 Employment knowledge-intensive services	Pillar 4
Oberbayern	de21	0,347	0,795	0,741	2	2	**11**	5	3	9	0,821
Karlsruhe	de12	0,412	0,694	0,722	3	3	**12**	6	2	**20**	0,815
Berlin	de3	0,594	0,585	0,711	1	1	9	3	**21**	7	0,858
Stuttgart	de11	0,249	0,782	0,597	4	4	**23**	10	1	**24**	0,597
Île de France	fr1	0,391	0,309	0,539	31	9	**1**	**2**	13	14	0,418
Eastern	ukh	0,523	0,435	0,482	15	25	6	1	25	10	0,430
Stockholm	se11	0,662	0,698	0,481	9	10	13	18	32	1	0,593
South East	ukj	0,677	0,373	0,452	19	18	4	13	24	6	0,440
South West	ukk	0,506	0,320	0,391	20	24	5	9	23	17	0,363
Est	fr4	0,191	0,228	0,385	34	19	2	7	8	34	0,222
Västsverige	se23	0,581	0,745	0,384	11	12	17	20	10	16	0,550
Sydsverige	se22	0,643	0,683	0,372	10	11	16	19	20	15	0,556
Vlaams Gewest	be2	0,402	0,457	0,371	6	13	24	17	14	21	0,290
Centre-Est	fr7	0,244	0,233	0,367	35	22	3	4	18	28	0,271
Utrecht	nl31	0,719	0,241	0,358	25	32	10	8	34	4	0,424
East Midlands	ukf	0,486	0,330	0,355	17	26	7	15	17	25	0,359
Région de Bruxelles	be1	0,476	0,262	0,344	18	7	27	28	33	2	0,322
Pais Vasco	es21	0,333	0,221	0,330	24	33	8	12	9	26	0,497
Noord-Holland	nl32	0,595	0,216	0,325	28	34	14	14	35	3	0,367
Lazio	ite4	0,245	0,131	0,316	32	20	15	23	28	8	0,516
Lombardia	itc4	0,049	0,261	0,311	21	21	22	32	6	12	0,579
Ostösterreich	at1	0,332	0,399	0,297	7	5	34	31	26	13	0,650
Westösterreich	at3	0,205	0,399	0,296	5	6	33	21	16	32	0,641
Etelä-Suomi	fi18	0,628	0,577	0,285	13	14	28	33	19	11	0,352
Piemonte	itc1	0,005	0,255	0,283	27	28	20	29	4	19	0,444
Région Wallonne	be3	0,292	0,412	0,277	16	15	21	22	29	27	0,434
Navarra	es22	0,301	0,204	0,268	26	31	26	**11**	**7**	35	0,689
Noord-Brabant	nl41	0,426	0,518	0,262	30	35	**18**	**16**	27	18	0,333
Länsi-Suomi	fi19	0,623	0,611	0,252	**12**	**16**	30	27	**12**	30	0,373
Emilia-Romagna	itd5	0,086	0,251	0,243	**14**	27	25	35	**5**	**22**	0,594
Madrid	es3	0,379	0,093	0,225	29	29	32	30	31	**5**	0,134
Cataluña	es51	0,265	0,123	0,220	**23**	30	31	26	**11**	**23**	0,524
Südösterreich	at2	0,234	0,410	0,212	**8**	**8**	35	34	**15**	33	0,582
Pohjois-Suomi	fi1a	0,647	0,548	0,210	**22**	**17**	29	**24**	**22**	31	0,328
Sud-Ouest	fr6	0,264	0,269	0,210	33	**23**	**19**	25	30	29	0,334

Notes: In black **bold**, for the first four best performing regions, we have the position greater than 10 (the relative worse performances), for the last nine worse performing regions we have the position smaller than 25 (the relative best performances), and in blue **bold** we have the outperforming positions of all the other regions.

In Table 3.6 the Oberbayern region (DE) is again (see Table 3.4 on Pillar 2) the best performer in Pillar 3 due to an interesting performance of simple indicators *product and/or process innovators* (ranks 2nd), *marketing and/or organization innovators* (ranks 2nd), and *employment high-tech manufacturing* (ranks 3rd). Table 3.6 shows a strong coherence at the top of the Pillar 3 ranking: the best four regions show no more than six indicators achieving a lower than the 10th position, and no regions have more than two worse indicators together. Île de France is an anomalous case because it outperforms in two single indicators *Resource efficiencies – labour* (ranks 1st) and *Resource efficiencies – energy* (ranks 2nd), while in *product/process innovation it* performs at the bottom scale of the regions (rank 31).

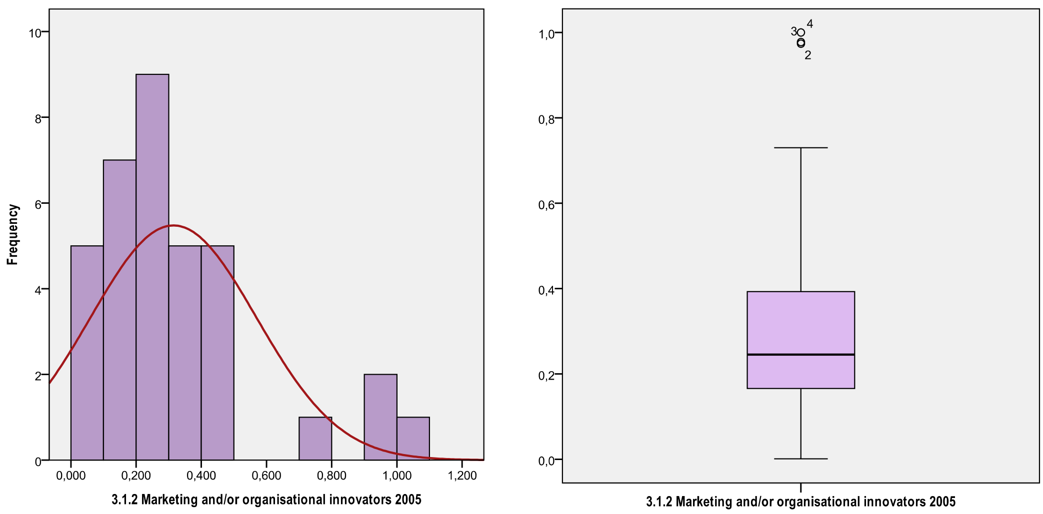
At the bottom of Table 3.6 we have a more mixed situation with 9 regions performing very bad (ranking over the 24th position) in at least half of the indicators (with the partial exclusion of Phjois-Suomi (FI) with a very critical performance in only two out of the six indicators).

Figure 3.4a – *Frequency distribution and boxplot of indicator 3.1.1: SMEs introducing product or process innovations*



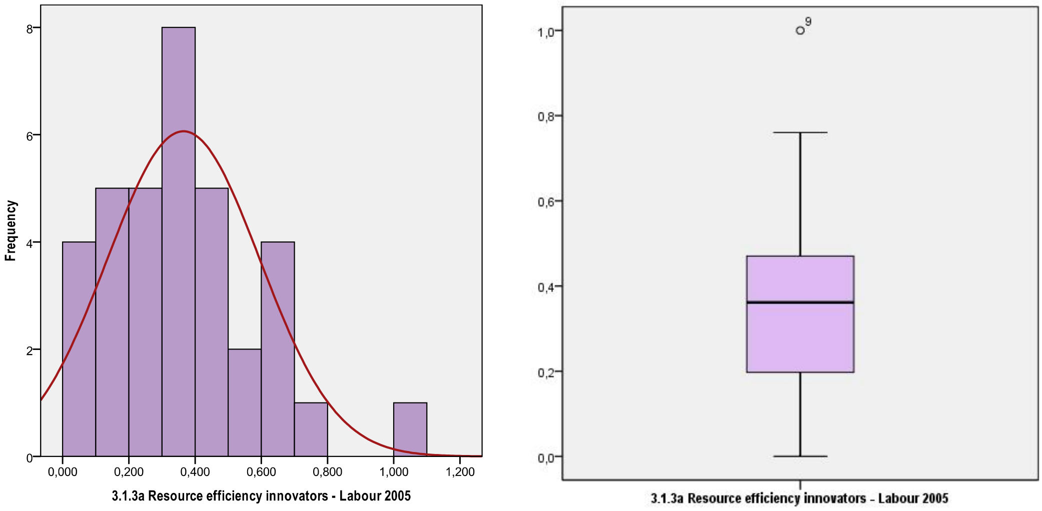
Notes: Mean = 0.36; Std.Dev. = 0.236; N = 35

Figure 3.4b – *Frequency distribution and boxplot of indicator 3.1.2: SMEs introducing marketing or organisational innovations*



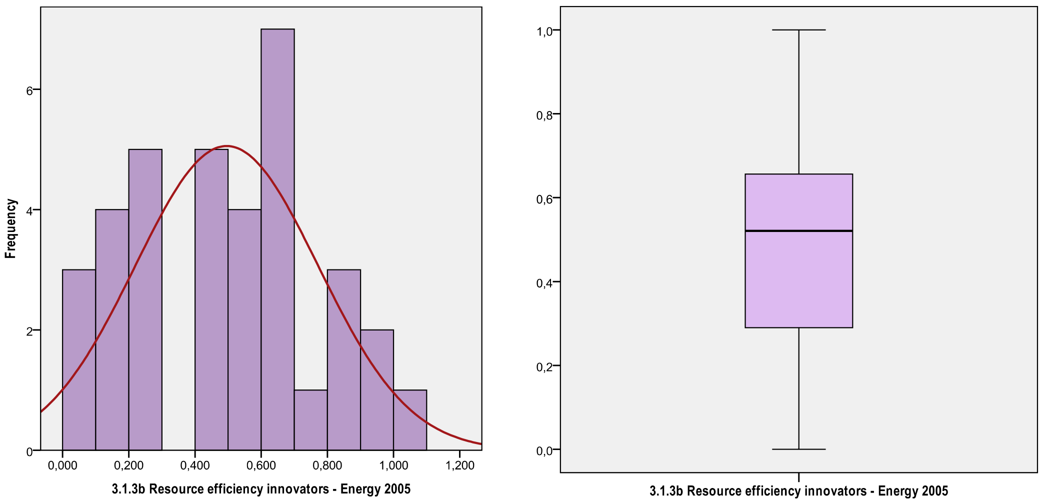
Notes: Mean = 0.31; Std.Dev. = 0.255; N = 35

Figure 3.4c – *Frequency distribution and boxplot of indicator 3.1.3a: Reduced labour costs*



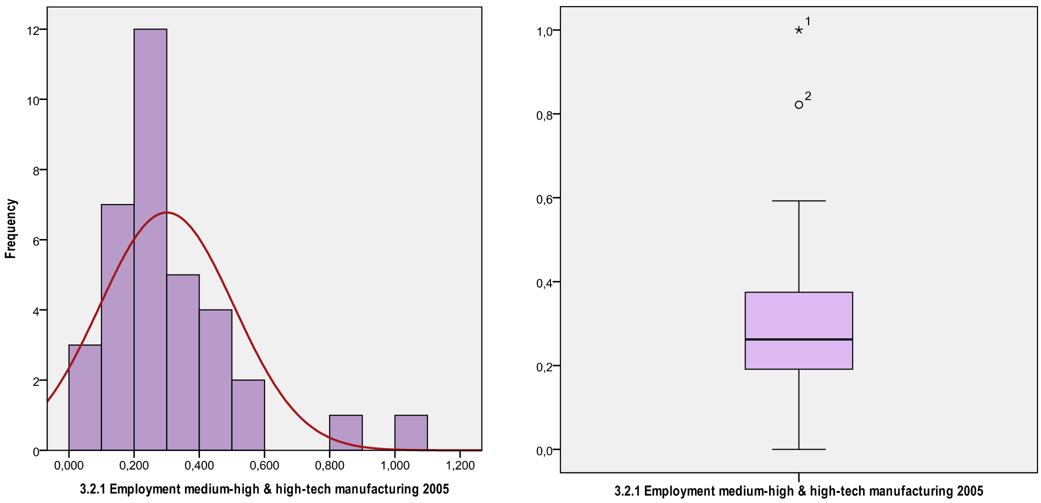
Notes: Mean = 0.36; Std.Dev. = 0.230; N = 35

Figure 3.4d – *Frequency distribution and boxplot of indicator 3.1.3b: Reduced use of materials and energy*



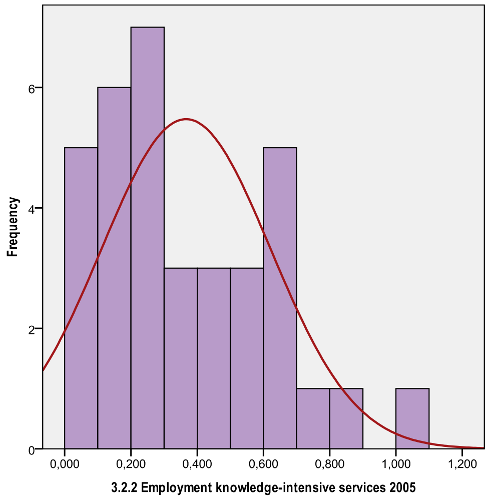
Notes: Mean = 0.50; Std.Dev. = 0.276; N = 35

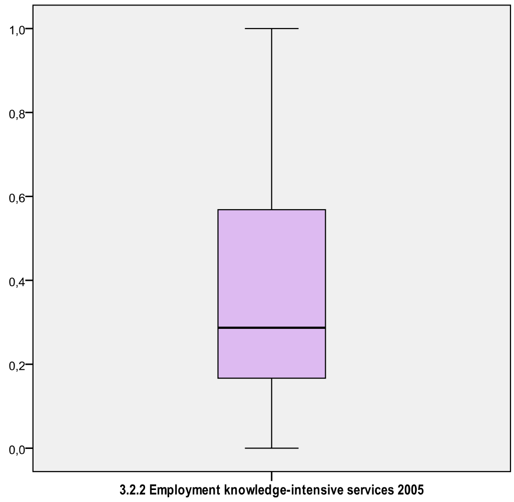
Figure 3.4e – *Frequency distribution and boxplot of indicator 3.2.1: Employment in medium-high and high-tech manufacturing*



Notes: Mean = 0.30; Std.Dev. = 0.206; N = 35

Figure 3.4f – *Frequency distribution and boxplot of indicator 3.2.2: Employment* *in knowledge-intensive services*





Notes: Mean = 0.37; Std.Dev. = 0.255; N = 35

Figures 3.4 (from *a* to *f*) report the frequency distribution of simple indicators and we can see a less homogeneous distribution with respect to Pillar 1, comparable to the one shown by Pillar 2: for all indicators we have a very fragmented distribution.

3.2.5 The forth PILLAR: outcomes (market results)

The forth Pillar includes only two indicators (see Table 3.7) capturing: *sales of new-to-market products* ('radical' product innovation) and *sales of new-to-firm products* ('incremental' product innovation). The related information derives from CIS (2006), the latest available at the time of the closure of the present Report, and it is therefore subject to all the shortcomings affecting that specific source. As already said these two indicators capture (at least partially) the final success of the innovation process. In fact, the simple introduction of a product innovation – or the realized saving on inputs (labour/energy) – may not necessarily imply the firm's market success: it is always a problem of *relative competitiveness* on the relevant market. Differently, when the firm obtains an important share of its turnover on new products this is a direct evidence of the capability of the firm to stand competition.

Table 3.7 – *Definition and measurement of sample indicators: PILLAR 4*

	Indicators	Numerator	Denominator	Ref. year	Source	Type
3.2.5	New-to-market sales (% of turnover)	Sum of total turnover of new or significantly improved products for all enterprises	Total turnover for all enterprises	2006	Eurostat	Outcome
3.2.6	New-to-firm sales (% of turnover)	Sum of total turnover of new or significantly improved products for the firm but not to the market for all enterprises	Total turnover for all enterprises	2006	Eurostat	Outcome

Source: European Innovation Scoreboard (PROINNO Europe, 2009).

In Table 3.8 the Berlin Länder (DE) is the best performer in Pillar 4 due to the best position in *new-to-firm sales* (ranks 1st) and Oberbayern region (DE) is still a strong competitor due to the second ranking in the same indicator (*new-to-firm sales*). Here the picture is less extreme in the sense that on the two indicators contributing to Pillar 4 normally only one is very good (*i.e.*, ranking less than 10th)

in the first 8 regions, with an outstanding exception of Navarra (ES). The same occurs at the bottom of the scale where the worst positions are characterized by two bad indicators (above 25) only in 4 cases out of 9 regions. This behavior seems to suggest that within the region radical product innovation is more easily alternative rather than complementary to the incremental product one.

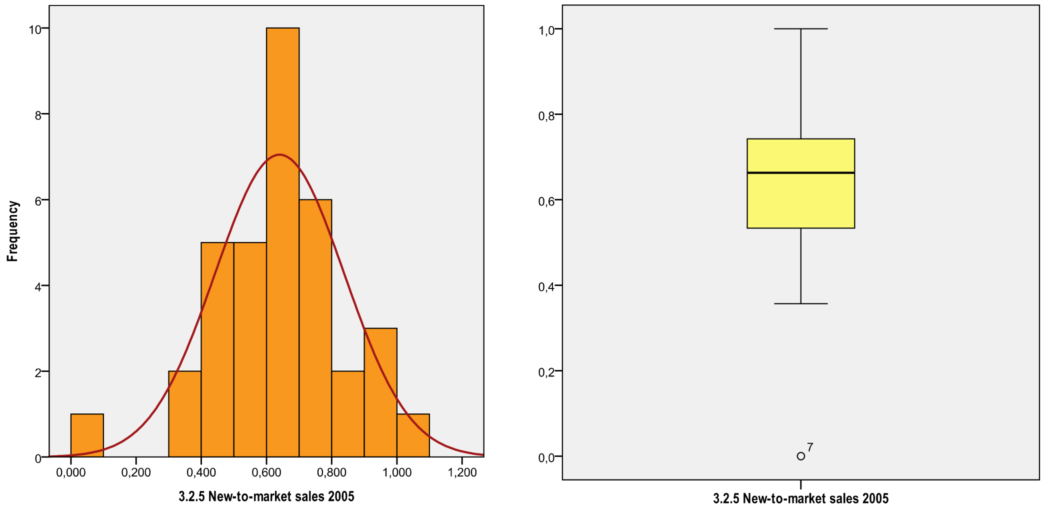
Table 3.8 – *Regions ranked for Pillar 4 indicator and single ranks of the two simple indicators within Pillar 4*

Regions	Cod	Pillar 1	Pillar 2	Pillar 3	Pillar 4	3.2.5 New-to-market sales	3.2.6 New-to-firm sales
Berlin	de3	0,594	0,585	0,711	0,858	**12**	1
Oberbayern	de21	0,347	0,795	0,741	0,821	**15**	2
Karlsruhe	de12	0,412	0,694	0,722	0,815	**17**	3
Navarra	es22	0,301	0,204	0,268	0,689	6	5
Ostösterreich	at1	0,332	0,399	0,297	0,650	1	**11**
Westösterreich	at3	0,205	0,399	0,296	0,641	2	**12**
Stuttgart	de11	0,249	0,782	0,597	0,597	30	**4**
Emilia-Romagna	itd5	0,086	0,251	0,243	0,594	**3**	13
Stockholm	se11	0,662	0,698	0,481	0,593	7	8
Südösterreich	at2	0,234	0,410	0,212	0,582	**4**	16
Lombardia	itc4	0,049	0,261	0,311	0,579	**5**	14
Sydsverige	se22	0,643	0,683	0,372	0,556	9	9
Västsverige	se23	0,581	0,745	0,384	0,550	10	10
Cataluña	es51	0,265	0,123	0,220	0,524	23	**7**
Lazio	ite4	0,245	0,131	0,316	0,516	8	17
Pais Vasco	es21	0,333	0,221	0,330	0,497	28	**6**
Piemonte	itc1	0,005	0,255	0,283	0,444	14	21
South East	ukj	0,677	0,373	0,452	0,440	16	22
Région Wallonne	be3	0,292	0,412	0,277	0,434	11	29
Eastern	ukh	0,523	0,435	0,482	0,430	18	24
Utrecht	nl31	0,719	0,241	0,358	0,424	13	27
Île de France	fr1	0,391	0,309	0,539	0,418	21	20
Länsi-Suomi	fi19	0,623	0,611	0,252	0,373	27	18
Noord-Holland	nl32	0,595	0,216	0,325	0,367	22	31
South West	ukk	0,506	0,320	0,391	0,363	24	26
East Midlands	ukf	0,486	0,330	0,355	0,359	25	28
Etelä-Suomi	fi18	0,628	0,577	0,285	0,352	29	**19**
Sud-Ouest	fr6	0,264	0,269	0,210	0,334	**20**	34
Noord-Brabant	nl41	0,426	0,518	0,262	0,333	26	32
Pohjois-Suomi	fi1a	0,647	0,548	0,210	0,328	31	23
Région de Bruxelles	be1	0,476	0,262	0,344	0,322	**19**	35
Vlaams Gewest	be2	0,402	0,457	0,371	0,290	32	30
Centre-Est	fr7	0,244	0,233	0,367	0,271	34	25
Est	fr4	0,191	0,228	0,385	0,222	33	33
Madrid	es3	0,379	0,093	0,225	0,134	35	**15**

Notes: In black **bold**, for the first six best performing regions, we have the position greater than 10 (the relative worse performances), for the last nine worse performing regions we have the position smaller than 25 (the relative best performances), and in blue **bold** we have the outperforming positions of all the other regions.

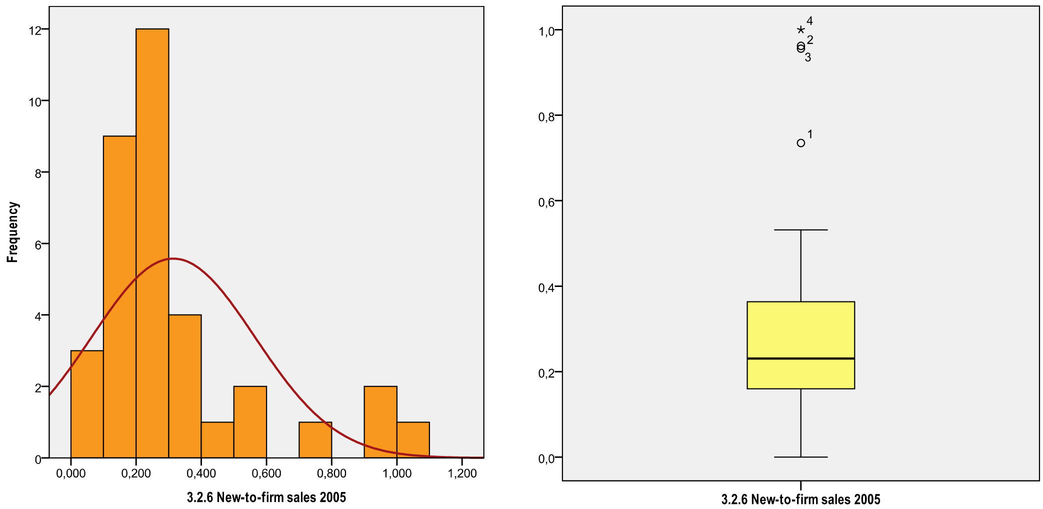
Figures 3.5 (from *a* to *b*) report the frequency distribution of simple indicators and we can see a more regular distribution with respect to Pillar 1 and 2 even if some outliers are still present.

Figure 3.5a – *Frequency distribution and boxplot of indicator 3.2.5: New-to-market sales*



Notes: Mean = 0.64; Std.Dev. = 0.198; N = 35

Figure 3.5b – *Frequency distribution and boxplot of indicator 3.2.6: New-to-firm sales*



Notes: Mean = 0.31; Std.Dev. = 0.250; N = 35

3.3 The simple indicators: time choices and missing values

Before passing to the statistical treatment of data some further preliminary choices are necessarily. The first one is related to the time dimension of the analysis. We have two points – 2004 and 2006 – for different regions deriving from the CIS survey but, sometimes, only one point or no one at all: we are so forced to use just one point in time out of the two. Simple indicators, in their turns, can be splitted into two very different categories: *i)* a sub set very stable (affected by only a very long term dynamics); and *ii)* a second sub-set strictly following the economic trend. In the first group we can recognize, for example, the *share of skilled population* (1.1.3), while in the second group we have *business R&D expenditures* (2.1.1) or *EPO numbers* (2.3.1). For the sake of homogeneity we choose to use the CIS reference and take 2005 as the average point in the triennium[19].

[19]The *Community Innovation Survey* (CIS 2006) collects information on European enterprises innovation activities between 2004 and 2006 included. In the harmonized survey questionnaire innovation is considered the introduction of a new or significantly improved product, process, organisational method, or marketing method by the enterprise. The innovation must be new to the

As far as missing values are concerned we have to deal with some 23.7% of empty cells and we adopt the methodology already used in the RIS (2009) Report which is a two steps one. In the first step researchers look for the enforceability of a linear regression procedure[20] but after regression only 13% of the missing values could be imputed, still leaving unknown a large number of the original cells. In the second step a hierarchical procedure is applied imputing firstly missing values at national level and secondly at regional level, using values at national level[21]. We have actually to distinguish two cases: for some NUTS2 regions NUTS2 values are not observed but NUTS1 values are available; in other cases only data at the Country level are available. In this case the procedure applied descends from the idea to 'spread' national values of the *i-th* indicator (unknown at the regional level) across the regions according to the average performance of those regions with respect to its Country.

Of course there are many shareable criticisms in using this kind of extensive imputation for missing data, and the debate is quite radical. It is not the problem, at a first instance, of the specific procedure of imputation applied, the question is why not to drop the variables with so many missing values?

A special point arises on the CIS survey – direct object of severe criticisms – which has not been originally designed to suit the regional dimension. But in consideration of its existence since the beginning of the present decade, and knowing that it has been improved in the years, reaching quite robust results at national level, we choose to use it for benchmarking innovation performance in this RIS exercise, fully aware of its well known shortcomings.

3.4 The simple indicators: multicollinearity

When the preliminary work on the data-set has been completed (filling the empty cells and rescaling the indicators, using the min–Max procedure) we have still to detect multicollinearity. If different indicators are measuring the same latent innovation determinants, than we are overweighting the contribution of these determinants on the composite and, as a consequence, Countries that score high in that field will receive better ranks.

Some of the correlations are suggested from theory. Technology oriented indicators, for example, are normally highly correlated, possibly measuring similar deep causes: *business R&D expenditure* (2.1.1), *EPO patents* (2.3.1) and *employment in high-tech manufacturing* (3.2.1). A second case is related to SMEs' indicators: small firms usually innovate in a 'less formalised' way, using *non R&D*

firm, although it could have been originally developed by other enterprises. It is quite understandable to take 2005, the median point, as the reference year for the analysis.

[20] *«Consider a missing value for indicator Y in region R for a given year, e.g. Y-2004.* ***If*** *a value is available for Y-2006 in region R,* ***then*** *apply a linear regression between Y-2004 and Y-2006,* ***else*** *find the indicator Z with the highest correlation with Y (Z can span both years).* ***If*** *correlation between Y and Z is > 0.6 and a value is available for Z in R* ***then*** *apply linear regression between Y and Z.»* (PROINNO Europe, 2009 – *Methodology,* p. 22).

[21] *«The procedure calculates for each indicator Y, where possible, the ratios between the values of Y for region R and for Country C. Then, the median across the indicators is calculated. The missing value for indicator Z in region R is imputed assuming that for Z the median ratio just computed applies between R and C. Given that all national values are available, all missing values at regional level can be imputed.»* (PROINNO Europe, 2009 – *Methodology,* p. 23).

innovation expenditures (2.1.3), *innovating in-house* (2.2.1) and, sometimes, *collaborating with others* (2.2.2).

Table 3.9 – *Pearson correlation, 17 simple indicators*

	Pillar 1			Pillar 2					Pillar 3						Pillar 4	
	1.1.4	1.2.4	1.2.1	2.1.1	2.1.3	2.2.1	2.2.2	2.3.1	3.1.1	3.1.2	3.1.3a	3.1.3b	3.2.1	3.2.2	3.2.5	3.2.6
1.1.3	0,233	**0,600**	0,244	0,049	–0,026	–0,024	0,330	–0,006	0,048	–0,007	0,128	0,323	–0,330	0,360	–0,408	0,066
1.1.4	1,000	**0,680**	0,256	0,415	0,369	0,101	**0,629**	0,090	0,017	–0,142	0,101	0,067	–0,343	0,236	0,018	–0,198
1.2.4		1,000	0,226	0,245	0,153	0,031	**0,549**	0,217	0,018	–0,171	0,010	0,169	–0,463	0,358	–0,215	–0,215
1.2.1			1,000	0,202	**0,490**	0,367	0,232	0,063	**0,451**	**0,548**	0,167	0,312	–0,137	0,414	0,072	0,423
2.1.1				1,000	**0,647**	0,386	**0,713**	**0,687**	**0,431**	**0,427**	0,009	0,217	0,397	–0,059	–0,066	0,375
2.1.3					1,000	0,612	**0,645**	**0,425**	**0,658**	**0,650**	0,112	0,251	0,226	0,073	0,267	**0,442**
2.2.1						1,000	0,312	**0,420**	**0,948**	**0,773**	–0,282	0,060	0,429	0,195	0,355	**0,731**
2.2.2							1,000	**0,457**	0,354	0,296	–0,075	0,073	0,026	–0,017	–0,048	0,046
2.3.1								1,000	**0,477**	0,460	–0,002	0,244	**0,496**	0,025	–0,001	0,431
3.1.1									1,000	**0,892**	–0,179	0,219	**0,468**	0,141	0,269	**0,808**
3.1.2										1,000	–0,008	0,306	**0,491**	0,144	0,192	**0,761**
3.1.3a											1,000	**0,761**	0,031	0,106	–0,202	–0,021
3.1.3b												1,000	0,152	0,089	–0,179	0,365
3.2.1													1,000	–0,403	0,006	**0,626**
3.2.2														1,000	0,019	0,043
3.2.5															1,000	0,140

Notes: 1.1.3 Tertiary education; 1.1.4 Life-long learning; 1.2.4 Broadband access; 1.2.1 Public R&D expenditures; 2.1.1 Business R&D expenditures; 2.1.3 Non-R&D innovation expenditures; 2.2.1 SMEs innovating in-house; 2.2.2 Innovative SMEs collaborating with others; 2.3.1 EPO patents; 3.1.1 Product and/or process innovators; 3.1.2 Marketing and/or organizational innovators; 3.1.3a Resource efficiency innovators – Labour; 3.1.3b Resource efficiency innovators – Energy; 3.2.1 Employment medium-high & high-tech manufacturing; 3.2.2 Employment knowledge-intensive services; 3.2.5 New-to-market sales; 3.2.6 New-to-firm sales.

Level of significance (p) for two-tailed test (d.f. = 35): 95% for cells > 0.325; 99% for cells > 0.418. In **bold** significance at 99%.

A quick look at the Table 3.9 shows three different results.

1. There is a certain degree of correlation within Pillars, but not in Pillar 4, which is not particularly disturbing. It is widely accepted that Pillars should be a unit of analysis capturing different macro factors, so simple indicators belonging to the Pillar can share some informational elements.
2. There are some high correlations outside the Pillars and we will go further in the analysis of these cases.
3. There are two simple indicators – one in Pillar 1 (1.2.1) and one in Pillar 3 (3.2.2) – which are not correlated with the other variables within that Pillar. *Public R&D expenditures* in not related with human capital nor with broadband infrastructure, and *employment in knowledge-intensive services* is even negatively correlated with *employment in high-tech manufacturing*, and this is a possible consequence of looking only to small firms.

A rule of thumb should be introduced to define a threshold beyond which the correlation is a symptom of double counting. In Table 3.10 we report all the couples of indicators showing a Person's R greater than .70 (our threshold in the present exercise), while in the following seven Figures we analyze the scatterplots of these pairs of indicators.

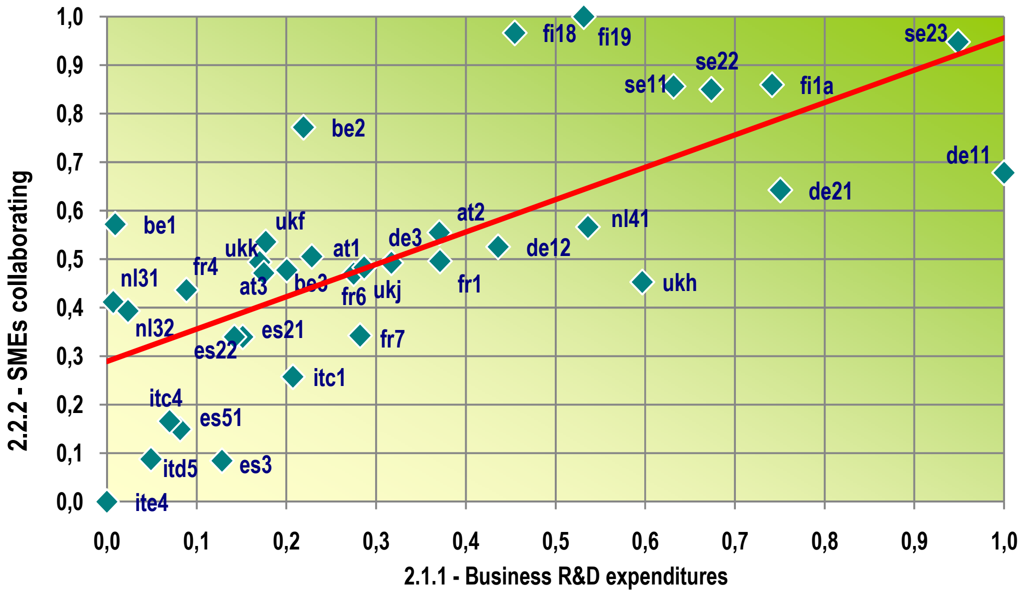
Table 3.10 – *High Pearson's R, selected pairs of indicators*

Indicator 1	Pearson's R	Indicator 2
2.2.1 – SMEs innovating in-house	0.948	3.1.1 – Product and/or process innovators
3.1.1 – Product and/or process innovators	0.892	3.1.2 – Marketing and/or organisational innovators
3.1.3a – Resource efficiency innovators–Labour	0.808	3.1.3b – Resource efficiency innovators–Energy
2.2.1 – SMEs innovating in-house	0.773	3.1.2 – Marketing and/or organisational innovators
3.1.1 – Product and/or process innovators	0.761	3.2.6 – New-to-firm sales
2.2.1 – SMEs innovating in-house	0.731	3.2.6 – New-to-firm sales
2.1.1 – Business R&D expenditures	0.713	2.2.2 – Innovative SMEs collaborating with others

3.4.1 Checking for highly correlated pairs of variables

The first scatterplot (see Figure 3.6) points out a relative orientation of SMEs towards forms of collaboration with external partners rather than towards internal R&D activity. We find out a confirmation of the preference expressed by small firms for 'less formalized' efforts in order to innovate (NESTA, 2009; Huang *et al.*, 2010; Stoneman, 2010).

Figure 3.6 – *Scatterplot of 2.1.1 and 2.2.2 – Pearson's R = 0.713*



If we look at the principal diagonal of the scatterplot we easily detect that the large majority of the regions are in the upper-left triangle, that is to say that the choice to collaborate is the preferred one. Only four regions go against the mainstream. The one at the bottom ranking is not interesting, while the three challenging cases are two German Länder (Stuttgard and Oberbayern) and an English region (Eastern) showing a relative propensity in investing in business R&D rather than collaborating outside.

Figure 3.7 shows a very strong co-presence of the achievement of innovation with the choice to do it in-house. Differently, the correlation with *marketing and organizational innovation* is less pronounced and it is quite understandable (see Figure 3.8). Small firms have more easiness to address outside suppliers in implementing organizational innovation.

Scatterplot 3.9 proves us another expected result. *Innovating in-house* – which is a strongly preferred way – brings to the realization of a product new for the firm. That's to say the auto-referentiality of small firms on innovation ground allows to reach an ‘incremental innovation’ more than a more radical product innovation (*new-to-market sales*).

Figure 3.7 – *Scatterplot of 2.2.1 and 3.1.1 – Pearson’s R = 0.948*

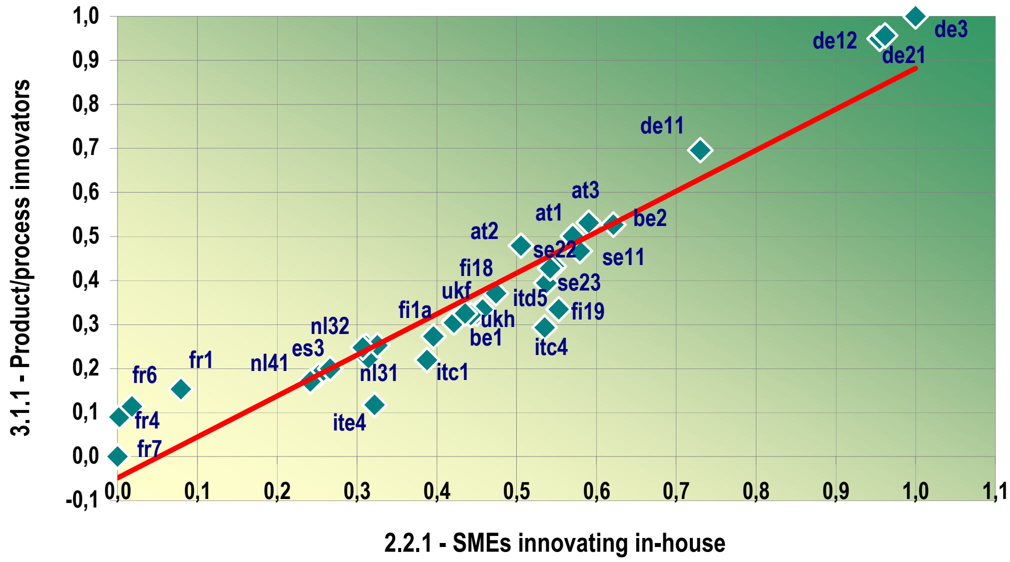
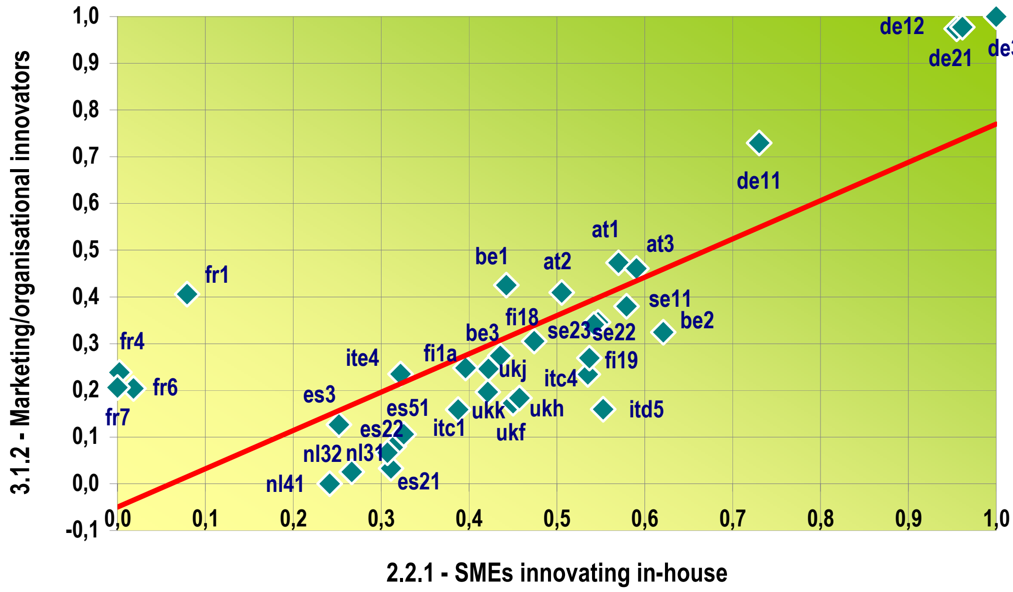


Figure 3.8 – *Scatterplot of 2.2.1 and 3.1.2 – Pearson’s R = 0.773*



With Figure 3.10 we change perspective passing from the ‘how’ question (the condition for innovation) to the ‘what’ question (the specific kind of innovation). Here it appears a quite strong co-presence of the two main macro-categories of innovation *product and/or process* jointly with *organizational and/or marketing*.

It can be read as an element of coherence in the innovative strategy of small firms: when SMEs introduce a new product they are interested in the best way to sell it in the market, and when innovation regards the process it has frequently meaningful impacts on firms’ organization.

In addition, we can easily detect that the large majority of regions is set below the principal diagonal, in the right-lower triangle. That is to say that SMEs are more prone to innovate their product and/or process rather than to introduce marketing and/or organizational innovations.

Figure 3.9 – *Scatterplot of 2.2.1 and 3.1.6 – Pearson's R = 0.731*

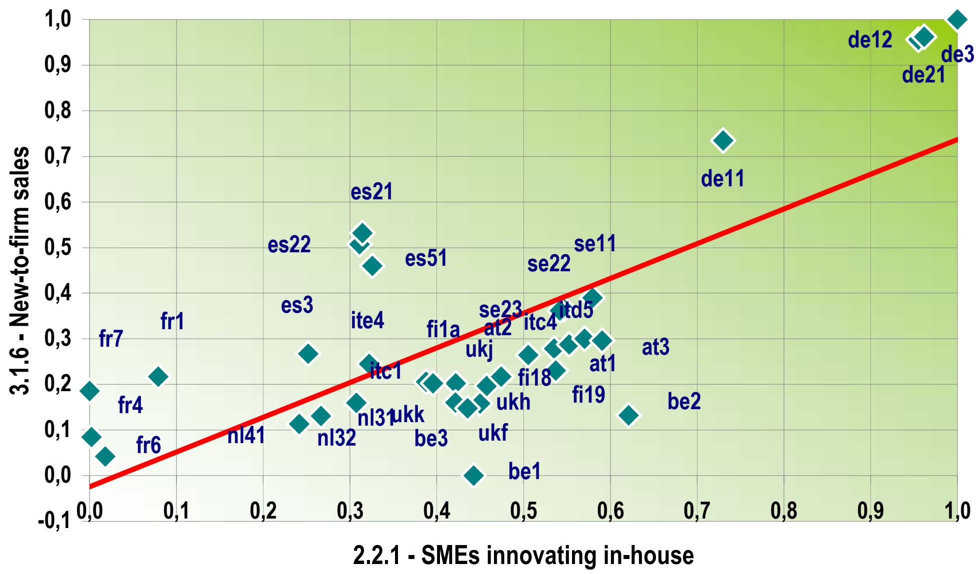


Figure 3.10 – *Scatterplot of 3.1.1 and 3.1.2 – Pearson's R = 0.892*

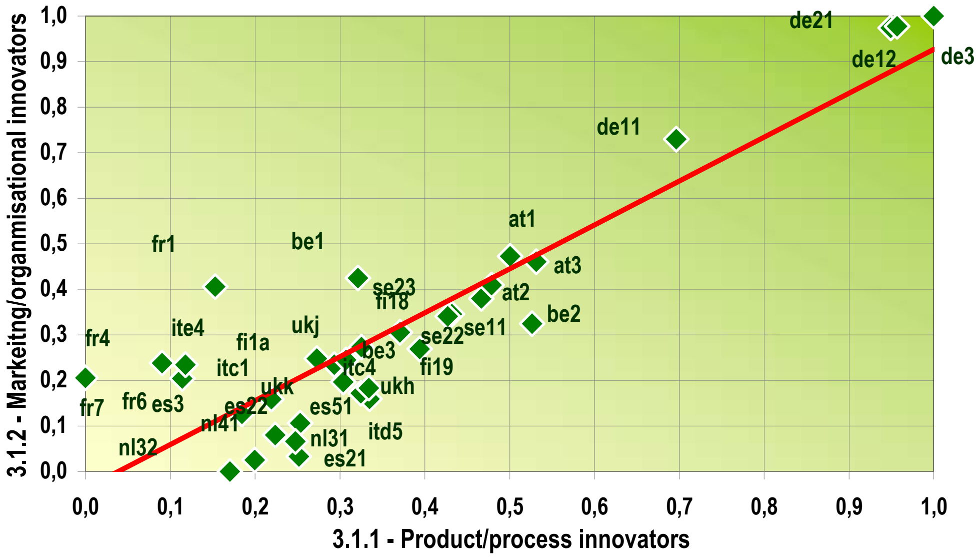


Figure 3.11 stresses once again how the large majority of innovation introduced by the firms (new product as well a as process innovations) leads to something new-to-firm (incremental innovation); while *new-to-market sales* (a proxy for a more radical innovation) are quite a rare event and are not correlate to the widespread activity of product/process innovation (Pearson's R = 0.269).

Finally, Figure 3.12 evidences how, in the search for resources efficiency, energy saving innovations go hand in hand with labour saving innovations but, at the same time, SMEs show that there are more margins of improvement in the energy field rather than on the labour market. As a matter of fact the large majority of regions are located in the left-upper triangle with only two cases ranking well against the mainstream: Île de France (FR) and South East (UK) showing labour saving innovations to be predominant on energy saving ones.

Figure 3.11 – *Scatterplot of 3.1.1 and 3.2.6 – Pearson's R = 0.808*

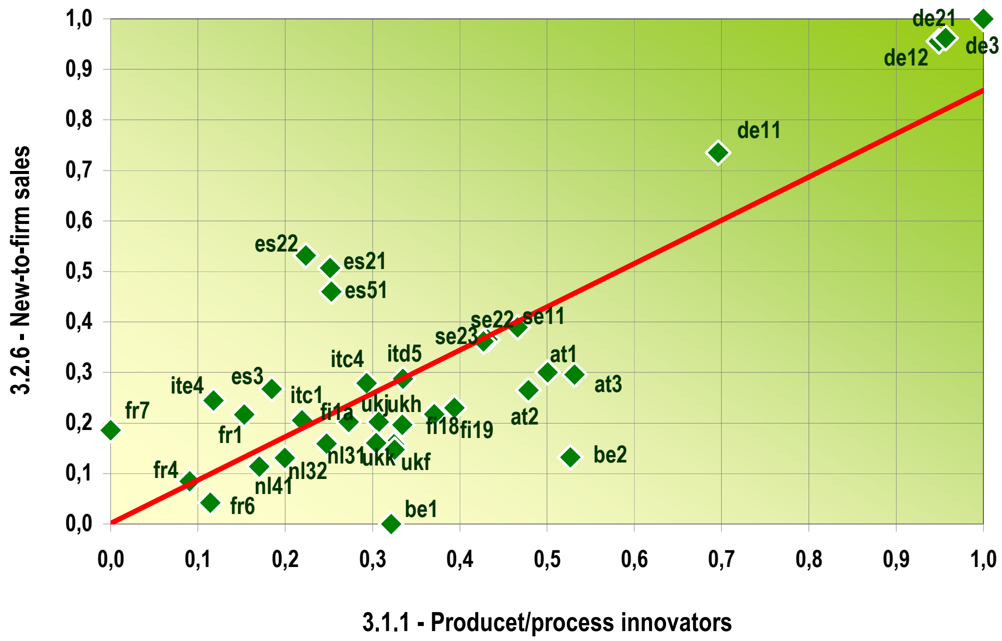
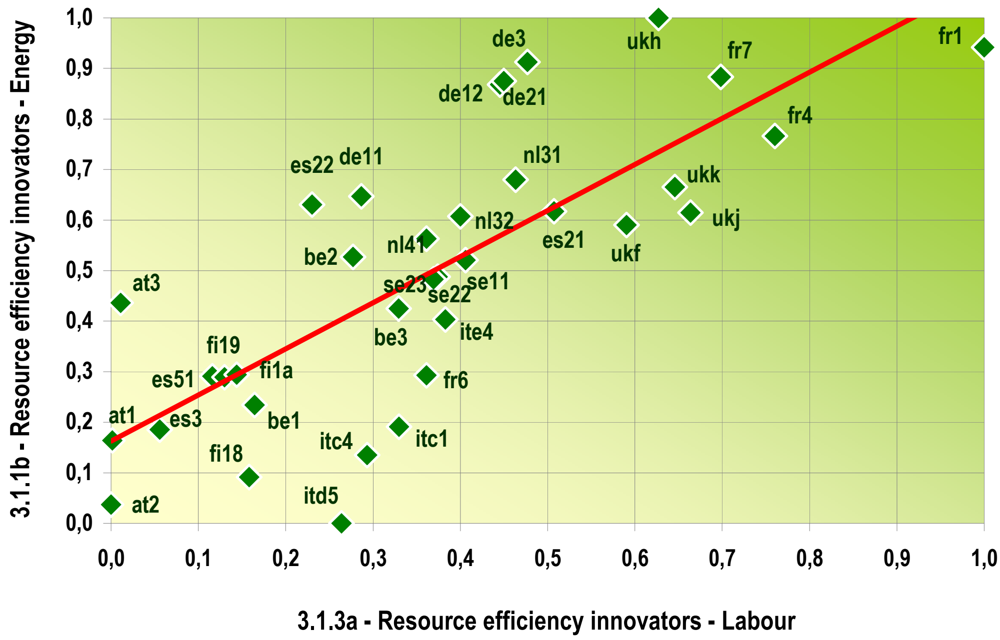


Figure 3.12 – *Scatterplot of 3.1.3a and 3.1.3b – Pearson's R = 0.761*



The general result stresses how SMEs are highly attentive to an efficient use of human resources (which are costly and not too flexible for the firm): it is not so frequent that innovation implies a meaningful decreasing of labour cost per unit of output.

Conclusively, from the correlation analysis we derive the appraisal that all the considered indicators are well set within this RIS exercise. The most disconnected variable from the whole set is certainly *employment knowledge-intensive service*

(3.2.2) which shows no correlation at all with the other indicators. It is not by chance that the relative strongest tie of 3.2.2 variable is with *public R&D expenditures* (1.2.1) which is, in turn, the less connected variable within Pillar 1.

On the contrary, *SME innovating in-house* (2.2.1) appears to be the most 'horizontal' variable, well connected with a number of other indicators scattered in different Pillars. The deriving multicollinearity effect, anyway, is not too worrying as SMEs are well diffused in all the studied regions and show a propensity to innovate 'in-house' at any latitude and in quite different contests.

4. Towards the construction of the composite

The data-set with absolute values (each indicator expressed in its proper unit of measurement) has been prepared. Imputation of missing values has been performed, the treatment of outliers enforced, and the data-set is finally ready for normalization of data. We choose the min–Max technique which re-scales indicators to an identical range [0, 1][22]. This normalization is also known as 'distance from the best and worst performers' where positioning is in relation to the global maximum and minimum, and the edge values should be red as laggards (0) or leaders (1).

4.1 The weighting and aggregating phases

Next step is related to weighting and aggregation. We consider the 'zero option' (or *base-line* option) as the equal weighting one, *i.e.* all variables are given the same weight as they are all considered equally helpful in the composite. It is also known as the *law of insufficient reason,* as in the absence of specific knowledge on the casual effect of each indicators, or in the lack of consensus on the alternatives, the 'zero option' – all variables carry equal weights – is by and large the most diffused one.

Here another choice has to be made. The 17 variables (ind_i, i =1, …, 17) are grouped into four dimensions (Pillars) that should be further aggregated into the composite. The alternative are: *i)* to assign a specific value to each Pillar – included the equal one – or *ii)* to attribute a weight proportional to the number of variables included in each Pillar (which could result in an unbalanced structure in the composite index). Here we apply a two steps weighting: firstly within Pillars, the simple average is used in order to compensate for the different number of single indicators present; secondly the equal weighting among Pillars assigns the same relative importance to the four Pillars:

$$CI = 0.25[(ind_1+ind_2+ind_3+ind_4)/4] + 0.25[(ind_5+ind_6+ind_7+ind_8+ind_9)/5] + 0.25[(ind_{10}+ind_{11}+ind_{12}+ind_{13}+ind_{14}+ind_{15})/6] + 0.25[ind_{16}+ind_{17})/2].$$

Many different alternatives are possible here and we will come back later to a specific one: the DEA analysis (see § 4.3).

Weights and aggregation methods, in addition, are strictly tied. For example, weights in additive aggregation take necessarily the meaning of substitution rates (trade-offs) and do not indicate the importance of the associated indicator (Munda and Nardo, 2005). For the weights to be interpreted as 'importance coefficients' – the greatest weights being placed on the most important 'dimension' – non-compensatory aggregation procedures must be used (Munda, 2008).

[22]The most used alternative is surely the normalization with Z-scores (standardization). Equally diffused, it converts indicators to a common scale with a mean of zero and standard deviation of one, but it implies negative values with some uncomfortable implications later on, in the construction of the composite.

4.1.1 The compensability debate

Also aggregation methods may vary a lot, but the 'big debate' is always between linear aggregation *vs.* non linear aggregation. The point is *compensability*[23] *vs.* (some degree of) *non compensability* between individual indicators or dimensions. A certain degree of compensability among variables can be possible and should be favourable, but its cost increases with 'unbalance' (Casadio Tarabusi and Guarini, 2010). With incomplete compensability only decreases in one single variable, smaller than a given amount, are compensable with suitable increases of the remaining variables[24].

Obviously the two alternatives are not neutral: *i)* using a linear aggregation, it is mandatory to check for preference independence (Munda, 2005) – which in turn implies the possibility to assess the marginal contribution of each variable separately. It is not only a problem of full compensability which emerges, we are also postulating the absence of synergies or trade-offs among variables; *ii)* using a geometric aggregation (a simple way to obtain partial non compensability) we should have in mind that the method rewards those regions with higher scores provided that no dimension is definitely bad (if I multiply any figure for a score very close to zero, I will get a very small indicator).

In particular, with geometric aggregation, compensability is lower for the composite indicators with low values and consequently:

«the marginal utility from an increase in low absolute score would be much higher than in a high absolute score under geometric aggregation. Consequently, a Country would have a greater incentive to address those sectors/activities/alternatives with low scores if the aggregation were geometric rather than linear, as this would give it a better chance of improving its position in the ranking.» (OECD–JRC, 2008: 33).

A strong policy implication is that Government has always to improve the worst (indicators, factors, macro dimensions) instead of facilitate the best ones.

More generally speaking, any idea of sustainable development – towards which even the innovation process is oriented – should be balanced along its three fundamental dimensions: economic, social and environmental development. When different goals are equally legitimate and important, a non-compensative logic might be necessary.

This is typically the field of the non-compensatory multi-criteria approach (MCA) (Munda, 2008), applied to find a suitable compromise among different equally legitimate goals:

«In its basic form this approach does not reward outliers, as it retains only ordinal information, i.e. those Countries having a greater advantage (disadvantage) in individual indicators. This method, however, could be computationally costly when the number of Countries is high, as the number of permutations to calculate increases exponentially.» (OECD–JRC, 2008: 33).

Generally speaking a multi-criteria problem doesn't offer a solution optimizing all the criteria at the same time, it is therefore requested a compromise solution. It was proved (Arrow and Raynaud, 1986) that the correct solution for a mul-

[23]According to OECD–JRC (2008), we defined compensability as a deficit in one dimension which can be offset (compensated) by a surplus in another. A preference relation is therefore considered non-compensatory if no trade-off occurs.

[24]The issue of 'partial compensatory approach' is highly interesting as regards the present discussion and therefore we devote a specific section to a more general discussion of the problem (see § 6.2).

ticriterion problem comes from a mono-criterion optimization, and no perfect aggregation rule may exist.

Conclusively, the absence of the *one-best-way* to determine weight and aggregation methods asks for clarity and transparency in the basic assumptions and methodological choices, and urges for a sound robustness analysis and a careful sensitivity analysis on the composite. Needless to say, these two last steps are very frequently omitted in a plethora of benchmarking exercises, weekly published in the economic press without any methodological rootedness. To these fundamental steps are devoted Chapters 7 and 8.

But before going on to the different alternative choices it is instructive to go straight forward to the composite indicator looking at the regional picture it delivers to us.

4.2 The Regional Innovation Composite Indicator (RICI)

According to the selected methodology[25] we calculate the composite indicator for regional innovation (RICI) (see Table 4.1).

Table 4.1 – *Regional Innovation Composite Indicator (RICI, 2005)*

Regions	Cod	Pillar 1 – Enabler	Pillar 2 – Firm Activities	Pillar 3 – Outputs (innovation)	Pillar 4 – Outputs (market)	CI (geometric)
Berlin	de3	0,594	0,585	0,711	0,858	0,678
Karlsruhe	de12	0,412	0,694	0,722	0,815	0,641
Oberbayern	de21	0,347	0,795	0,741	0,821	0,640
Stockholm	se11	0,662	0,698	0,481	0,593	0,603
Västsverige	se23	0,581	0,745	0,384	0,550	0,550
Sydsverige	se22	0,643	0,683	0,372	0,556	0,549
Stuttgart	de11	0,249	0,782	0,597	0,597	0,513
South East	ukj	0,677	0,373	0,452	0,440	0,473
Eastern	ukh	0,523	0,435	0,482	0,430	0,466
Etelä-Suomi	fi18	0,628	0,577	0,285	0,352	0,437
Länsi-Suomi	fi19	0,623	0,611	0,252	0,373	0,435
Île de France	fr1	0,391	0,309	0,539	0,418	0,406
Utrecht	nl31	0,719	0,241	0,358	0,424	0,403
Ostösterreich	at1	0,332	0,399	0,297	0,650	0,400
Pohjois-Suomi	fi1a	0,647	0,548	0,210	0,328	0,396
South West	ukk	0,506	0,320	0,391	0,363	0,389
East Midlands	ukf	0,486	0,330	0,355	0,359	0,378
Vlaams Gewest	be2	0,402	0,457	0,371	0,290	0,375
Noord-Brabant	nl41	0,426	0,518	0,262	0,333	0,372
Westösterreich	at3	0,205	0,399	0,296	0,641	0,353
Noord-Holland	nl32	0,595	0,216	0,325	0,367	0,352
Région Wallonne	be3	0,292	0,412	0,277	0,434	0,347
Région de Bruxelles	be1	0,476	0,262	0,344	0,322	0,343
Pais Vasco	es21	0,333	0,221	0,330	0,497	0,331
Südösterreich	at2	0,234	0,410	0,212	0,582	0,330

[25] Summing up, the different underlying methodological choices have been: *i)* imputation of missing values (regression, plus two stages estimate); *ii)* four Pillars (instead of three); *iii)* rescaling original values with min–Max procedure; *iv)* equal weighting (two stages weighting, within Pillars and among Pillars); *v)* geometric aggregation, partially non compensatory (applied to the Pillars level).

(Table 4.1) continued

Regions	Cod	Pillar 1 – Enabler	Pillar 2 – Firm Activi-ties	Pillar 3 – Outputs (innovation)	Pillar 4 – Outputs (market)	CI (geomet-ric)
Comunidad Foral de Navarra	es22	0,301	0,204	0,268	0,689	0,326
EU27	**EU27**	**0,219**	**0,258**	**0,467**	**0,408**	**0,322**
Centre-Est	fr7	0,244	0,233	0,367	0,271	0,274
Lazio	ite4	0,245	0,131	0,316	0,516	0,269
Sud-Ouest	fr6	0,264	0,269	0,210	0,334	0,266
Cataluña	es51	0,265	0,123	0,220	0,524	0,248
Est	fr4	0,191	0,228	0,385	0,222	0,247
Emilia-Romagna	itd5	0,086	0,251	0,243	0,594	0,236
Lombardia	itc4	0,049	0,261	0,311	0,579	0,219
Comunidad de Madrid	es3	0,379	0,093	0,225	0,134	0,180
Piemonte	itc1	0,005	0,255	0,283	0,444	0,110
min		[itc1] 0,005	[es3] 0,093	[fr6] 0,210	[es3] 0,134	[itc1] 0,110
max		[nl31] 0,719	[de21] 0,795	[de21] 0,741	[de3] 0,858	[de3] 0,678
average		0,400	0,402	0,368	0,477	0,387
std		0,191	0,201	0,144	0,170	0,134
skewness		–0,126	0,509	1,360	0,431	0,390
curtosi		–0,835	–0,855	1,306	–0,077	–0,087

Due to the min–Max rescaling also the RICI fluctuates in the range [0,1] but, in dependence of the geometric aggregation (where very low scores have a higher impact), the upper value reaches ‘only’ 0.68, around two thirds of the whole scale.

EU 27 average shows a 0.32 value, less than half of the best case, while at the bottom of the distribution we have regions scoring very low, down to 0.11 in the case of Piemonte (IT).

For the Italian regions (with the exception of Lazio) it is very clear that the strongly negative performance is mainly to be attributed to very poor scores of Pillar 1 (see Table 3.2), due to the role of the geometric aggregation.

The reader should have in mind an attention regarding the interpretation of figures. All the numbers present in Table 4.1 are exclusively ‘relative’: they depend on the number of regions on which the absolute values have been rescaled. When considering the whole set of 271 NUTS2 EU 27 regions the most of them would perform worse than the bottom tail in Table 4.1 and, therefore, the value of *CI* for these regions would substantially improve[26].

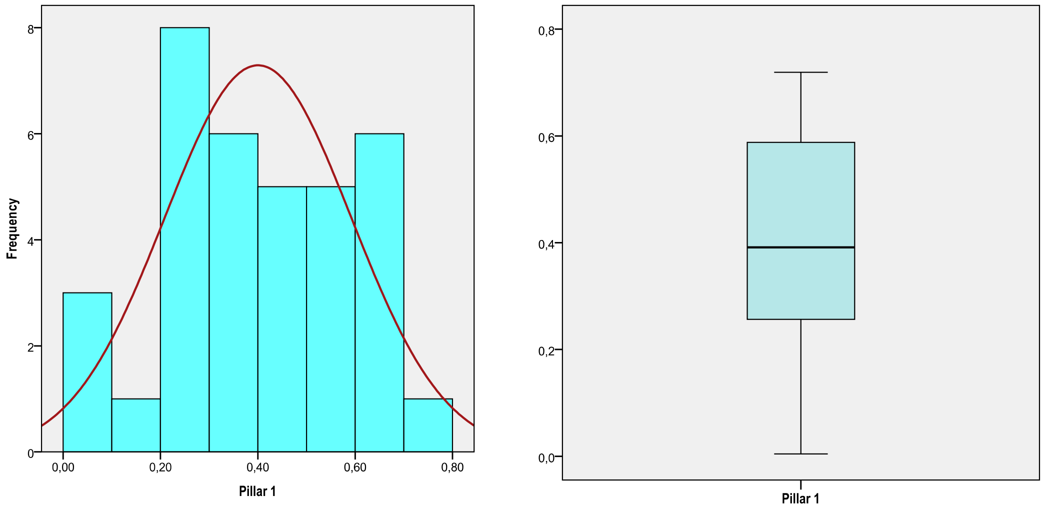
Figures 4.1 (from *a* to *e*) reports the distribution of the four Pillars and the resulting composite. We can see a quite regular distribution except for Pillar 3, showing a pattern squeezed on the low values. The composite, which is a combination of the previous Pillars is more normally distributed.

Figure 4.2 gives us a confirmation of the normality of distribution which is clearly assured in two cases out of four: Pillar 1 and Pillar 4 evidence a clear-cut alignment on the red diagonal. The normal Q-Q chart plots the value you should expect to get if the distribution were normal (expected values[27]) against the value actually seen in the data set (observed values).

[26]This is implicit in the fact that we assign a zero score to the minimum value in the selected set of regions, whatever would be the absolute value in the indicator.

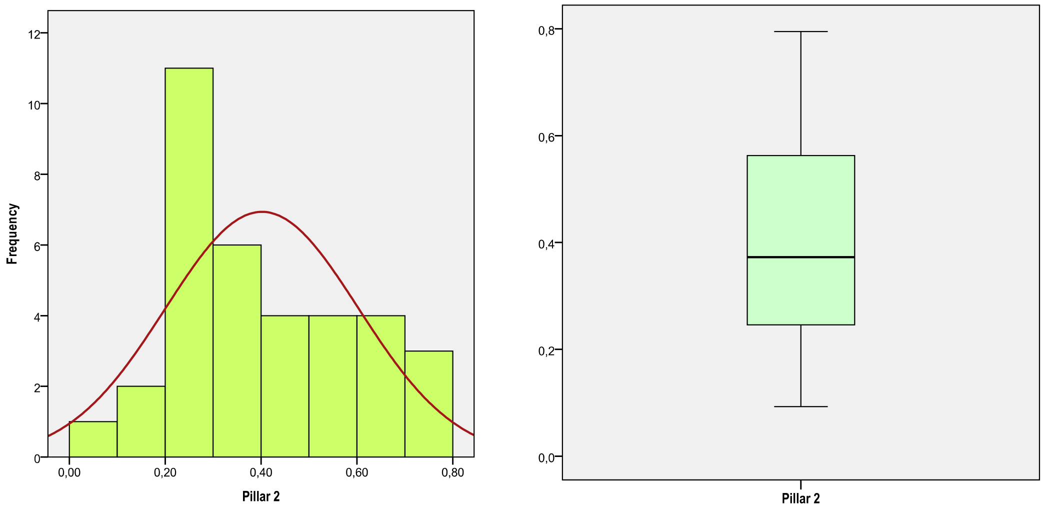
[27]The expected values are a straight diagonal line whereas the observed values are plotted as individual point.

Figure 4.1a – *Frequency distribution and boxplot of PILLAR 1 (enablers)*



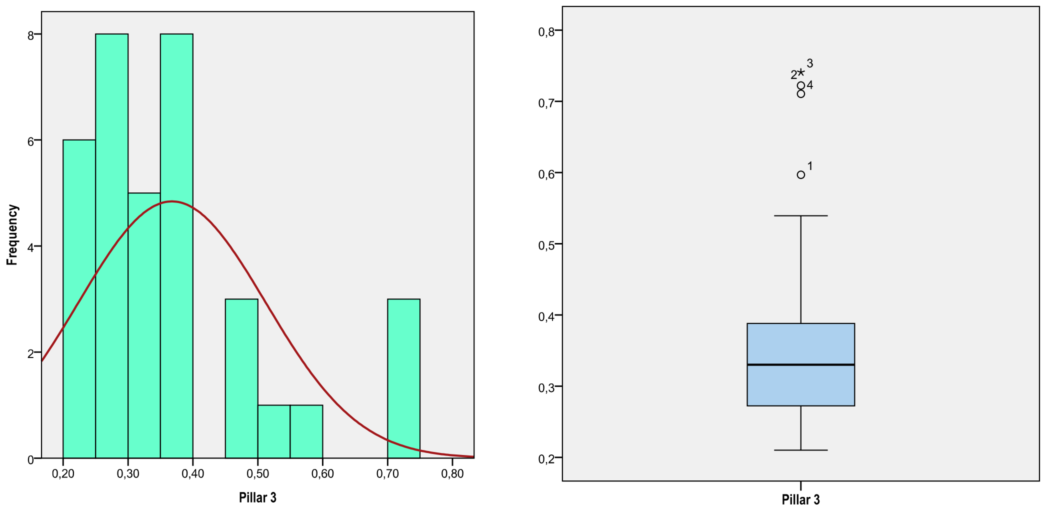
Notes: Mean = 0.40; Std.Dev. = 0.191; N = 35

Figure 4.1b – *Frequency distribution and boxplot of PILLAR 2 (firm activities)*



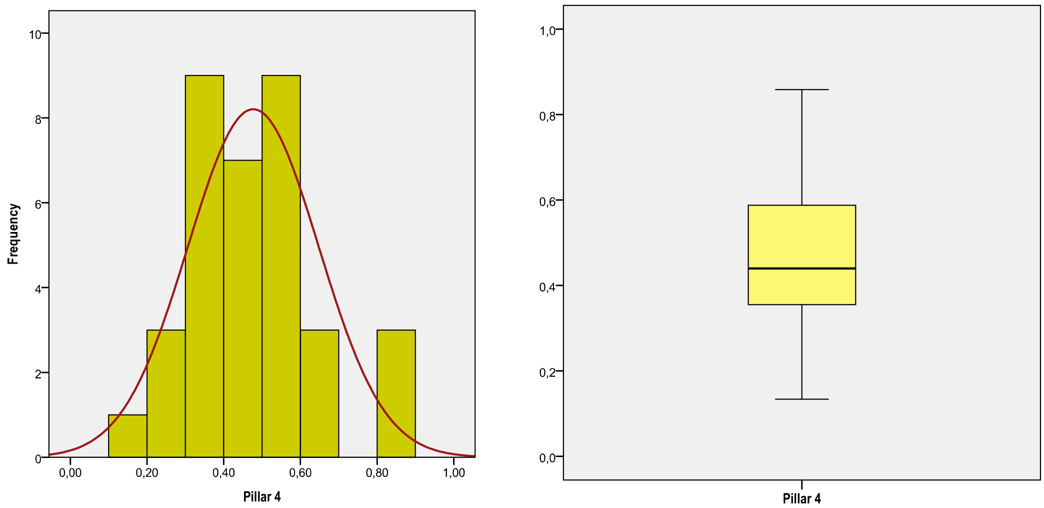
Notes: Mean = 0.40; Std.Dev. = 0.201; N = 35

Figure 4.1c – *Frequency distribution and boxplot of PILLAR 3 (outputs–innovation)*



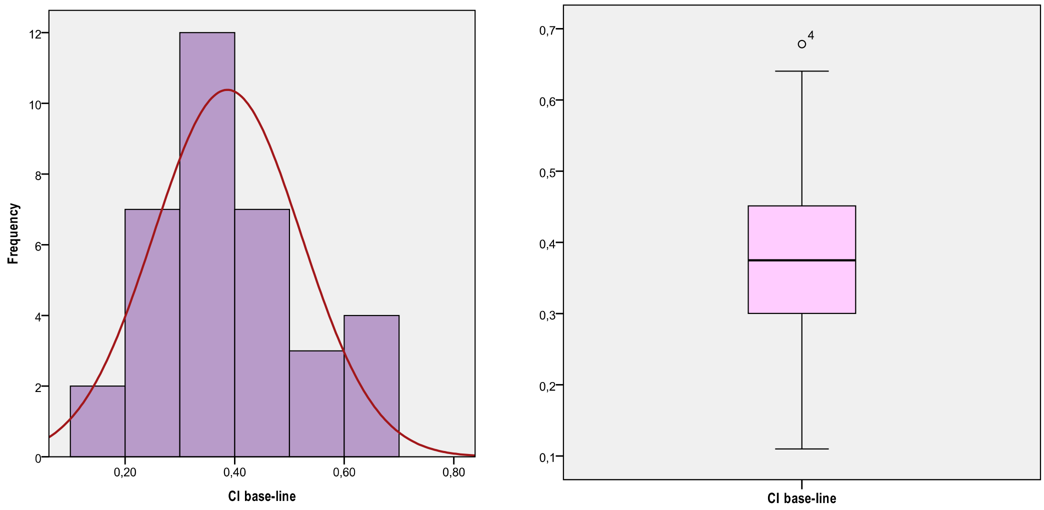
Notes: Mean = 0.37; Std.Dev. = 0.144; N = 35

Figure 4.1d – *Frequency distribution and boxplot of PILLAR 4 (outputs–market)*



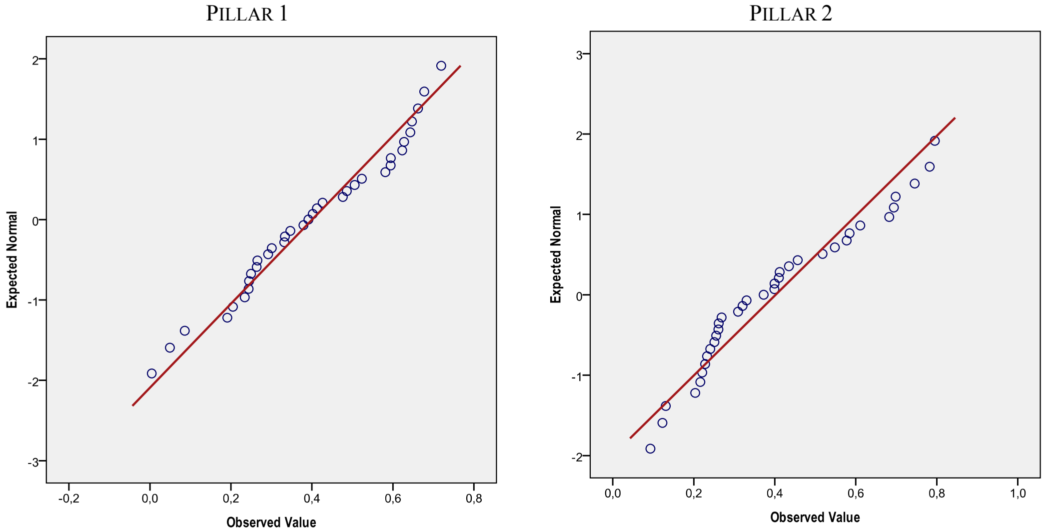
Notes: Mean = 0.48; Std.Dev. = 0.170; N = 35

Figure 4.1e – *Frequency distribution and boxplot of CI (geometric)*



Notes: Mean = 0.39; Std.Dev. = 0.134; N = 35

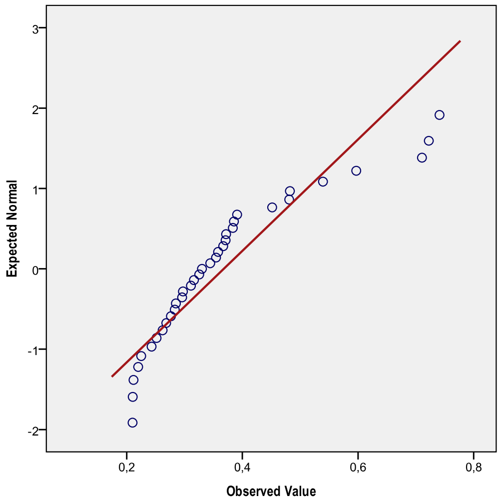
Figure 4.2 – *Normal Q–Q plot of the four PILLARS and Kolmogorov–Smirnov test*



Notes: Statistics = 0.113; Significance = 0.200*; df = 35 Notes: Statistics = 0.146; Significance = 0.057*; df = 35

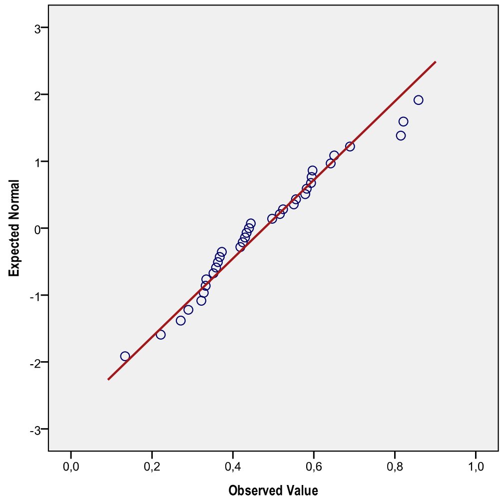
(Figure 4.2) continued

PILLAR 3



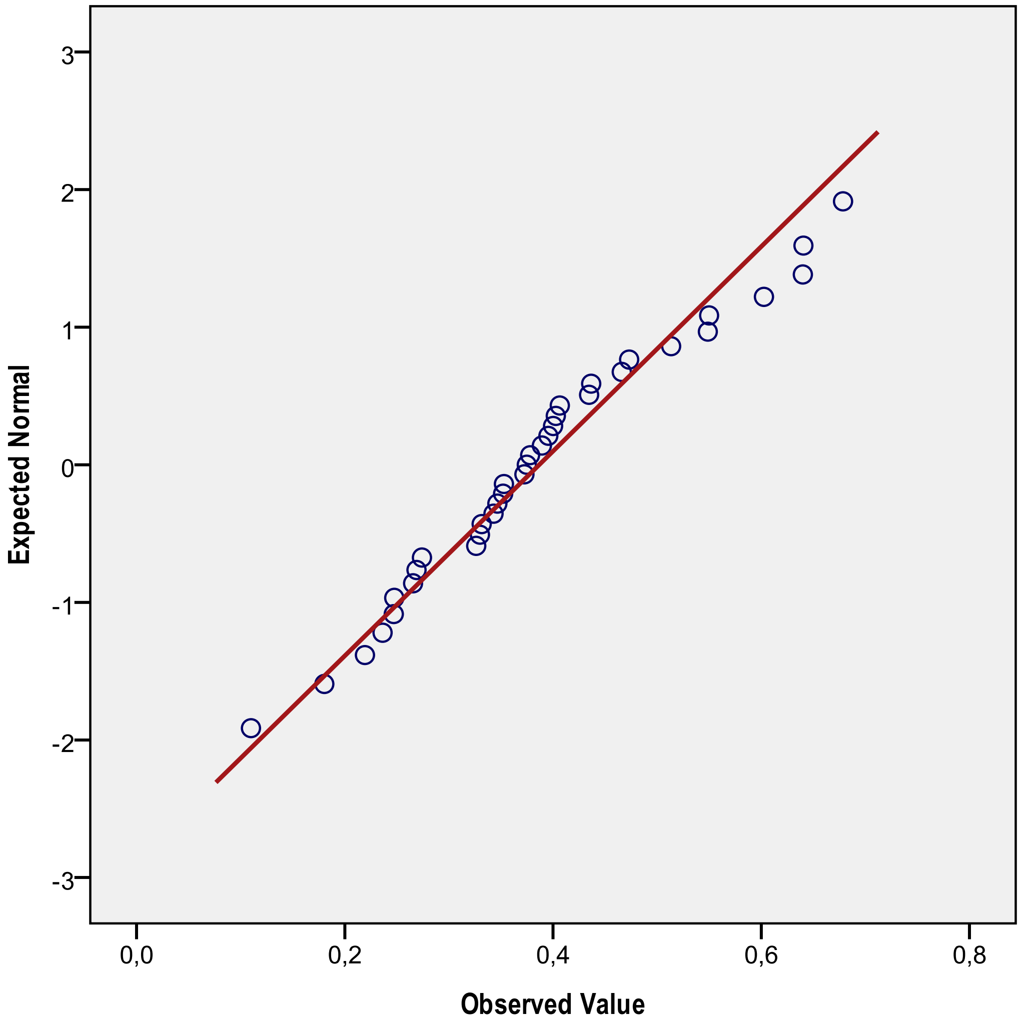
Notes: Statistics = 0.208; Significance = 0.001*; df = 35

PILLAR 4



Notes: Statistics = 0.190; Significance = 0.200*; df = 35

Figure 4.3 – *Normal Q–Q plot of the CI (geometric)*



Notes: Statistics = 0.127; Significance = 0.164*; df = 35

Figure 4.3 reports the same K-S test for the composite index (*base-line*) which looks approximately normally distributed. In the figure the largest observed values fall quite a bit below the predicted normal line, indicating that the tail towards large values is shorter than it would be if the distribution were normal.

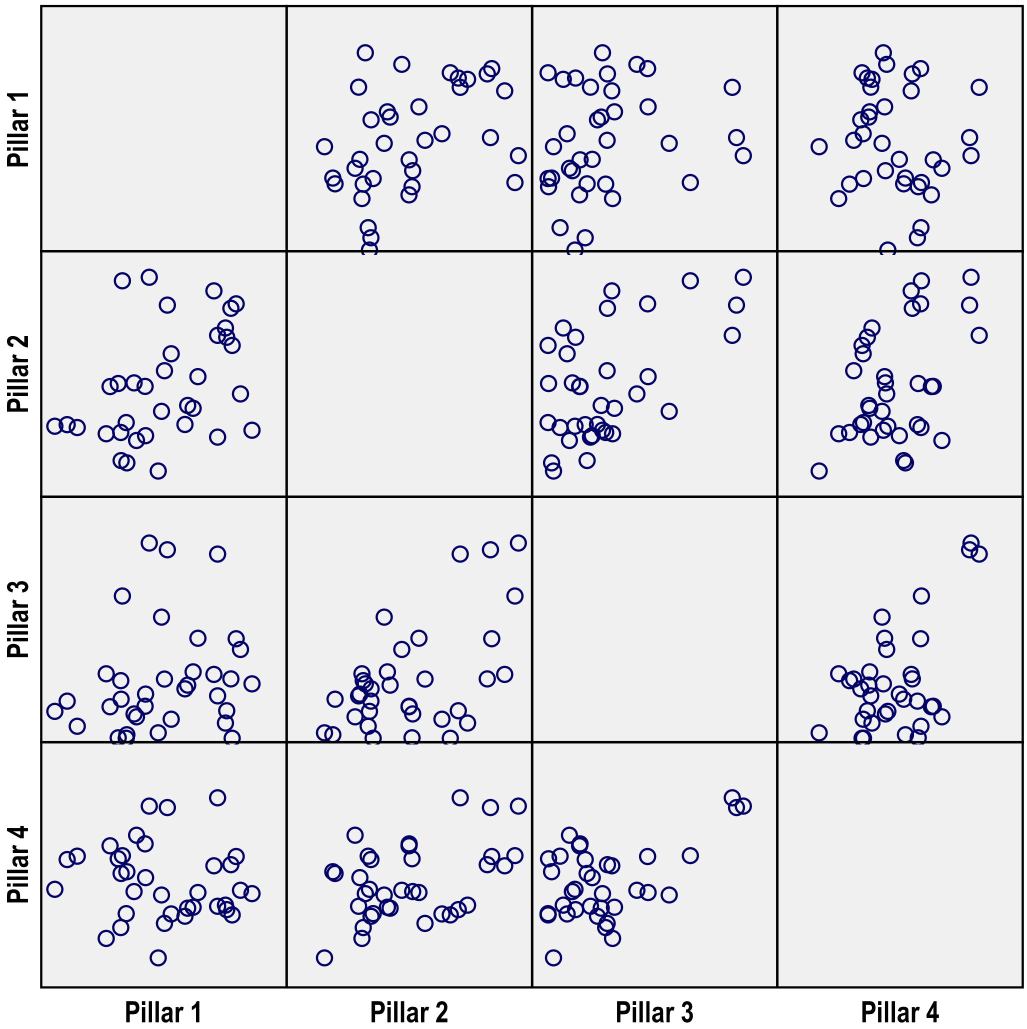
Table 4.2 – *Pearson's R among PILLARS and CI*

	Pillar 1	Pillar 2	Pillar 3	Pillar 4	CI
Pillar 1	1,000	**0,417****	0,206	–0,071	**0,657****
Pillar 2		1,000	**0,553****	**0,491****	**0,834****
Pillar 3			1,000	**0,548****	**0,739****
Pillar 4				1,000	**0,568****
CI					1,000

Notes: Level of significance (p) for two-tailed test (d.f. = 35): 95% for cells > 0.325*; 99% for cells > 0.418**. In **bold** significance at 99%.

Table 4.2 reports the Pearson correlation coefficients for the four Pillars, and behind this correlation there is the situation presented in Figure 4.4, no clear-cut patterns emerge and this is a confirmation that the different Pillars capture different information about the innovation process under scrutiny.

Figure 4.4 – *Scatter diagram of the four PILLARS*



So, the right way to read Table 4.1 is to consider the bottom regions as the worse performing within the club of the top innovative regions in Europe. Obviously, the EU 27 average represents a more solid reference point: it is absolutely coherent that in Table 4.1 we have 26 regions above average and only 9 regions definitely below. It is quite instructive to look at the correlation matrix among the four Pillars and the CI (see Table 4.2).

The correlation among Pillars is as small as it should be (see Figure 4.4) – we have chosen Pillars to capture different macro factors affecting regions' innovation performance – only between Pillar 2 and 3 it exceeds 0.5, while decidedly higher is the correlation between Pillars and CI, with two cases above 0.70. The joint analysis of the two scatterplots highlights the stronger relation of Pillar 2 with the composite (see Figures 4.5, 4.6).

Figure 4.5 – *Scatterplot of PILLAR 2 and CI (geometric) – Pearson's R = 0.834*

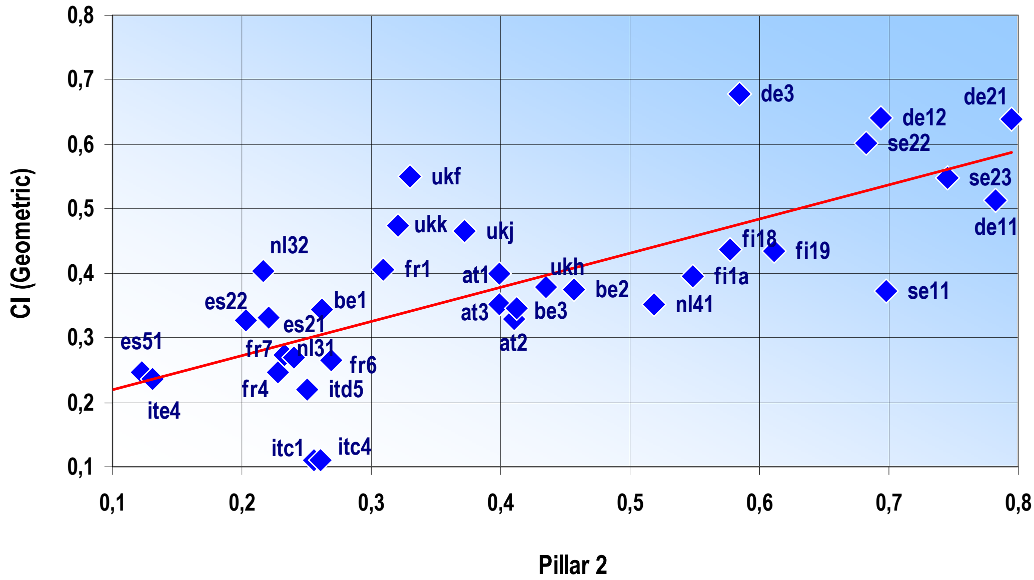
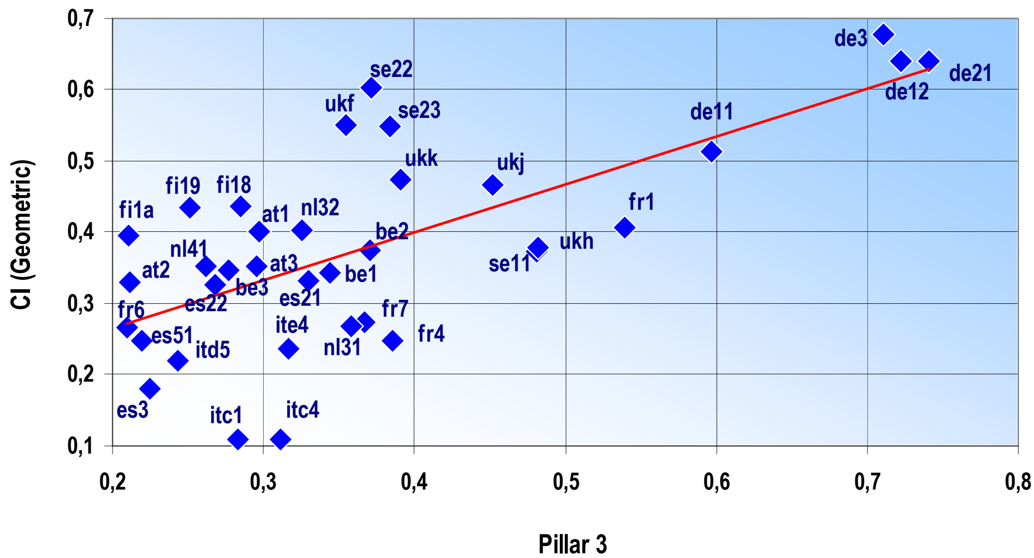


Figure 4.6 – *Scatterplot of PILLAR 3 and CI (geometric) – Pearson's R = 0.739*



4.2.1 An analysis of CI (base-line) ranks

We present the same data with ranks instead of absolute values (see Table 4.3) and we add a last column which is the sum of ranks of the four Pillars. This is a very rough proxy for the CI_r and we detect an expected very high correlation (Pearson's R = 0.955) (see Figure 4.7).

Due to this strong robustness of ranking, it should be more interesting to look at the changes occurring in the rankings of a single region in dependence of the use of CI_r rank instead of the sum of the ranking of the four Pillars (see Table 4.4).

Table 4.3 – *Regional Innovation Composite Indicator: Ranks (2005)*

Regions	Cod	Pillar 1 – Enabler	Pillar 2 – Firm Activities	Pillar 3 – Outputs (innovation)	Pillar 4 – Outputs (market)	CI (geometric)	Sum of ranks*
Berlin	de3	11	9	3	1	1	24
Karlsruhe	de12	20	5	2	3	2	30
Oberbayern	de21	25	1	1	2	3	29
Stockholm	se11	3	4	7	10	4	24
Västsverige	se23	12	3	14	14	5	43
Sydsverige	se22	5	6	15	13	6	39
Stuttgart	de11	36	2	4	8	7	50
South East	ukj	2	23	10	23	9	58
Eastern	ukh	14	15	6	25	10	60
Etelä-Suomi	fi18	7	10	31	36	11	84
Länsi-Suomi	fi19	8	7	38	30	12	83
Île de France	fr1	22	26	5	27	15	80
Utrecht	nl31	1	35	18	26	17	80
Ostösterreich	at1	27	21	28	5	18	81
Pohjois-Suomi	fi1a	4	12	44	40	19	100
South West	ukk	16	25	12	33	21	86
East Midlands	ukf	17	24	20	34	22	95
Vlaams Gewest	be2	21	14	16	42	24	93
Noord-Brabant	nl41	19	13	36	39	25	107
Westösterreich	at3	41	22	29	7	26	99
Noord-Holland	nl32	10	39	25	31	28	105
Région Wallonne	be3	29	19	34	24	29	106
Région de Bruxelles-Capitale	be1	18	30	22	41	30	111
Pais Vasco	es21	26	38	24	20	31	108
Südösterreich	at2	39	20	43	11	32	113
Comunidad Foral de Navarra	es22	28	40	35	4	33	107
EU27	**EU27**	**40**	**32**	**8**	**28**	**34**	**108**
Centre-Est	fr7	38	36	17	43	35	134
Lazio	ite4	37	43	26	17	36	123
Sud-Ouest	fr6	33	29	45	38	37	145
Cataluña	es51	32	44	42	15	38	133
Est	fr4	42	37	13	45	39	137
Emilia-Romagna	itd5	43	34	40	9	41	126
Lombardia	itc4	45	31	27	12	42	115
Comunidad de Madrid	es3	23	46	41	46	45	156
Piemonte	itc1	46	33	32	22	46	133

Notes: *The sum of ranks is a very rough proxy of *CI*, as it would be to consider the average of the ranks instead of the sum. In the last column the smaller the better, the minimum theoretical value is 4 and the maximum is 35x4 = 140.

There is a central group of 9 regions for which no variations occur. If we widen this band up to a variation of maximum ±2 positions we add some further 14 regions. So, 23 regions (out of 35) are substantially stable under the two different algorithms.

At the two extremes of the ranking we can detect 6 regions (plus EU 27) which experienced a significant improvement in their relative positions when looking at the average of the ranking; that is to say they are 'penalized' by absolute values and specifically: Piemonte, Lombardia, and Emilia Romagna (IT) for a very low performance in Pillar 1 and 3 (strongly below the EU 27 average); Navarra (ES) and Utrech (NL) for unsatisfactory performance in Pillars 2 and 3; while Stockholm (SE) for a relative less performing Pillar 3 (but it would be the top performing region looking at the average of the ranking of the four Pillars).

Figure 4.7 – *Scatterplot of CI (Ranks) and Sum of the Ranks – Pearson's R = 0.955*

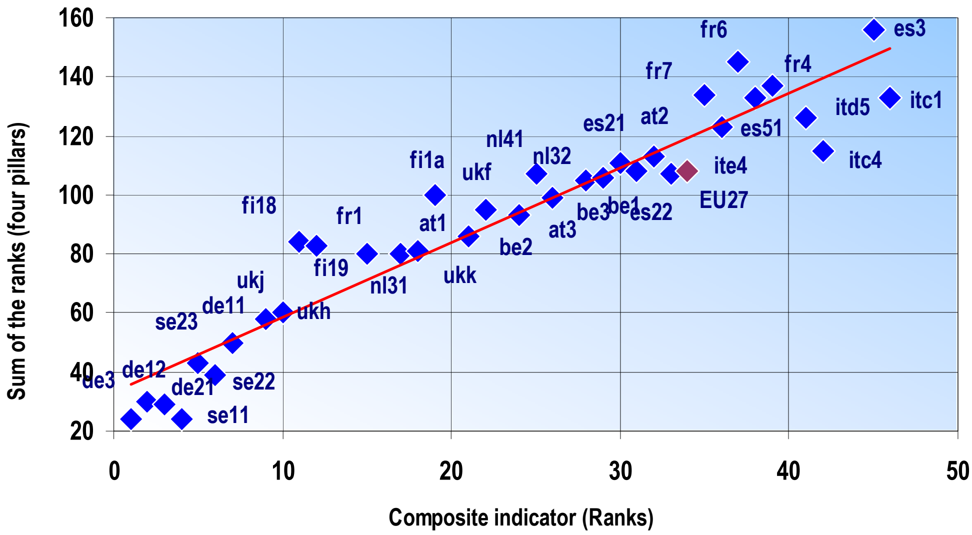


Table 4.4 – *Comparing regional different position for CI (ranks) and average sum of the ranks*

Regions	Cod	CI (rank)	Average sum of the ranks (4 Pillars)	Difference in ranking position
Lombardia	itc4	34	28	6
Piemonte	itc1	36	31	5
Comunidad Foral de Navarra	es22	26	22	4
Stockholm	se11	4	1	3
Utrecht	nl31	13	10	3
EU27	**EU27**	**27**	**24**	**3**
Emilia-Romagna	itd5	33	30	3
Île de France	fr1	12	10	2
Ostösterreich	at1	14	12	2
Vlaams Gewest	be2	18	16	2
Westösterreich	at3	20	18	2
Sydsverige	se22	6	5	1
South West	ukk	16	15	1
Noord-Holland	nl32	21	20	1
Région Wallonne	be3	22	21	1
Berlin	de3	1	1	0
Oberbayern	de21	3	3	0
Stuttgart	de11	7	7	0
South East	ukj	8	8	0
Eastern	ukh	9	9	0

(Table 4.4) continued

Regions	Cod	CI (rank)	Average sum of the ranks (4 Pillars)	Difference in ranking position
East Midlands	ukf	17	17	0
Pais Vasco	es21	24	24	0
Lazio	ite4	29	29	0
Cataluña	es51	31	31	0
Västsverige	se23	5	6	–1
Comunidad de Madrid	es3	35	36	–1
Karlsruhe	de12	2	4	–2
Länsi-Suomi	fi19	11	13	–2
Südösterreich	at2	25	27	–2
Est	fr4	32	34	–2
Noord-Brabant	nl41	19	22	–3
Région de Bruxelles	be1	23	26	–3
Etelä-Suomi	fi18	10	14	–4
Pohjois-Suomi	fi1a	15	19	–4
Centre-Est	fr7	28	33	–5
Sud-Ouest	fr6	30	35	–5

At the bottom line of the table (see Table 4.4) we have 6 regions which worsen their relative positions passing from the ranking of CI to the average of the ranking of the Pillars; that is absolute value are more advantageous than the simple position in the list. Specifically: Noord-Brabant (NL) shows a quite good value in Pillar 2; Région de Bruxelles (BE) in Pillar 1; while Etelä-Suomi and Pohjois-Suomi (FI) in both Pillars 1 and 2. Centre-Ouest (FR) shows a better value in Pillar 2 and Centre-Est (FR) in Pillar 3.

5. The weighting choices

We are coming back here to the weighting choices as this subject is one of the most controversial. In this case, as in many others, there is no one model, clearly explaining how the intervening variables (the simple indicators) contribute to the final result of the innovative performance of the regions. But when used in a benchmarking framework, weights have a meaningful effect on the composite and, therefore, on regions ranking (Oecd–Jrc, 2008).

It is precisely for this reason – and for the more general consideration that weights are essentially ‘value judgments’ – that policy makers pay more attention on the implications of the weighting procedure.

Fundamentally, we have two broad families of methods: *i)* statistical ones and *ii)* experts’ opinions which try to reflect better on policy priorities or theoretical hypothesis. While the first aims at assessing the importance of different variables with regard to the entity, idea, or concept that they measure, and than at obtaining those weights intrinsically (Munda and Nardo, 2005), in the second family the weights are obtained from exogenous information.

We can consider stronger the outcome of experts’ evaluation ***iff*** we are convinced of the proper selection of the experts and of their autonomous assessment capacities and so, to some extent, we are simply moving the problem of the ‘value judgment’ a step behind[28]. For this reason, and for the intrinsic expansiveness of the process, methods like budget allocation processes (BAP) are not so frequently used.

Experts’ methods (or ‘subjective’ ones, such as equal weights, voting, ect.) are applied when we have some strong expectation from theory or, alternatively, when we want to explore ‘edge solutions’. Statistical methods, differently, try to be ‘endogenous’ and data–driven, applying different statistical models (factor analysis, PCA[29], BoD, and others) to capture the intrinsic structure of the data.

As already said our ‘zero option’ has been equal weighting, explicitly assigning the same contribution to all the variables, but we don’t think this is necessarily the best solution. We applied, therefore, a DEA (*Data Envelopment Analysis*) exercise in order to better evaluate the weighting step of the composite procedure.

5.1 Standard, unconstrained DEA (*Data Envelopment Analysis*)

DEA was introduced in 1978 by Charnes, Cooper and Rhodes (CCR model) who demonstrated how to change a fractional linear measure of efficiency[30] into a linear programming format (Talluri, 2000). So, Decision Making Units (DMU) could be assessed on the basis of multiple inputs and outputs, even if the produc-

[28]Normally, there is only disparate expert opinions available about the appropriate weights to be used in an aggregation function.

[29]*Principal Components Analysis* is a very widespread and probably the most used method to extract weights from the data. The weights are determined such that the sum of the squared coefficients of correlation between the index *(I)* and the variables *(X)* is maximized. Denoting $R(I, X_j)$ as a coefficient of correlation between I and X_j, than PCA weights maximize the $\sum_j R^2(I,X_j)$. (Manly, 2005).

[30]Efficiency = (weighted sum of outputs)/(weighted sum of inputs).

tion function was unknown (Adler, Firedman and Sinuany-Stern, 2002). DEA uses mathematical programming techniques to evaluate the performance of peer units (in this case regions) in terms of multiple inputs (here 17 simple indicators) and output produced (CI_r) (Cooper, Seiford, and Zhu, 2004).

DEA's empirical orientation and the absence of *a-priori* assumptions have resulted in a very flexible instrument[31] which we can apply to the study of the efficient frontier estimation (Büschken, 2009). This is even more useful as we deal with relationships between inputs and output that are complex and involve unknown tradeoffs. In addition, DEA is suitable for performing weighting and aggregation steps simultaneously.

In its most simple formulation a DEA-based composite may be presented as the following linear programming problem for each region *j:*

$$CI_j = \underset{w_{ij}}{Max} \sum_{i=1}^{m} y_{ij} \cdot w_{ij} \qquad \text{with } j = 1, \ldots, n; \text{ and } i = 1, \ldots, m$$

$$\text{s.t.} \qquad \sum_{i=1}^{m} y_{ij} \cdot w_{ij} \leq 1 \qquad \text{(bounding constraint)}$$

$$w_{ij} \geq 0 \qquad \text{(non-negativity constraint)}$$

where the letters have the following meanings: we consider a set of *m* sub-indicators for *n* regions: y_{ij} is the value of sub-indicator *i* in region *j* (higher values indicate better performance); *CI* is the weighted average of *m* sub-indicators; and w_i is the weight of the i-*th* sub-indicator.

In general, a DEA exercise is applied to measure the relative performance of a region – or whatever DMU is considered – against a benchmark, and the benchmark should be a unit within the sample of regions as well as an 'ideal region', an abstraction appositely created to have the best score in each of the simple indicators. Obviously, if we have *a-priori* information about the right weights we can use it (Thanassoulis *et al.,* 2004), but if we are in doubt (about the weights) we had better benefit-of-the-doubt (BoD), choosing the weights such as the evaluated region has a maximal composite indicator value[32] (Mazziotta and Vidoli, 2009). In this case we find out an 'optimal vector' of weights – one for each region – that guarantees the best position for the associated region *vis-à-vis* all the other regions in the sample.

The resulting composite will range between *0* (worst possible performance) and *1* (the benchmark region). A BoD approach assigns higher weights to indicators on which performance is better and lower weights to indicators on which performance is poorer[33] (Rogge, 2009). To some extents BoD:

«can be connected to a game-theoretic set-up: they can be conceived of as Nash equilibria in an evaluation game between a regulator and an organization.» (Cherchye *et al.*, 2008: 5).

One major problem emerging from this approach is that we may find out multipla equilibria, that is weights might be not uniquely determined. In fact, while

[31]This flexibility may help to foster acceptance of the eventual result by the different stakeholders implied.

[32]If another regions gets a higher overall score, using the same weighting scheme, we surely considered that region outperforming us.

[33]Needless to say the BoD procedure is particularly useful in policy arena, since policy-makers could not complain about unfair weighting: any other weighting scheme would have generated lower composite scores.

the objectiveness of the method consists of the fact it doesn't need any preference information, the shortcoming is that it frequently lacks discriminatory power[34].

Table 5.1 – *Standard DEA, unconstrained weights*

	Pillar 1				Pillar 2					Pillar 3						Pillar 4	
Region	**1.1.3**	**1.1.4**	**1.2.4**	**1.2.1**	**2.1.1**	**2.1.3**	**2.2.1**	**2.2.2**	**2.3.1**	**3.1.1**	**3.1.2**	**3.1.3a**	**3.1.3b**	**3.2.1**	**3.2.2**	**3.2.5**	**3.2.6**
de11	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
de12	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
de21	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
de3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
es21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
es22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
es3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
es51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
fr1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
fr4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
fr6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
fr7	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
itc1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
itc4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
itd5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ite4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ukf	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ukh	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
ukj	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ukk	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
be1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
be2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
be3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
nl31	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nl32	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nl41	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
fi18	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
fi19	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
fi1a	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
se11	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
se22	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
se23	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
at1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
at2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
at3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Notes: 1.1.3 Tertiary education; 1.1.4 Life-long learning; 1.2.4 Broadband access; 1.2.1 Public R&D expenditures; 2.1.1 Business R&D expenditures; 2.1.3 Non-R&D innovation expenditures; 2.2.1 SMEs innovating in-house; 2.2.2 Innovative SMEs collaborating with others; 2.3.1 EPO patents; 3.1.1 Product and/or process innovators; 3.1.2 Marketing and/or organizational innovators; 3.1.3a Resource efficiency innovators – Labour; 3.1.3b Resource efficiency innovators – Energy; 3.2.1 Employment medium-high & high-tech manufacturing; 3.2.2 Employment knowledge-intensive services; 3.2.5 New-to-market sales; 3.2.6 New-to-firm sales.

The wider the range of variation of weights [0,1], the lower the possibility to obtain a unique solution, and the multiplicity of solutions is likely to depend upon

[34]Basic DEA simply group the DMUs into two set, those that are efficient and define the Pareto frontier and those that are inefficient. This means that several DMUs will receive a score of 1.0; if a region's value in a given sub-indicator dominates those of other regions, this region would always obtain a score of 1.0 even if it has very low value in many other sub-indicators.

a set of constraints imposed on the weights of the maximization problem[35]. A number of formulation have been proposed in the literature to overcome the problem of uniqueness (Čaklović and Hunjak, 2000). Doyle and Green (1994) have developed a whole set of alternative methods; Andersen and Petersen (1993) and Rousseau and Semple (1995) suggested other ranking methods beyond cross-efficiencies (see § 5.2.1).

The complete flexibility of weights may give rise to unintended and undesirable results. The model ends up by assigning unreasonably low (close to 0) or excessively high (close to 1) values to the multipliers in an attempt to drive the efficiency rating of a specific region as high as possible (see Table 5.1).

A performing region may become so by assigning a zero weight[36] to the inputs on which its performance is worst. But by so doing, the underlain framework of the composite (the structure, the different Pillars, etc.) does no more exist and a region is evaluated on a single indicator instead of on the whole set initially chosen.

In conclusion, the unconstrained model seems to be useful only in the identification of inefficiency. As a matter of fact, if we run a DEA analysis and we allow for unrestricted weight flexibility in determining the efficiency scores of a region, and one region still performs poorly, this is certainly the case for declaring that region as inefficient (*i.e.* very distant from the benchmark).

That is exactly what appears in Table 5.1 when a standard DEA is runned with unconstrained weights (with the only limit of $0 \leq w_i \leq 1$, and $\sum_i w_i = 1$). The algorithm chooses just one indicator for each region, the best performer, and gives to it the maximum weight of 1 leaving all the other indicators at zero. Further more, in Table 5.5, we can read the value of the standard DEA scores which are always at their maximum value, but we also see that we have 11 'efficient regions' scoring 1 and a consequent very low discriminatory capability.

Another short comment regards the number of 1 in each column. We can see a quite concentrated picture:

- four indicators (2.2.1, 3.1.1, and 3.2.2) receive no signalling, that is in each region there is at least another indicator which is performing better. Looking at the indicators we could say that private R&D expenditure and skill employment are not determining the best regional performance;
- four indicators appear 3–4 times as the best performer (1.13, 3.1.3b, 1.14 and 2.2.2). Some of the indexes are quite surprising: *life-long learning* and *collaboration among small firms* seem very important for region outperforming;
- one single indicator (3.2.5) registers a stellar performance allowing 10 regions to reach the maximum, ant it is 'new-to-market sales' the most challenging issue and proxy of the stronger innovative level.

[35]Another point to remember is that the obtained weights may be often unrealistic. That is, for each region the simple indicators with good performance receive extremely high weights while those showing bad performance end up receiving outermost small weights. And the consequence is to ignore the impact of indicators with extremely small weights values in the composite calculation (Torabi, 2010).

[36]The existence of zero weights is always problematic, not only because the region is ignoring some inputs, but also because zero weights imply undefined marginal rates of transformation and substitution among simple indicators.

5.2 Incorporating value judgments

The idea to incorporate value judgments into DEA has a quite long history (Thanassoulis *et al.,* 2004). Most of the developments were led by real-life applications, supported by a number of different reasons.

Table 5.2 – *Standard DEA, constrained weights (equal weights ± 25%)*

	Pillar 1				Pillar 2					Pillar 3						Pillar 4	
Region	1.1.3	1.1.4	1.2.4	1.2.1	2.1.1	2.1.3	2.2.1	2.2.2	2.3.1	3.1.1	3.1.2	3.1.3a	3.1.3b	3.2.1	3.2.2	3.2.5	3.2.6
de11	0,044	0,044	0,044	0,044	0,074	0,059	0,074	0,074	0,074	0,074	0,074	0,044	0,044	0,074	0,044	0,044	0,074
de12	0,044	0,044	0,044	0,074	0,044	0,074	0,074	0,044	0,044	0,074	0,074	0,044	0,074	0,074	0,044	0,059	0,074
de21	0,044	0,044	0,044	0,044	0,074	0,074	0,074	0,044	0,074	0,074	0,074	0,044	0,074	0,044	0,044	0,059	0,074
de3	0,074	0,044	0,044	0,074	0,044	0,074	0,074	0,044	0,044	0,074	0,074	0,044	0,074	0,044	0,044	0,059	0,074
es21	0,074	0,044	0,044	0,044	0,044	0,059	0,074	0,074	0,044	0,044	0,044	0,074	0,074	0,074	0,044	0,074	0,074
es22	0,074	0,044	0,044	0,044	0,044	0,044	0,074	0,074	0,044	0,059	0,044	0,074	0,074	0,074	0,044	0,074	0,074
es3	0,074	0,044	0,074	0,074	0,059	0,044	0,074	0,044	0,044	0,074	0,044	0,044	0,074	0,044	0,074	0,044	0,074
es51	0,074	0,044	0,074	0,044	0,044	0,044	0,074	0,044	0,044	0,074	0,044	0,044	0,074	0,074	0,059	0,074	0,074
fr1	0,074	0,044	0,044	0,074	0,059	0,044	0,044	0,074	0,044	0,044	0,074	0,074	0,074	0,044	0,074	0,074	0,044
fr4	0,074	0,044	0,059	0,044	0,044	0,074	0,044	0,074	0,044	0,044	0,074	0,074	0,074	0,074	0,044	0,074	0,044
fr6	0,074	0,044	0,044	0,074	0,074	0,074	0,044	0,074	0,044	0,044	0,059	0,074	0,074	0,044	0,044	0,074	0,044
fr7	0,074	0,044	0,044	0,074	0,074	0,074	0,044	0,074	0,044	0,044	0,044	0,074	0,074	0,059	0,044	0,074	0,044
itc1	0,044	0,044	0,044	0,044	0,059	0,074	0,074	0,074	0,044	0,074	0,044	0,074	0,044	0,074	0,074	0,074	0,044
itc4	0,044	0,044	0,044	0,044	0,044	0,074	0,074	0,044	0,044	0,074	0,059	0,074	0,044	0,074	0,074	0,074	0,074
itd5	0,044	0,044	0,044	0,044	0,044	0,074	0,074	0,044	0,059	0,074	0,044	0,074	0,044	0,074	0,074	0,074	0,074
ite4	0,044	0,044	0,044	0,074	0,044	0,074	0,074	0,044	0,044	0,044	0,059	0,074	0,074	0,044	0,074	0,074	0,074
ukf	0,074	0,074	0,074	0,044	0,044	0,059	0,074	0,074	0,044	0,044	0,044	0,074	0,074	0,044	0,044	0,074	0,044
ukh	0,044	0,074	0,074	0,044	0,074	0,074	0,059	0,044	0,044	0,044	0,044	0,074	0,074	0,044	0,074	0,074	0,044
ukj	0,074	0,074	0,074	0,074	0,044	0,059	0,044	0,044	0,044	0,044	0,044	0,074	0,074	0,044	0,074	0,074	0,044
ukk	0,074	0,074	0,074	0,044	0,044	0,074	0,059	0,074	0,044	0,044	0,044	0,074	0,074	0,044	0,044	0,074	0,044
be1	0,074	0,059	0,074	0,044	0,044	0,044	0,074	0,074	0,044	0,074	0,074	0,044	0,044	0,044	0,074	0,074	0,044
be2	0,074	0,044	0,074	0,044	0,044	0,074	0,074	0,074	0,044	0,074	0,059	0,044	0,074	0,044	0,044	0,074	0,044
be3	0,074	0,044	0,074	0,044	0,044	0,074	0,074	0,074	0,044	0,059	0,044	0,074	0,074	0,044	0,044	0,074	0,044
nl31	0,074	0,074	0,074	0,074	0,044	0,044	0,044	0,059	0,044	0,044	0,044	0,074	0,074	0,044	0,074	0,074	0,044
nl32	0,074	0,074	0,074	0,044	0,044	0,059	0,044	0,074	0,044	0,044	0,044	0,074	0,074	0,044	0,074	0,074	0,044
nl41	0,074	0,074	0,074	0,044	0,074	0,044	0,044	0,074	0,074	0,044	0,044	0,059	0,074	0,044	0,044	0,074	0,044
fi18	0,074	0,074	0,074	0,059	0,044	0,074	0,074	0,074	0,044	0,044	0,044	0,044	0,044	0,044	0,074	0,074	0,044
fi19	0,074	0,074	0,074	0,044	0,074	0,074	0,074	0,074	0,044	0,059	0,044	0,044	0,044	0,044	0,044	0,074	0,044
fi1a	0,074	0,074	0,074	0,074	0,074	0,074	0,059	0,074	0,044	0,044	0,044	0,044	0,044	0,044	0,044	0,074	0,044
se11	0,074	0,074	0,059	0,044	0,074	0,074	0,074	0,074	0,044	0,044	0,044	0,044	0,044	0,044	0,074	0,074	0,044
se22	0,074	0,074	0,074	0,044	0,074	0,074	0,074	0,074	0,044	0,044	0,044	0,044	0,059	0,044	0,044	0,074	0,044
se23	0,059	0,074	0,074	0,044	0,074	0,074	0,074	0,074	0,044	0,044	0,044	0,044	0,074	0,044	0,044	0,074	0,044
at1	0,044	0,044	0,074	0,059	0,044	0,074	0,074	0,074	0,044	0,074	0,074	0,044	0,044	0,044	0,074	0,074	0,044
at2	0,044	0,059	0,044	0,074	0,074	0,074	0,074	0,074	0,044	0,074	0,074	0,044	0,044	0,044	0,044	0,074	0,044
at3	0,044	0,074	0,044	0,044	0,044	0,074	0,074	0,074	0,044	0,074	0,074	0,044	0,074	0,044	0,044	0,074	0,059

Notes: 1.1.3 Tertiary education; 1.1.4 Life-long learning; 1.2.4 Broadband access; 1.2.1 Public R&D expenditures; 2.1.1 Business R&D expenditures; 2.1.3 Non-R&D innovation expenditures; 2.2.1 SMEs innovating in-house; 2.2.2 Innovative SMEs collaborating with others; 2.3.1 EPO patents; 3.1.1 Product and/or process innovators; 3.1.2 Marketing and/or organizational innovators; 3.1.3a Resource efficiency innovators – Labour; 3.1.3b Resource efficiency innovators – Energy; 3.2.1 Employment medium-high & high-tech manufacturing; 3.2.2 Employment knowledge-intensive services; 3.2.5 New-to-market sales; 3.2.6 New-to-firm sales.

Just to mention the four more relevant cases for our work we recall:

- the need to capture prior views on the marginal rate of substitution of the different inputs on the final result;
- the need to capture special interdependencies because not all chosen inputs are perfect substitutes;
- the need to improve discrimination among different regions whenever we have a too large number of *1* values (the efficiency frontier);
- the need to ensure that widely differing weights are not assigned to the same indicator, as a matter of fact it may be desirable to reduce the dispersion in the optimal weights assigned to each factor by each region.

Having decided to incorporate value judgments we can do it in two different broad classes of methods: *i)* apply restrictions on the DEA weights; or *ii)* change the comparative set of regions.

If we apply weight restrictions, this in turn, generate some new problems. The use of bounds on the weights (or of an *assurance region*, as it is called) surely increases the differentiability among the unit scores by reducing the number of efficient regions. But decision-makers do not always have a workable rule to apply in order to choose a proper assurance region. Without any specific value judgment, what we can do is simply to constraint weights in order to preserve the structural frame of the different Pillars and we let them vary within a bandwidth of ±25% around the equal weight[37] (0.059 ± 0.0148, for the 17 simple indicators in our case, see Table 5.2).

The DEA standard model is independent from units of measurement (UoM) of inputs and outputs – that is, if some indicators x_i are scaled by a factor a_i the resulting efficiency scores do not change.

Differently, the value of the weights change when UoM change, meaning that though the DEA model in not sensitive to UoM, weights are (and, therefore, also marginal rates of substitution depend on UoM). We call 'virtual inputs' the product of observed values by weights, and 'pie shares' the ratio between virtual inputs and the sum of them:

$$pie\,share = \frac{w_i \cdot x_i}{\sum_i w_i \cdot x_i}$$

Pie shares do not depend on UoM (Cherchye *et al.,* 2008). So, in order to interpret and compare weights – where larger weight means larger importance attached to a given input – we have to consider pie shares or we should have previously operated a normalization of original data.

5.2.1 The cross efficiency DEA

The 'standard DEA' allows us to position all the regions comparing them to an *efficiency frontier* (which may be the best performing regions as well as an external benchmark) but it is not possible to have a complete ranking of all the regions (due to the fact that to each region we have applied a different vector of weights).

Complete ranking, however, remains a prioritarian interest of most decision-makers and there is a an impressive literature on DEA and ranking issue (Doyle and Green, 1994; Shinn, 2004). If cross-efficiency remains certainly the most

[37] A certain amount of variation is allowed, viz. minus 25% (lower bound) and plus 25% (upper bound) on the average equal weights. This choice is justified on the basis of an evaluation of the robustness of the selected structure (we will not reduce the set of 17 indicators), and on the choice of a band of oscillation (± 25%) on which we can even run sensitivity modifying the selected range.

widespread a survey articles (Adler *et al.,* 2002; see also Wu *et al.,* 2009, and Zhu 2009) has grouped the ranking methods into six basic areas. Beyond cross-efficiency – whereby the DMUs are both self and peer evaluated – the authors distinguish: *i)* super-efficiency technique; *ii)* benchmarking approach; *iii)* multivariate statistical tools; *iv)* ranking of inefficient DMUs; *v)* cross-pollination between multi-criteria decision making methodologie and DEA. Addressing all the different typologies is far beyond the aim of the Report and therefore we go straith forward to the cross-efifceincy ranking method.

Cross efficiency is a two stages process (Sexton *et al.,* 1986): *i)* in the first one we compute an efficiency score for each region *n* times, using the optimal weights evaluated by the *n* linear programming algorithm (Adler *et al.*, 2002); *ii)* in the second stage every region is compared with all the other regions, applying the weights of the other regions from the original DEA.

The resulting evaluation is aggregated in a *cross-efficiency matrix* (CEM, see Table 5.4) in which the element in i-th row and j-th column represents the efficiency of region j when evaluated with respect to the optimal weights of region i.

All the elements in the matrix are between 0 and 1 – $0 \leq h_{ij} \leq 1$ – and the elements in the diagonal, h_{ii}, represent the standard DEA efficiency score: $h_{ii} = 1$ for efficient units and $h_{ii} < 1$ for inefficient units.

A region which is a good overall performer, should have several high cross efficiency scores along its column in the CEM. The column means can be computed to effectively differentiate between good and poor performers (Boussafiane *et al.,* 1991).

The final score of region j is the averaged[38] cross efficiency e_j:

$$e_j = \frac{\sum_{i=1}^{n} h_{ij}}{n}$$

where h_{ij} represents the score given to region j when optimizing region i, that is region j is evaluated by the optimal weights of region i.

Cross efficiency, therefore, allows analysis based on peer appraisal with weights which are internally derived rather than externally imposed (Čaklović and Hunjak, 2000). From a validation perspective cross efficiency is a means of validating DEA scores using different weighting schemes: the efficiencies determined for each region by using optimal weighting from the other $n{-}1$ regions.

No matter which combination of weights are used on a regional inputs, if a region has a high cross efficiency score on average, we can assume it is actually using its inputs efficiently. From this point of view the cross efficiency scores may be read as representing a true peer assessment as each region is appraised according to its performance using all the other regions cross efficiency weights, thereby reflecting a region all round performances (Wu *et al.,* 2009). The variance of the average score is a simple measure of the (minimum) deviation of each region from its highest efficiency score, that is the smaller variance the lower the level of uncertainty. A larger variance may point to variables being omitted from the original model, impacting upon the weighting structure.

[38] Averaging is not the only possibility, as the median, minimum, or variance of scores could also be applied.

5.3 Application of DEA to the RICI composite

In Table 5.3 appear the 'main ingredients' for the construction of the composite. We look at the first Pillar as an exemplification; the first four columns report the computed weights (these weights are the outcome of a maximization process with constraints varying ± 25% around the average equal weights) for the first four indicators in all the 35 regions. The last four columns report the pie-shares deriving by the product of the rescaled absolute values by computed weights, divided by the sum of all the products.

Table 5.3 – *Construction of the BoD weighting constrained matrix (equal weights ± 25%)*

Regions	Cod	Computed weights				Pie-shares			
		1.1.3	1.1.4	1.2.1	1.2.4	1.1.3	1.1.4	1.2.1	1.2.4
Stuttgart	de11	0,044	0,044	0,044	0,044	0,031	0,010	0,024	0,007
Karlsruhe	de12	0,044	0,044	0,044	0,074	0,027	0,010	0,021	0,076
Oberbayern	de21	0,044	0,044	0,044	0,044	0,033	0,008	0,018	0,027
Berlin	de3	0,074	0,044	0,044	0,074	0,075	0,016	0,022	0,100
Pais Vasco	es21	0,074	0,044	0,044	0,044	0,174	0,025	0,031	0,003
Navarra	es22	0,074	0,044	0,044	0,044	0,146	0,017	0,026	0,020
Madrid	es3	0,074	0,044	0,074	0,074	0,206	0,021	0,120	0,082
Cataluña	es51	0,074	0,044	0,074	0,044	0,140	0,009	0,097	0,019
Île de France	fr1	0,074	0,044	0,044	0,074	0,107	0,014	0,030	0,066
Est	fr4	0,074	0,044	0,059	0,044	0,071	0,016	0,037	0,021
Sud-Ouest	fr6	0,074	0,044	0,044	0,074	0,097	0,017	0,029	0,093
Centre-Est	fr7	0,074	0,044	0,044	0,074	0,085	0,018	0,029	0,061
Piemonte	itc1	0,044	0,044	0,044	0,044	0,002	0,002	0,002	0,005
Lombardia	itc4	0,044	0,044	0,044	0,044	0,008	0,011	0,012	0,002
Emilia-Romagna	itd5	0,044	0,044	0,044	0,044	0,010	0,018	0,013	0,015
Lazio	ite4	0,044	0,044	0,044	0,074	0,025	0,018	0,014	0,138
East Midlands	ukf	0,074	0,074	0,074	0,044	0,078	0,148	0,085	0,015
Eastern	ukh	0,044	0,074	0,074	0,044	0,037	0,116	0,079	0,025
South East	ukj	0,074	0,074	0,074	0,074	0,081	0,131	0,087	0,080
South West	ukk	0,074	0,074	0,074	0,044	0,083	0,149	0,075	0,019
Région de Bruxelles	be1	0,074	0,059	0,074	0,044	0,179	0,036	0,088	0,020
Vlaams Gewest	be2	0,074	0,044	0,074	0,044	0,104	0,019	0,103	0,020
Région Wallonne	be3	0,074	0,044	0,074	0,044	0,115	0,003	0,084	0,013
Utrecht	nl31	0,074	0,074	0,074	0,074	0,122	0,084	0,152	0,082
Noord-Holland	nl32	0,074	0,074	0,074	0,044	0,124	0,104	0,143	0,027
Noord-Brabant	nl41	0,074	0,074	0,074	0,044	0,082	0,076	0,127	0,001
Etelä-Suomi	fi18	0,074	0,074	0,074	0,059	0,081	0,125	0,093	0,055
Länsi-Suomi	fi19	0,074	0,074	0,074	0,044	0,108	0,112	0,094	0,027
Pohjois-Suomi	fi1a	0,074	0,074	0,074	0,074	0,093	0,128	0,099	0,074
Stockholm	se11	0,074	0,074	0,059	0,044	0,078	0,105	0,051	0,032
Sydsverige	se22	0,074	0,074	0,074	0,044	0,061	0,123	0,077	0,035
Västsverige	se23	0,059	0,074	0,074	0,044	0,044	0,114	0,075	0,023
Ostösterreich	at1	0,044	0,044	0,074	0,059	0,028	0,036	0,067	0,049
Südösterreich	at2	0,044	0,059	0,044	0,074	0,019	0,049	0,022	0,063
Westösterreich	at3	0,044	0,074	0,044	0,044	0,016	0,062	0,031	0,010

Notes: 1.1.3 = Population with tertiary education per 100 population aged 24-64; 1.1.4 = Participation in life-long learning per 100 population aged 24-64; 1.2.1 = Public R&D expenditures (% of GDP); 1.2.4 = Broadband access by firm (% of firms).

The sum by rows of the pie-shares tells us something of the relevance of the first Pillar for different regions. We can easily see that Utrecht (nl31) is the region where Pillar 1 is very important (44% of the total) followed by Madrid (es3), while three Italian regions count less than 6% (Emilia Romagna, itc5), 4% (Lombardia, itc4) and 1% (Piemonte, itc1), respectively. Obviously it means that

Pillar 1 ranks very bad in these three last Italian regions, while the opposite occurs with regions with a high pie-share.

We make the product, absolute values by weights, for all the indicators and than sum them up. We obtain a vector[39] [35, 1] for each region representing the best set of weights consigning the top possible performance for the single region's CI (see the last row of Table 5.4).

Table 5.4 – *Final composite indicator (BoD weighting procedure), cross-efficiency matrix*

Best weights for Regions	Cod	de21	de3	de12	se11	se23	de11	se22	ukj	ukh
Stuttgart	de11	0,714	0,668	0,690	0,582	0,561	0,629	0,543	0,441	0,443
Karlsruhe	de12	0,714	0,719	0,712	0,582	0,543	0,594	0,540	0,466	0,462
Oberbayern	de21	0,727	0,698	0,699	0,596	0,562	0,616	0,550	0,456	0,470
Berlin	de3	0,712	0,734	0,700	0,598	0,546	0,577	0,547	0,477	0,469
Pais Vasco	es21	0,689	0,679	0,672	0,597	0,560	0,587	0,551	0,486	0,485
Navarra	es22	0,690	0,680	0,673	0,589	0,553	0,588	0,543	0,483	0,482
Madrid	es3	0,684	0,701	0,660	0,601	0,539	0,561	0,536	0,486	0,480
Cataluña	es51	0,689	0,686	0,672	0,590	0,543	0,583	0,537	0,482	0,480
Île de France	fr1	0,672	0,682	0,644	0,614	0,552	0,551	0,547	0,501	0,491
Est	fr4	0,679	0,668	0,662	0,603	0,567	0,581	0,557	0,492	0,487
Sud-Ouest	fr6	0,678	0,680	0,654	0,618	0,579	0,568	0,569	0,498	0,496
Centre-Est	fr7	0,672	0,669	0,651	0,614	0,579	0,572	0,567	0,497	0,496
Piemonte	itc1	0,689	0,667	0,661	0,617	0,572	0,586	0,558	0,486	0,479
Lombardia	itc4	0,702	0,692	0,682	0,600	0,546	0,583	0,539	0,477	0,466
Emilia-Romagna	itd5	0,698	0,680	0,677	0,600	0,546	0,585	0,540	0,475	0,466
Lazio	ite4	0,695	0,712	0,677	0,612	0,546	0,555	0,547	0,496	0,488
East Midlands	ukf	0,656	0,661	0,635	0,626	0,585	0,551	0,580	0,520	0,514
Eastern	ukh	0,660	0,652	0,627	0,635	0,587	0,553	0,577	0,518	0,522
South East	ukj	0,639	0,666	0,621	0,627	0,560	0,519	0,563	0,529	0,511
South West	ukk	0,655	0,660	0,634	0,632	0,591	0,550	0,586	0,521	0,514
Région de Bruxelles	be1	0,676	0,680	0,645	0,625	0,565	0,560	0,560	0,497	0,478
Vlaams Gewest	be2	0,694	0,697	0,672	0,621	0,578	0,579	0,571	0,493	0,491
Région Wallonne	be3	0,679	0,682	0,657	0,620	0,577	0,567	0,571	0,504	0,502
Utrecht	nl31	0,635	0,659	0,616	0,625	0,560	0,519	0,562	0,529	0,510
Noord-Holland	nl32	0,645	0,651	0,615	0,638	0,579	0,536	0,574	0,527	0,516
Noord-Brabant	nl41	0,651	0,626	0,619	0,619	0,588	0,569	0,576	0,503	0,506
Etelä-Suomi	fi18	0,654	0,668	0,628	0,649	0,588	0,541	0,586	0,518	0,494
Länsi-Suomi	fi19	0,666	0,658	0,636	0,639	0,608	0,572	0,595	0,503	0,496
Pohjois-Suomi	fi1a	0,651	0,658	0,629	0,637	0,603	0,554	0,594	0,509	0,493
Stockholm	se11	0,665	0,657	0,625	0,653	0,602	0,564	0,590	0,509	0,499
Sydsverige	se22	0,665	0,657	0,635	0,639	0,609	0,572	0,595	0,507	0,506
Västsverige	se23	0,670	0,659	0,641	0,637	0,609	0,575	0,595	0,508	0,514
Ostösterreich	at1	0,691	0,696	0,667	0,627	0,570	0,566	0,565	0,489	0,472
Südösterreich	at2	0,695	0,694	0,675	0,620	0,588	0,582	0,578	0,483	0,474
Westösterreich	at3	0,702	0,701	0,682	0,623	0,584	0,582	0,579	0,492	0,492
CI DoB scores		0,679	0,677	0,655	0,617	0,572	0,569	0,565	0,496	0,490

Notes: The table reports only the first nine regions sorted on the CI BoD scores.

At the end of the process we have a matrix [35, 35] in which every column is the vector of weights optimizing the CI for one of the regions[40]. If we look at the first column in Table 5.4 we see 35 CI (one for each regions); we read in the first cell the value 0.714: it represents the CI for Oberbayern Länder (DE) when the

[39]The vector provides the most favourable aggregated performance score for region *i* in terms of all the underlying sub-indicators.

[40]In the cross-efficiency matrix the vector *i* score better represents the unit evaluation since it measures the overall ratios over all the runs of all the units.

vector of weights most favorable to Stuttgard Länder (DE) is applied. The second cell (value 0.714) is the CI for Oberbayern Länder (DE) when the vector of weights most favorable to Karlsruhe Länder (DE) is applied, and so on.

Table 5.5 – *Comparing different weights constrains*

Regions	Unconstrained: $0 \le w_i \le 1$			Light constrained: $0.01 < w_i < 0.84$			Constrained: $0.0441 \le w_i \le 0.0735$		
	Cross efficiency scores	Standard DEA scores	False Positive Index	Cross efficiency scores	Standard DEA scores	False Positive Index	Cross efficiency scores	Standard DEA scores	False Positive Index
de11	0,512	1,000	0,951	0,523	0,928	0,774	0,569	0,629	0,105
de12	0,588	0,974	0,656	0,600	0,920	0,534	0,655	0,712	0,086
de21	0,619	0,978	0,579	0,629	0,927	0,473	0,679	0,727	0,071
de3	0,634	1,000	0,577	0,640	0,943	0,475	0,677	0,734	0,084
es21	0,391	0,871	1,229	0,379	0,778	1,050	0,337	0,368	0,091
es22	0,461	0,848	0,840	0,436	0,757	0,737	0,326	0,359	0,100
es3	0,156	0,715	3,591	0,167	0,631	2,787	0,220	0,255	0,161
es51	0,308	0,592	0,921	0,298	0,533	0,791	0,253	0,281	0,114
fr1	0,525	1,000	0,906	0,508	0,903	0,777	0,437	0,475	0,086
fr4	0,352	0,769	1,183	0,340	0,686	1,017	0,290	0,327	0,126
fr6	0,400	0,630	0,575	0,376	0,567	0,507	0,273	0,298	0,092
fr7	0,361	0,884	1,449	0,350	0,784	1,242	0,300	0,329	0,098
itc1	0,299	0,686	1,296	0,288	0,610	1,115	0,242	0,269	0,109
itc4	0,356	0,880	1,472	0,342	0,777	1,272	0,282	0,315	0,115
itd5	0,346	0,902	1,608	0,331	0,793	1,395	0,266	0,298	0,121
ite4	0,360	0,790	1,194	0,346	0,702	1,032	0,284	0,319	0,124
ukf	0,509	0,864	0,697	0,488	0,783	0,604	0,398	0,430	0,078
ukh	0,598	1,000	0,673	0,577	0,911	0,578	0,490	0,522	0,066
ukj	0,598	0,943	0,578	0,579	0,865	0,496	0,496	0,529	0,067
ukk	0,522	0,898	0,720	0,502	0,814	0,622	0,413	0,444	0,075
be1	0,463	1,000	1,160	0,445	0,890	1,002	0,369	0,411	0,115
be2	0,454	0,774	0,706	0,444	0,710	0,598	0,414	0,442	0,068
be3	0,471	0,839	0,781	0,450	0,755	0,679	0,364	0,390	0,072
nl31	0,550	1,000	0,818	0,528	0,902	0,707	0,437	0,482	0,104
nl32	0,491	0,827	0,685	0,470	0,749	0,593	0,382	0,424	0,110
nl41	0,497	1,000	1,014	0,479	0,896	0,873	0,392	0,444	0,131
fi18	0,550	0,967	0,758	0,536	0,882	0,646	0,471	0,506	0,074
fi19	0,586	1,000	0,708	0,565	0,909	0,609	0,475	0,513	0,080
fi1a	0,555	0,861	0,550	0,534	0,788	0,474	0,441	0,484	0,097
se11	0,722	1,000	0,385	0,702	0,933	0,328	0,617	0,653	0,058
se22	0,694	1,000	0,440	0,670	0,924	0,378	0,565	0,595	0,054
se23	0,703	0,949	0,351	0,678	0,883	0,302	0,572	0,609	0,064
at1	0,530	1,000	0,886	0,505	0,895	0,772	0,396	0,423	0,069
at2	0,471	0,901	0,913	0,446	0,803	0,800	0,336	0,368	0,094
at3	0,518	0,987	0,905	0,490	0,879	0,794	0,366	0,397	0,084
average	*0,490*	*0,895*	*0,936*	*0,475*	*0,812*	*0,795*	*0,414*	*0,450*	*0,093*
std	*0,125*	*0,115*	*0,556*	*0,123*	*0,111*	*0,438*	*0,128*	*0,134*	*0,024*

Notes: de11 = Stuttgart ; de12 = Karlsruhe ; de21 = Oberbayern; de3 = Berlin; es21 = Pais Vasco; es22 = Navarra; es3 = Madrid; es51 = Cataluña; fr1 = Île de France; fr4 = Est; fr6 = Sud-Ouest; fr7 = Centre-Est; itc1 = Piemonte; itc4 = Lombardia; itd5 = Emilia-Romagna; ite4 = Lazio; ukf = East Midlands; ukh = Eastern; ukj = South East; ukk = South West; be1 = Région de Bruxelles; be2 = Vlaams Gewest; be3 = Région Wallonne; nl31 = Utrecht; nl32 = Noord-Holland; nl41 = Noord-Brabant; fi18 = Etelä-Suomi; fi19 = Länsi-Suomi; fi1a = Pohjois-Suomi; se11 = Stockholm; se22 = Sydsverige; se23 = Västsverige; at1 = Ostösterreich; at2 = Südösterreich; at3 = Westösterreich.

We can say that the average cross efficiency score (e_{ip}) is more representative than the standard DEA efficiency score (e_{ii}) as all the elements of the CEM are considered in the first, including the diagonal (see Table 5.5) (Hollingsworth and Wildman, 2002). Following Talluri and Sarkis (1997), we can easily compute a false positive index (FPI) for each of the 35 regions.

The FPI_i relates to the percentage increment in efficiency that a region i achieves when moving from the peer-appraisal (cross efficiency) to self-appraisal (simple efficiency scores)[41]. The higher the value of FPI_i the more 'false positive' is region *i:*

$$FPI_i = \frac{e_{ii} - (\sum_i e_{ip})}{\sum_i \frac{e_{ip}}{n}}$$

where e_{ii} is the simple efficiency score of region i and e_{ip} is the cross efficiency score of region i evaluated with region i's weights while $\sum_i$ *denominator* is the mean score of region i obtained from the CEM.

When the most favorable vector for Karlsruhe is applied no other region reaches efficiency (a score equal 1) and the same is true for the other best performing regions.

In general, no cross efficiency score is above 0.73 because with the weights constraints we have imposed also to very poor indicators to maintain a role in the contribution of composite. To reach the efficiency (score equal 1) we have to relax constraints and let weights free move to whatever value.

In Table 5.5 we compare different schemes of weights constrains and more precisely: the unconstrained case, the faintly constrained scenario, and the constrained case with a moving band of ± 25% around equal weights. We can mainly show three things: *i)* cross efficiency scores are always smaller that standard DEA scores. The thing it is mainly due to the resulting role of constraints which bind on them; *ii)* standard DEA scores are decreasing accordingly to the rising restrictiveness of weights, and reach full efficiency (score 1) only in the case of totally unconstrained weights; *iii)* FPI shows us how much we gain in efficiency passing from cross efficiency to standard scores. Interesting to look at average and standard deviation of FPI: we pass from a mean of 0.94 to a 0.795 value and finally to 0.093 as we increase weights constraints.

Figures 5.1 (from *a* to *c*) evidence the distribution of the increment in efficiency due to a move from cross-efficiency to simple efficiency scores. Clearly the *False Positive Index* (FPI) increases passing from a fully constrained DEA to an unconstrained DEA (because the standard DEA scores increase substantially).

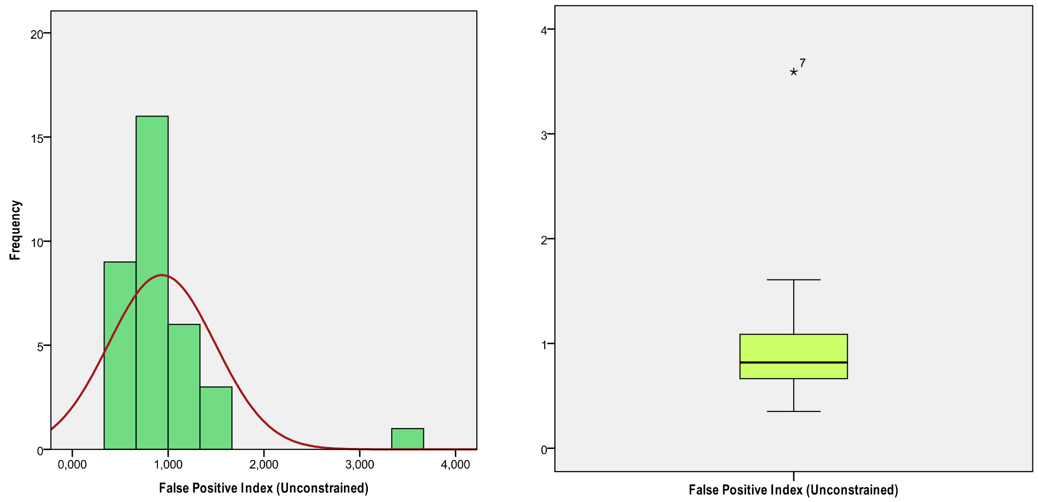
But the most interesting coincidence is that growing the FPI the distribution becomes more asymmetric, deviates from the normal one and is subject to the effects of outliers.

Figure 5.2 reports the scatterplot of unconstrained cross efficiency scores against standard DEA scores. Efficiency (scores equal 1) is reached by 11 different regions but the possibility to discriminate rises sharply passing to the cross efficiency scores.

It is totally a different picture from the one presented in Figure 5.3, where the two DEA scores are compared. The correlation is almost perfect (Pearson's R = 0.998) and we have simply a slightly higher absolute value in standard DEA scores as they represent the values on the diagonal, the maximum ones.

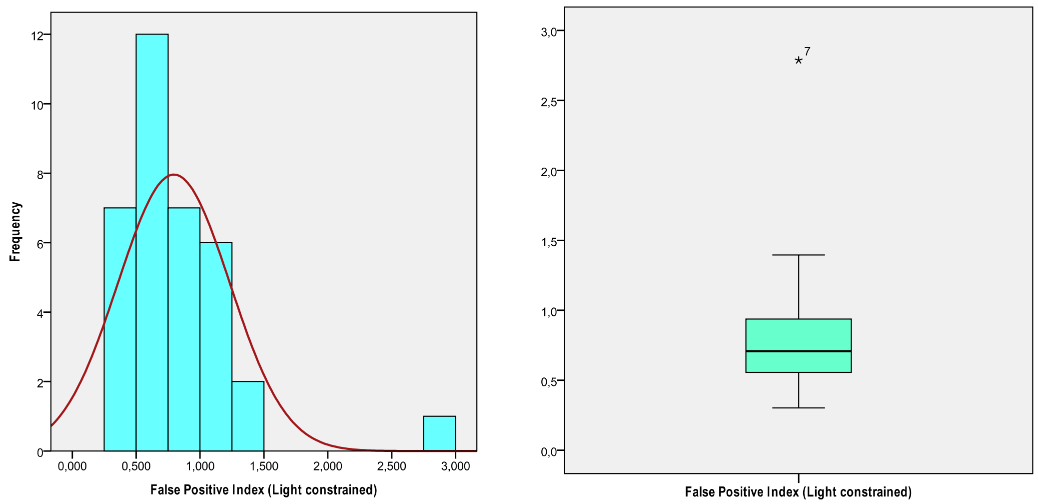
[41] A low FPI for a region indicates that it benefited the least when moving from peer appraisal to self appraisal.

Figure 5.1a – *Frequency distribution and boxplot of False Positive Index: unconstrained weights*



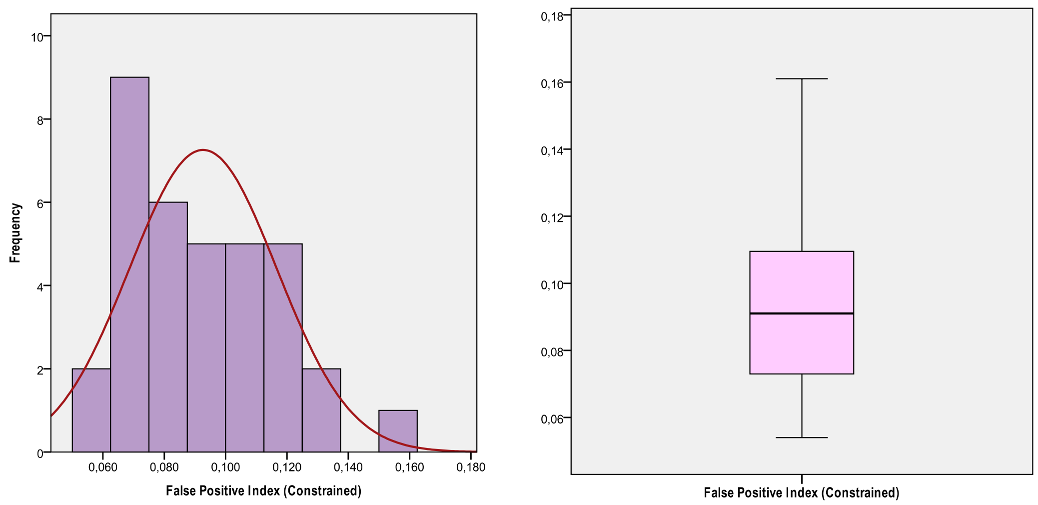
Notes: Mean = 0,094; Std.Dev. = 0,556; N = 35

Figure 5.1b – *Frequency distribution and boxplot of False Positive Index: light constrained (0.001<w_i<0.084)*



Notes: Mean = 0,80; Std.Dev. = 0,439; N = 35

Figure 5.1c – *Frequency distribution and boxplot of False Positive Index: constrained (0.0441<w_i<0.0735)*



Notes: Mean = 0,80; Std.Dev. = 0,439; N = 35

Figure 5.2 – *Scatterplot of cross-efficiency scores and standard DEA scores (unconstrained weights) – Pearson's R = 0.734*

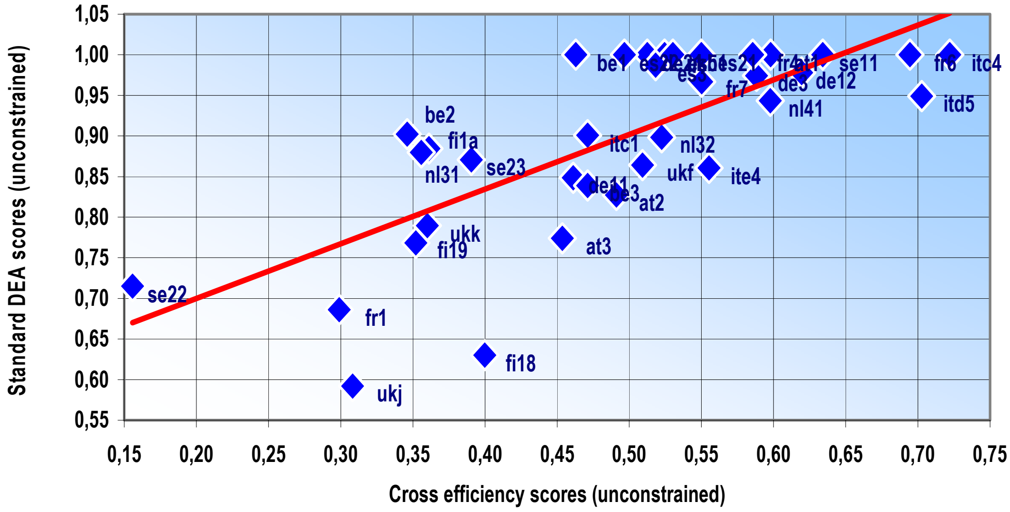
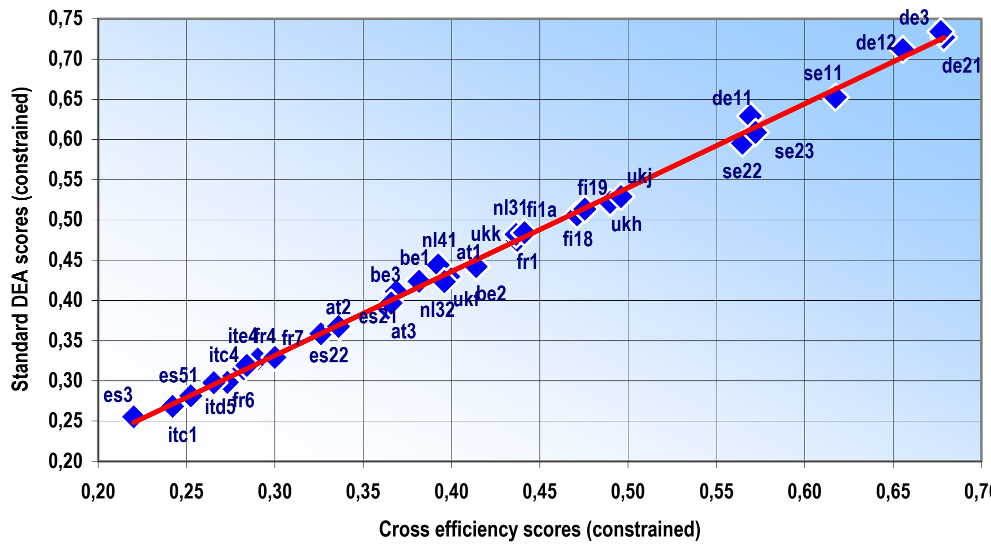


Figure 5.3 – *Scatterplot of cross-efficiency scores and standard DEA scores (constrained: equal weights ± 25%) – Pearson's R = 0.998*



5.4 Two alternative ways for summarizing results

We need to synthetize the information offered by the cross-efficiency matrix [35, 35] and we have two options: *i)* the first looks at the average of the columns and gives back the composite reported in the last row of Table 5.4; *ii)* the second looks at a frequency matrix, built passing for the matrix of ranks [35, 35], and counts the number of times which a single region results first, second, third, etc. in the whole ranking.

Table 5.4 shows only the first nine regions ranked according to descending values of the CI (BoD weights), but the scatterplot in Figure 5.4 allows us to appreciate the correlation between this last composite and the original one ('zero option') reported in Table 4.1.

The correlation is undoubtedly strong but Figures 5.4–5.5 exposes some important differences in the ranking of the single regions and Table 5.6 gives us the exact evaluation of those changes. Apart from a central band of 13 regions which maintain their positions, on the hedges of Table 5.6, a stronger variation of ranking among regions is clear.

Figure 5.4 – *Scatterplot CI-1 (equal weights) and CI-2 (BoD weights) – Pearson's R = 0.835*

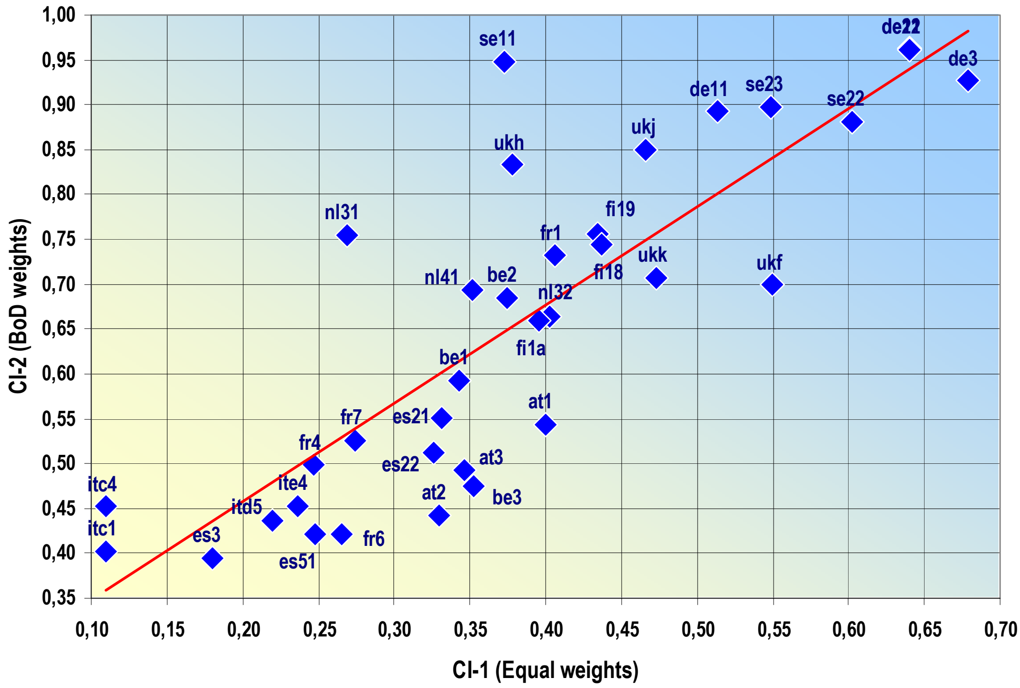
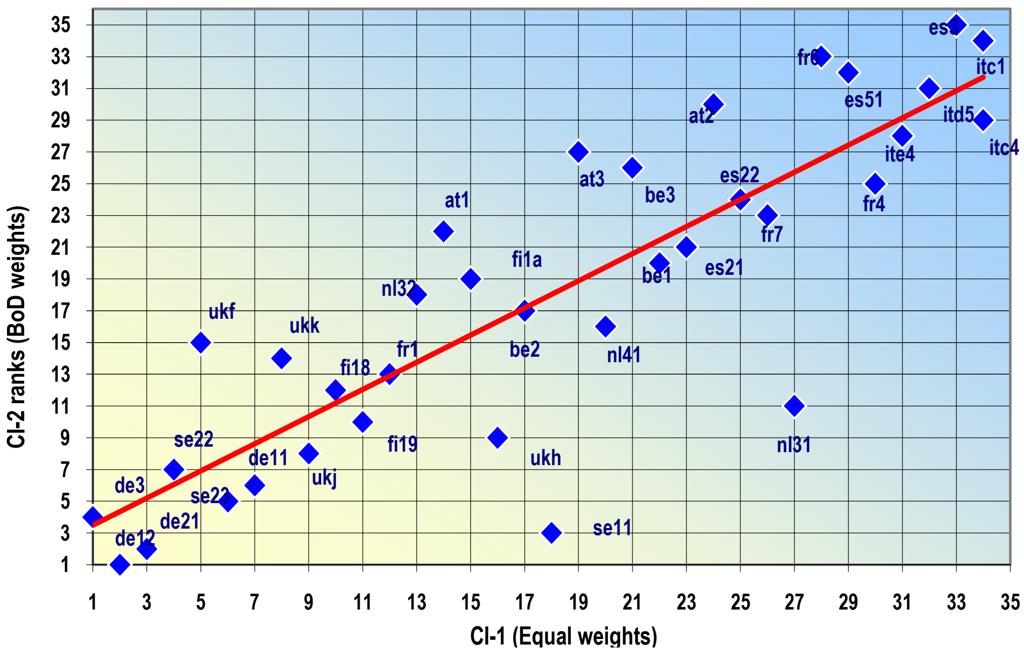


Figure 5.5 – *Scatterplot CI-1 Ranks (equal weights) and CI-2 Ranks (BoD weights) – Pearson's R = 0.851*



Specifically, on the upper hedge of Table 5.6 we have three regions – all located in the lower half of the whole ranking – significantly improving their positions when passing from equal weighting to BoD weighting procedure – Région de Bruxelles (BE), Navarra (ES), and Est (FR) – all of them gaining five positions.

Table 5.6 – *Comparing different ranking for CI-1 and CI-2*

Regions	Cod	CI-1 equal weighting	CI-2 BoD (benefit of the doubt)	Rank CI-1	Rank CI-2	Changes in ranking (CI-1 – CI-2)
Région de Bruxelles	be1	0,343	0,647	23	18	5
Navarra	es22	0,326	0,563	26	21	5
Est	fr4	0,247	0,493	31	26	5
South West	ukk	0,389	0,709	16	12	4
East Midlands	ukf	0,378	0,700	17	13	4
Noord-Holland	nl32	0,352	0,648	21	17	4
Lombardia	itc4	0,219	0,487	33	29	4
South East	ukj	0,473	0,851	8	5	3
Eastern	ukh	0,466	0,821	9	6	3
Utrecht	nl31	0,403	0,737	13	10	3
Centre-Est	fr7	0,274	0,513	27	24	3
Vlaams Gewest	be2	0,375	0,665	18	16	2
Pais Vasco	es21	0,331	0,561	24	22	2
Emilia-Romagna	itd5	0,236	0,469	32	30	2
Karlsruhe	de12	0,641	0,889	2	1	1
Oberbayern	de21	0,640	0,885	3	2	1
Île de France	fr1	0,406	0,731	12	11	1
Lazio	ite4	0,269	0,492	28	27	1
Piemonte	itc1	0,110	0,422	35	34	1
Stockholm	se11	0,603	0,868	4	4	0
Stuttgart	de11	0,513	0,805	7	7	0
Noord-Brabant	nl41	0,372	0,642	19	19	0
Madrid	es3	0,180	0,372	34	35	-1
Berlin	de3	0,678	0,873	1	3	-2
Västsverige	se23	0,550	0,797	5	8	-3
Sydsverige	se22	0,549	0,789	6	9	-3
Länsi-Suomi	fi19	0,435	0,697	11	14	-3
Région Wallonne	be3	0,347	0,500	22	25	-3
Sud-Ouest	fr6	0,266	0,440	29	32	-3
Cataluña	es51	0,248	0,432	30	33	-3
Etelä-Suomi	fi18	0,437	0,679	10	15	-5
Pohjois-Suomi	fi1a	0,396	0,600	15	20	-5
Südösterreich	at2	0,330	0,448	25	31	-6
Westösterreich	at3	0,353	0,487	20	28	-8
Ostösterreich	at1	0,400	0,556	14	23	-9

At the opposite edge of the Table 5.6 we have five regions deteriorating their positions while passing from equal weights to BoD weights procedure. This worsening is much more intense – with two Austrian regions loosing nine and eight positions – and all these regions start from a relatively better ranking.

A first preliminary conclusion is that the 'benefit of the doubt' seems to offer advantage to relatively worse performing regions (with the meaningful exception of two English regions, South East and Eastern).

A second way to present the result from the BoD weighting is to offer a frequency matrix of the ranking results of the procedure (see Table 5.7).

The reading of the Table 5.7 is quite easy, in the cells we see the percentage of the occurrences in which the corresponding region has ranked in the first-second-third position (or forth-fifth-sixth, and so on). So, the best performing region – Karlsruhe Länder (DE) – results 15 times in the first three positions (1-2-3), 6 times in the second three positions (4-5-6), 7 times in the third three positions (7-

8-9), and so on[42]. The last column is the Borda score[43] and is calculated assigning a score to each column (the first row of Table 5.7) and multiplying it by the cells numbers of each region, and summing up along any single row.

A possible shortcoming of Borda rule is derived from the fact that it is based on the concept of *intensity of preference* – being this intensity measured by the score given according to the rank positions – but the rank position of a given region depends on the number of regions considered, so *preference reversal phenomena* may easily occur (Fishburn, 1984; 1991).

Table 5.7 – *Frequencies matrix of CI-2 (BdO weights)*

		11	10	9	8	7	6	5	4	3	2	1	0	
Regions	**Cod**	**1-2-3**	**4-5-6**	**7-8-9**	**10-11-12**	**13-14-15**	**16-17-18**	**19-20-21**	**22-23-24**	**25-26-27**	**28-29-30**	**31-32-33**	**34-35**	**Borda score**
Karlsruhe	de12	42,86	17,14	20,00	14,29	5,71								342
Berlin	de3	45,71	14,29	17,14	8,57		8,57	5,71						332
Oberbayern	de21	34,29	5,71	40,00	14,29	5,71								332
South East	ukj	31,43	17,14	22,86	14,29	14,29								328
Stockholm	se11	40,00	20,00	5,71	17,14	5,71	2,86	5,71	2,86					324
Eastern	ukh	17,14	20,00	20,00	11,43	20,00	8,57		2,86					302
Västsverige	se23	17,14	17,14	17,14	8,57	17,14	14,29		8,57					288
Stuttgart	de11	17,14	22,86	11,43	5,71	14,29	11,43	14,29		2,86				285
Sydsverige	se22	8,57	37,14	5,71		14,29	20,00	8,57	5,71					281
Utrecht	nl31	25,71	11,43	5,71	14,29	11,43	5,71	2,86	5,71	8,57	5,71	2,86		264
Île de France	fr1	22,86	2,86	8,57	5,71	20,00	17,14	5,71	11,43	2,86		2,86		256
South West	ukk	5,71		14,29	22,86	11,43	20,00	20,00	2,86	2,86				243
Länsi-Suomi	fi19	5,71	8,57	11,43	22,86	8,57	20,00	0,00	11,43	5,71	5,71			241
East Midlands	ukf		2,86	20,00	20,00	8,57	5,71	28,57	11,43	2,86	0,00			231
Etelä-Suomi	fi18		2,86	20,00	25,71	2,86	11,43	8,57	17,14	8,57	2,86			226
Vlaams Gewest	be2	2,86		2,86	11,43	17,14	31,43	31,43	2,86					220
Région de Bruxelles	be1	14,29	5,71	0,00	5,71	8,57	11,43	20,00	14,29	5,71	8,57	5,71		205
Noord-Holland	nl32		5,71	8,57	14,29	17,14	11,43	8,57	8,57	5,71	8,57	8,57	2,86	195
Noord-Brabant	nl41	5,71		5,71	2,86	22,86	11,43	17,14	8,57	14,29	8,57	2,86		192
Pohjois-Suomi	fi1a	2,86	2,86	2,86	5,71	17,14	11,43	20,00	11,43	2,86	8,57	14,29		178
Ostösterreich	at1		2,86	2,86	5,71	11,43	17,14	14,29	5,71	14,29	20,00	5,71		163
Pais Vasco	es21	5,71	2,86	2,86	2,86	5,71	2,86	14,29	28,57	11,43	5,71	11,43	5,71	154
Navarra	es22	2,86		5,71	11,43		2,86	11,43	20,00	20,00	14,29	8,57	2,86	150
Centre-Est	fr7	2,86	2,86		5,71	8,57	2,86	8,57	11,43	28,57	5,71	8,57	14,29	133
Westösterreich	at3			8,57	5,71	2,86		8,57	17,14	14,29	14,29	25,71	2,86	123
Lombardia	itc4	2,86	5,71	5,71	2,86	5,71			11,43	8,57	22,86	28,57	5,71	123
Lazio	ite4		2,86		2,86	8,57	11,43	11,43	2,86	11,43	17,14	22,86	8,57	119
Est	fr4		5,71	2,86	5,71		8,57		5,71	14,29	25,71	25,71	5,71	113
Emilia-Romagna	itd5	8,57	5,71		2,86		5,71		0,00	14,29	14,29	28,57	20,00	108
Région Wallonne	be3							11,43	31,43	22,86	28,57	5,71	0,00	110
Südösterreich	at2				2,86	8,57	8,57	8,57	8,57	11,43	2,86	28,57	20,00	98
Sud-Ouest	fr6						2,86	2,86	8,57	25,71	40,00	14,29	5,71	83
Piemonte	itc1			5,71	2,86	2,86	5,71	2,86	8,57	2,86	14,29	17,14	37,14	81
Madrid	es3				2,86	2,86	8,57	5,71	8,57	8,57	5,71	11,43	45,71	72
Cataluña	es51							2,86	5,71	28,57	20,00	20,00	22,86	64

Notes: The Borda score (Borda, 1784) is obtained multiplying each cell value by the score reported in the first row [0,11] and summing up along the row.

[42]The total absolute value by row is 35, the number of regions.

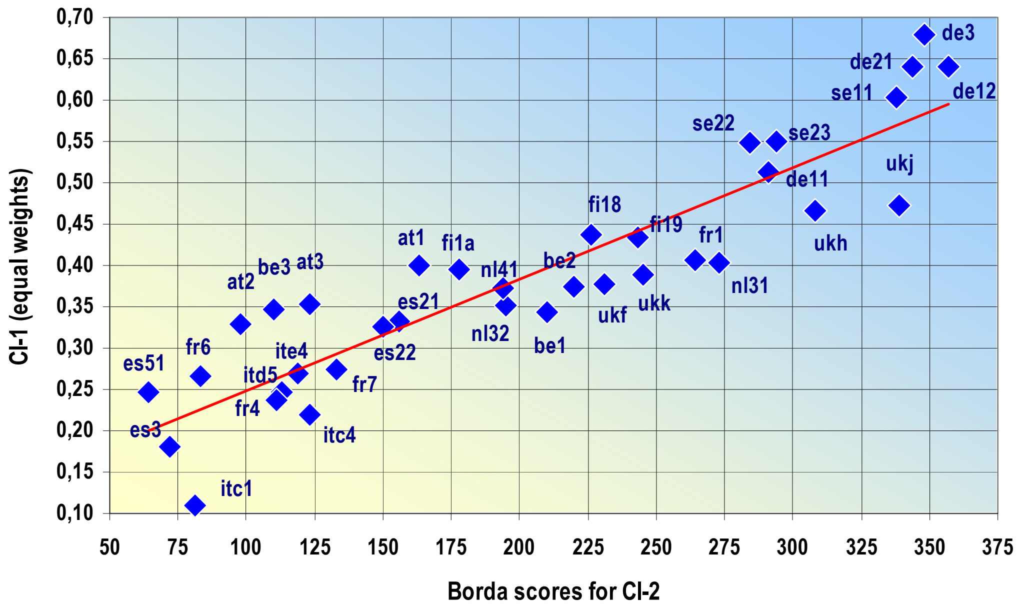
[43]The Borda (1784) solution uses the following scoring rule: given N regions, if a region is ranked last it receives no points; it receives 1 point if ranked next to last (or to the variation range chosen). While the region ranking first gains, in this case, 11 scores. Borda winner is the region with the highest total score.

Figure 5.6 reports the scatterplot of this last measure (Borda score) with the equal weights RICI, showing a good robustness of the two different measures particularly in the central band, while on both the extremes there is a relatively higher differentiation among regions.

In addition, in this specific case, weights are not so meaningful in the form of trade-offs but rather as importance coefficients, so that the Cordoncet (1785) approach[44] should be preferable to Borda one, even if it has many practical difficulties to be implemented (we have 35 regions and therefore 35! permutations to calculate).

Anyway, we are not compelled to choose the 'best' composite (that obviously does not exist), more simply we are adding different alternatives to our uncertainty analysis which should be the final step.

Figure 5.6 – *Scatterplot CI-1 (equal weights) and Borda scores for CI-2 (BoD weights) – Pearson's R = 0.912*



[44]*«The Cordoncet rule is based on a pair-wise comparison between all alternatives considered. For each pair, a concordance index is computed by counting how many criteria are in favour of each alternatives (...). The pairs whose concordance index is higher than 50% of criteria are selected. Given the transitivity property, a final ranking is determined.»* (Munda, 2008: 115).

6. The aggregation choices

Once concluded the weighting step, we turn now to the aggregation issue which is determinant, above all, due to the compensability problem. As we have already stressed the additive aggregation methods – in their double declination of weighted and normalized individual indicators or ranks of them – are by and large the most widespread aggregations. Sometimes researchers are not fully aware that linear aggregation imposes restrictions on the nature of individual indicators and requires very strong assumptions, such as *preference independence* (Fishburn, 1991).

Given the individual indicators $\{ x_1, x_2, \ldots, x_n \}$ an additive function exists ***iff*** these indicators are *mutually preferencially independent* [45]. The condition is quite strong and restrictive as it implies that a trade-off ratio between two variables $x_{1,2}$ is independent of the values on the *n–2* other variables.

In the present work our 'zero option' is a linear aggregation within Pillars – arithmetic average with equal weighting – and a geometric aggregation among the four Pillars, assigning the same contribution to the different Pillars independently of the number of single indicators belonging to each of them.

The underneath idea is that within Pillars we do (fully) accept compensability[46]: we have put different indicators into one Pillar, exactly to capture a specific 'macro factor' for which a unique indicator does not exist – otherwise we would have used that proper indicator instead of a Pillar – and the macro factor is captured by a limited number of simple indicators which give us similar information[47].

On the contrary, among Pillars we do not admit (ful) compensability: we are not interested in conceding that very low 'skilled human capital' to be compensated by high 'business R&D expenditures'. We want to have both factors; moreover, we know that interrelations and synergies between factors are at work: a poor human capital may imply a very low productivity of business R&D and, due to this interrelation, an increase in the firm's R&D expenditures without an investment on human capital may resolve in a pure waste of money. It is exactly for

[45]Attribute x_1 is said to be preferencial independent of attribute x_2 ***if*** preferences for specific outcomes of x_1 do not depend on the level of attribute x_2. ***If*** x_1 is preferencial independent of x_2 ***and*** x_2 is preferencial independent of x_1, ***then*** x_1 and x_2 are *mutually preferencial independent* (Kenney and Raiffa, 1976).

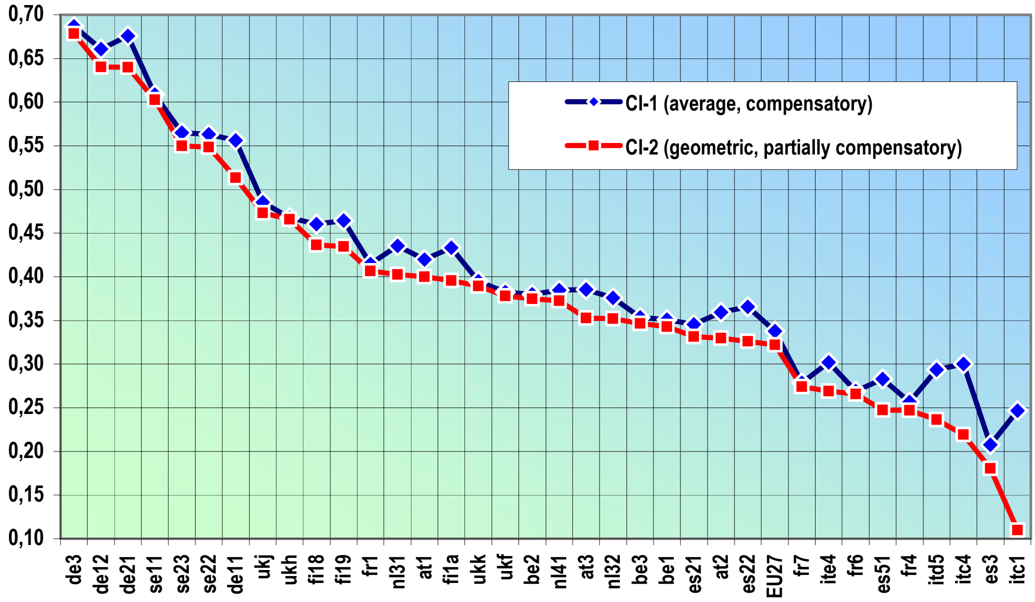
[46]The geometric average 'preserves the product' but is not easily readable in the interpretation of the interactions among Pillars. We are anyway interested in preserving a *non compensatory* approach (al least not fully compensatory) and to this purpose interesting opportunities are offered by the OWA operators (see later § 6.1).

[47]We simply should not put in one Pillar indicators for which we can't admit compensability. In addition to compensability, in order to correctly apply linear aggregation, we should postulate, as already mentioned, that the four indicators of the first Pillar, for example, should be *mutually preferential independent*. That is that a high level of *participation in life-long learning* (1.1.4) does not depend on the share of *population with tertiary education* (1.1.3), or that a high share of *broadband access by firm* (1.2.4) is equally independent of *public R&D expenditure* (1.2.1), and it is not always necessarily so.

this reason that the aggregation among Pillars in the 'zero option' composite takes the form of a geometric function[48].

We are anyway interested in deepening the aggregation issue looking at alternative methods to put the data together in order to obtain a meaningful composite, but before passing on we can compare the totally linear aggregation and the geometric one plotting them together in Figure 6.1.

Figure 6.1 – '*Linear fully compensatory' vs. 'geometric partially compensatory' composite – Pearson's R = 0.982*



Notes: de3=Berlin; de12=Karlsruhe; de21=Oberbayern; se11=Stockholm; se23=Västsverige; se22=Sydsverige; de11=Stuttgart; ukj=South East; ukh=Eastern; fi18=Etelä-Suomi; fi19=Länsi-Suomi; fr1=Île de France ; nl31=Utrecht; at1=Ostösterreich; fi1a=Pohjois-Suomi; ukk=South West; ukf=East Midlands; be2=Vlaams Gewest; nl41=Noord-Brabant; at3=Westösterreich; nl32=Noord-Holland; be3=Région Wallonne; be1=Région de Bruxelles; es21=Pais Vasco; at2=Südösterreich; es22=Navarra; **EU27=EU27;** fr7=Centre-Est; ite4=Lazio; fr6=Sud-Ouest; es51=Cataluña; fr4=Est; itd5=Emilia-Romagna; itc4=Lombardia; es3=Comunidad de Madrid; itc1=Piemonte.

The diagram shows that linear aggregation is affected by a higher degree of variation. Even if the two alternatives are not dramatically divaricated, we can detect a wider spectrum for worse performing regions which are exactly the ones with the greater compensatory problems.

6.1 OWA (*Ordered Weighted Averaging*) operators for aggregation purposes

Ronald R. Yager (1988) firstly introduced a new aggregation technique based on the *ordered weighted averaging* (OWA) operators (Yager, 1996; Carlsson and Fullér, 1997; Fullér, 2007).

[48]The geometric aggregation, also called *deprivational index,* is a partially non compensatory measure: $CI_r = \prod_{i=1}^{n} x_{i,r}^{w_i}$ for region r, CI_r is the product of all the simple indicators x_i raised at the weights w_i. As a matter of fact, also in DEA it may be applied a multiplicative model (Charmes *et al.,* 1994) transforming data using a logarithmic structure.

An OWA operator of dimension n is a mapping $F: \mathbb{R}^n \rightarrow \mathbb{R}$ that has an associated weighting vector $W=(w_1, \ldots, w_n)$ of having the properties:

$$w_1 + \ldots + w_n = 1,\ 0 \leq w_i \leq 1,\ i = 1, \ldots, n,$$

and such that

$$F\,(a_1, \ldots, a_n) = \Sigma_i\, w_i b_i,$$

where b_i is the i-th largest element of the collection of the aggregated objects $\{a_1, \ldots, a_n\}$.

A fundamental aspect of this operator is the re-ordering step; specifically, the a_i element in the mapping $F\,(a_1, \ldots, a_n)$ is not associated with a particular weight w_i but, rather, a weight w_i is associated with a particular ordered position of the a_i element. A characterising measure associated with the weighting vector W of an OWA operator is the measure of *orness* of the aggregation, defined as:

$$orness(\mathrm{W}) = \frac{1}{n-1}\sum_{i=1}^{n}(n-1)\cdot w_i\ .$$

Orness(W) belongs to the range [0,1] for any weighting vector, where 1 represents the *or* alternative and 0 the opposite, called the *and* alternative[49]. The actual type of aggregation depends on the form of the weighting vector W and we have a number of different approaches suggested to obtain the associated weights (Fullér, 2007).

In addition, we can have a 'window-type' OWA operator which takes the average of the m arguments about the center. We have:

$$w_i^* \begin{bmatrix} 0 & if & i<k \\ 1/m & if & k \leq i < k+m \\ 0 & if & i \geq k+m \end{bmatrix}$$

This operator takes the arithmetic mean[50] of all but the best and the worst scores of an alternative (Fullér, 1996).

The OWA operator[51] is a technique for aggregating the information providing a parametrized family of operators including the maximum (optimistic OWA), the minimum (pessimistic OWA) and the average among others. And in fact in the whole set of possible vectors three special cases of OWA aggregations are:

F^* where $W^* = [1, 0, \ldots, 0]$ *(optimistic)* ⇨ $Max_i\,(a_i)$

F_* where $W_* = [0, 0, \ldots, 1]$ *(pessimistic)* ⇨ $min_i\,(a_i)$

F_{AVE} where $W_{AVE} = [1/n, 1/n, \ldots, 1/n]$ *(average)* ⇨ $1/n \sum_i (a_i)$.

An important implication is that for $F^* \rightarrow orness(\mathrm{W}^*) = 1$ the Max value of *orness* coincides with a *fully compensatory aggregation:* I'm weighting 1 the best outcome a_i and therefore the aggregation F receives the score of its highest performer even if in all the other elements a_i it records very low values. Note that the

[49]The operator *andness*(W) is defined as: [1 – *orness*(W)]. For *orness*(W) > 0.5 we call the vector W an *orlike* operator, while for *orness*(W) < 0.5 an *andlike* operator.

[50]For example, let $m=3$ and $k=2$. The weights of the window-type OWA operator are calcutated as: $w_1=0;\ w_2=w_3=w_4=1/3;\ w_5=0$.

[51]The OWA operator benefits of some useful properties: it is commutative, monotonic, bounded, and idempotent.

pessimist OWA operator[52] represents a *fully non-compensatory aggregation*[53]: $F_* \rightarrow$ *orness*(W_*) = *0* and, therefore, *andness*(W_*) = *1.*

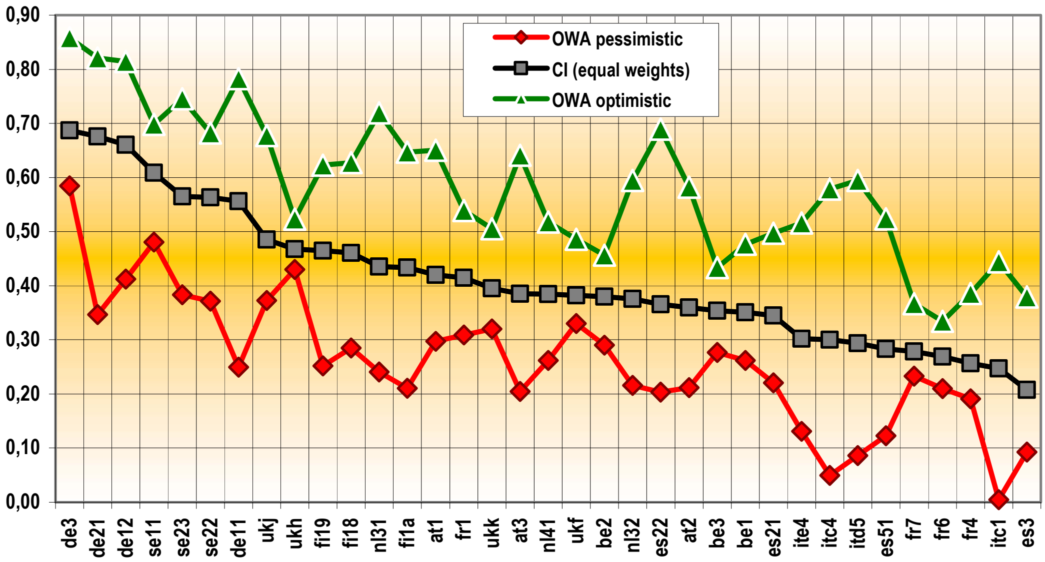
For all OWA operators it is true: $F_* <$ OWA $< F^*$, and therefore the two F* represent the boundaries of the distribution.

We can compute the two extreme bounds – the optimistic and pessimistic OWAs (see Figure 6.2) – and the distance between the two represents the range of variability of each region[54] (see Figure 6.3). The regions with the maximum distance are the most influenced by compensability effects so that a change in the weighting scheme highly affects the final score.

Figure 6.2 plots the reference composite ('zero option') – already presented in § 4.2 – and the upper and lower edges of the OWA band. Both the pessimistic and optimistic OWA operators show a high degree of variability with respect to the F_{AVE}, – characterised by an *orness*(W) ≡ *endness*(W) = 0.5 – but even in the plot we can easily detect some regions with very small variations (see Figure 6.3).

In the first quartile (up to an absolute difference of 0.194) we have 8 regions – 3 English, 3 French, and 2 Belgian ones – showing a strong consistency between optimistic and pessimistic OWAs, while the distance rapidly increases with 3 regions above 0.5 – 2 Italian, and 1 German ones – all regions with very low performance in Pillar 1.

Figure 6.2 – *Comparing optimistic, equal weights, and pessimistic OWA operators (calculated on four Pillars)*

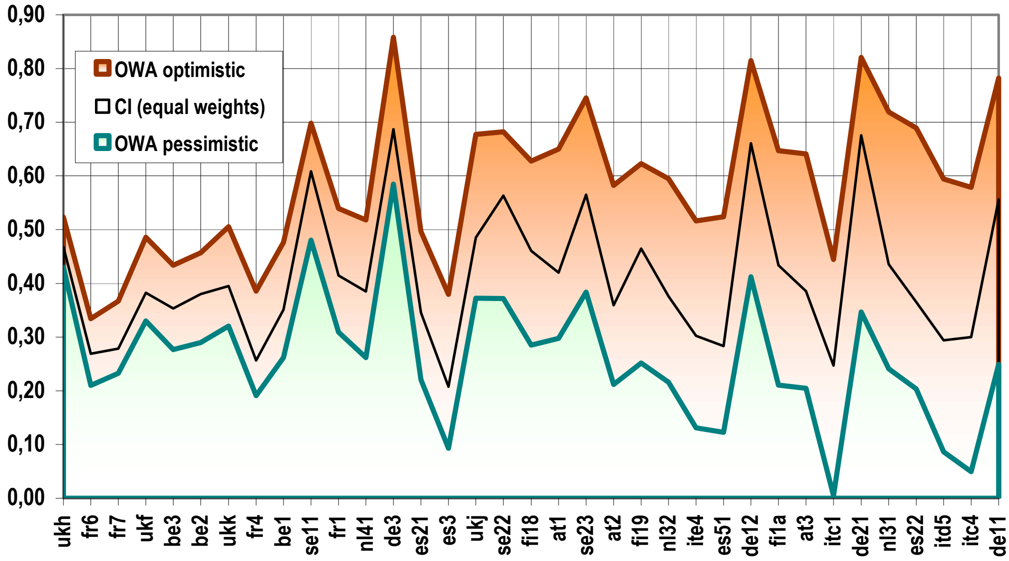


[52]In this case *andness*(W_*) = *1,* all the criteria must be satisfied and therefore *F* receives the score of its lower performer: in no way can we compensate for the weakness of a particular element a_i.

[53]As a mater of fact the most simple non-compensatory approach uses the minimun function *min(z),* that associates to the vector $z = (z_1, \ldots, z_n)$ of variables their minimum value independently of any weight. This function assumes non-compensability among indicators: for every *i,j* any excess value z_i with respect to z_j does not increase the value of the index.

[54]For an application to the 'Competitiveness Index', see Annoni and Kozovska (2010).

Figure 6.3 – *Comparing optimistic, equal weights, and pessimistic OWA operators, ranked for increasing absolute distance (optimistic – pessimistic)*



The correlation between the two OWA operators is quite low (Pearson's R = 0.517**, while it increases considerably between OWA and the average, equal weights, composite: optimistic R = 0.858**, pessimistic R = 0.824** (at a 99% level of confidence). Figure 6.3 shows the band of variation between optimistic and pessimistic OWA operators, ranked for increasing distance: no specific pattern linking the bandwidth with the absolute value of the composite, appears.

6.2 Partially compensatory approaches: a generalisation

As already underlined we are interested in a strong multidimensional approach truly considering unbalance (among the different Pillars) as opposed to a weak approach, when analysts consider that low performance in some dimensions can be compensated by good performance in others, without costs (Casadio Tarabusi and Guarini, 2010).

This is all the most important where a harmonious growth of the various Pillars can be an important pre-condition for the sustainability of innovative performances. The OWA operators are certainly interesting but to some extent they are too extreme. There is a family of aggregation functions – *F(x)* – which are explicitly designed to consider the complementarity between factors (in the present case Pillars) and the intensity of penalisation of unbalance.

We can use, among others, the *concave average aggregation function* (Casadio Tarabusi and Palazzi, 2004), that can be written as:

$$CI_r(x_1, x_2, \ldots x_n) = \sum_{i=1}^{n} w_i \left(x_i - \alpha_i e^{-\beta_i x_i}\right)$$

where α_i and β_i are parameters related to the intensity of penalisation of unbalance and of complementarity between factors. Another generalised aggregation function has been proposed by Casadio Tarabusi and Guarini (2010) and is called the *Mean–min function:*

$$F = CI_r(x_1, x_2, \ldots x_n) = \bar{x} - \alpha\left[\sqrt{\left(\bar{x} - \min(x)\right)^2 + \beta^2} - \beta\right]$$

with the parameters representing, as in the previous function: $0 \leq \alpha \leq 1$ the intensity of penalisation, and $\beta \geq 0$ the intensity of complementarity between factors.

An interesting characteristic of the *Mean–min function* is that it allows compensability among different dimensions but with a cost increasing with the unbalance, so that for each dimension exists an upper bound of its decrease beyond which the same index value cannot be restored by increases in the other dimensions[55].

Table 6.1 – *Composite with Mean-min aggregation function*

Regions	α.β=1	Arithmetic mean α=β=0	Minimum function α=1 β=0	Proportional compensability α=0.5 β=0	α=0.5 β=1
de11	0.461	0.570	0.091	0.330	0.515
de12	0.534	0.652	0.153	0.403	0.593
de21	0.535	0.673	0.128	0.401	0.604
de3	0.555	0.664	0.185	0.424	0.609
es21	0.273	0.318	0.012	0.165	0.295
es22	0.261	0.306	0.000	0.153	0.283
es3	0.190	0.212	0.000	0.106	0.201
es51	0.212	0.238	0.009	0.124	0.225
fr1	0.365	0.423	0.079	0.251	0.394
fr4	0.238	0.274	0.002	0.138	0.256
fr6	0.227	0.255	0.018	0.136	0.241
fr7	0.247	0.287	0.000	0.144	0.267
itc1	0.203	0.228	0.000	0.114	0.216
itc4	0.233	0.266	0.006	0.136	0.250
itd5	0.219	0.250	0.000	0.125	0.234
ite4	0.233	0.268	0.000	0.134	0.251
ukf	0.327	0.379	0.052	0.215	0.353
ukh	0.423	0.472	0.157	0.314	0.448
ukj	0.427	0.480	0.151	0.315	0.454
ukk	0.344	0.394	0.075	0.234	0.369
be1	0.289	0.348	0.000	0.174	0.319
be2	0.360	0.394	0.132	0.263	0.377
be3	0.287	0.339	0.013	0.176	0.313
nl31	0.334	0.416	0.002	0.209	0.375
nl32	0.298	0.362	0.000	0.181	0.330
nl41	0.313	0.384	0.000	0.192	0.349
fi18	0.394	0.459	0.092	0.276	0.427
fi19	0.399	0.459	0.107	0.283	0.429
fi1a	0.369	0.426	0.083	0.255	0.398
se11	0.488	0.601	0.112	0.356	0.544
se22	0.502	0.549	0.241	0.395	0.525
se23	0.526	0.556	0.309	0.433	0.541
at1	0.309	0.377	0.001	0.189	0.343
at2	0.269	0.319	0.000	0.159	0.294
at3	0.291	0.345	0.011	0.178	0.318
Pearson's R	**α.β=1**	**α=β=0**	**α=1 β=0**	**α=0.5 β=0**	**α=0.5 β=1**
α.β=1	1.000	0.988**	0.995**	0.872**	0.996**
α=β=0		1.000	0.969**	0.788**	0.998**
α=1 β=0			1.000	0.915**	0.984**
α=0.5 β=0				1.000	0.829**
α=0.5 β=1					1.000

Notes: Significance** 99%.

[55]If we compensate a decrease of variable x_1 with an increase, lets say, of x_2 this increase needs to be more than proportional.

The name directly descends from the range of variation of the function:

$$\min x \leq F(x) \leq \bar{x}$$

where *F(x)* includes the two extreme cases of penalisation: the zero penalisation of the weighted arithmetic mean and the maximum penalisation coinciding with the min.

Some particular cases are: *i)* $\alpha=0$ (and β is here irrelevant) the aggregation function *F(x)* coincides with the arithmetic mean; *ii)* $\alpha=1$ and $\beta=0$ we have the minimum function; *iii)* with $0<\alpha<1$ and $\beta=0$ the function has proportional compensability.

In Table 6.1 we compare the CI_r for five different pairs of coefficients using the Mean-min aggregation function, we have the Pearson's R statistics – the most different case is the minimum one.

A possible conclusion is that even if there isn't a dramatic difference between the fully compensable aggregation (arithmetic mean) and the partially compensability function (Mean-min, with $\alpha=0.5;\ \beta=1$), the progressive unbalance cost signals that the easiest way to let the less performing regions improve on their innovation composite is to balance different dimensions: they have better to improve all the Pillars in order to gain positions among the best innovative European regions.

Figure 6.4 compares the arithmetic mean composite (total compensability) with proportional compensability composite. It is evident, in spite of a quite perfect correlation, than the higher level of *a* – which is the intensity of penalisation for unbalance – moving from 0 (total compensability) to 0.5 (proportional compensability) – implies a lower value of the composite.

Figure 6.4 – *Scatterplot total compensability and proportional compensability – Pearson's R = 0.988*

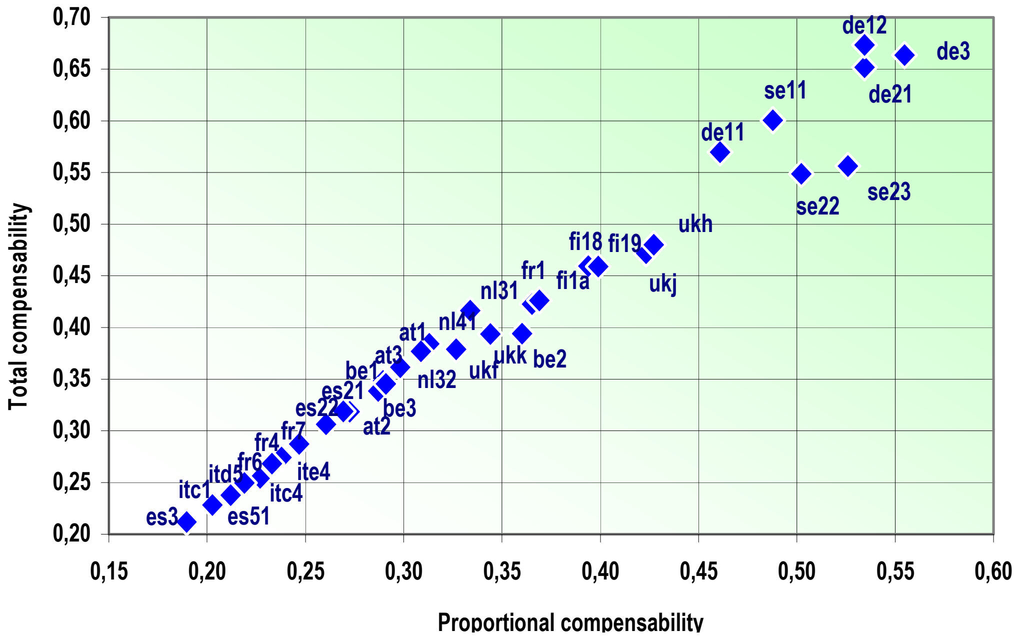


Table 6.2 definitely compares the previous extreme aggregates with OWA functions with proportional compensability which results somewhere in between the extreme bounds of the distribution.

Table 6.2 – *Regions ranked by absolute differences in alternative aggregation functions*

Regions	Cod	OWA (1) pessimistic	CI (equal weights)	OWA (2) optimistic	Proportional compensability	
					α=0.5 β=0	α=0.5 β=1
Eastern	ukh	0.430	0.468	0.523	0.314	0.448
Sud-Ouest	fr6	0.210	0.269	0.334	0.136	0.241
Centre-Est	fr7	0.233	0.279	0.367	0.144	0.267
East Midlands	ukf	0.330	0.382	0.486	0.215	0.353
Région Wallonne	be3	0.277	0.354	0.434	0.176	0.313
Vlaams Gewest	be2	0.290	0.380	0.457	0.263	0.377
South West	ukk	0.320	0.395	0.506	0.234	0.369
Est	fr4	0.191	0.257	0.385	0.138	0.256
Région de Bruxelles	be1	0.262	0.351	0.476	0.174	0.319
Stockholm	se11	0.481	0.609	0.698	0.356	0.544
Île de France	fr1	0.309	0.415	0.539	0.251	0.394
Noord-Brabant	nl41	0.262	0.385	0.518	0.192	0.349
Berlin	de3	0.585	0.687	0.858	0.424	0.609
Pais Vasco	es21	0.221	0.345	0.497	0.165	0.295
Comunidad de Madrid	es3	0.093	0.208	0.379	0.106	0.201
South East	ukj	0.373	0.485	0.677	0.315	0.454
Sydsverige	se22	0.372	0.563	0.683	0.395	0.525
Etelä-Suomi	fi18	0.285	0.460	0.628	0.276	0.427
Ostösterreich	at1	0.297	0.420	0.650	0.189	0.343
Västsverige	se23	0.384	0.565	0.745	0.433	0.541
Südösterreich	at2	0.212	0.360	0.582	0.159	0.294
Länsi-Suomi	fi19	0.252	0.465	0.623	0.283	0.429
Noord-Holland	nl32	0.216	0.376	0.595	0.181	0.330
Lazio	ite4	0.131	0.302	0.516	0.134	0.251
Cataluña	es51	0.123	0.283	0.524	0.124	0.225
Karlsruhe	de12	0.412	0.661	0.815	0.403	0.593
Pohjois-Suomi	fi1a	0.210	0.433	0.647	0.178	0.318
Westösterreich	at3	0.205	0.385	0.641	0.255	0.398
Piemonte	itc1	0.005	0.247	0.444	0.114	0.216
Oberbayern	de21	0.347	0.676	0.821	0.401	0.604
Utrecht	nl31	0.241	0.436	0.719	0.209	0.375
Comunidad Foral de Navarra	es22	0.204	0.365	0.689	0.153	0.283
Emilia-Romagna	itd5	0.086	0.294	0.594	0.125	0.234
Lombardia	itc4	0.049	0.300	0.579	0.136	0.250
Stuttgart	de11	0.249	0.556	0.782	0.330	0.515

We have fully exhausted the reasoning on weighting and aggregation and we can now turn to the robustness issue, that is to put together and to confront different vectors [35,1] of composite obtained combining the different technical choices operated in all the previous sections of the Report.

We can firstly compare the discrete case (40 different scenarios) (see Chapter 7), and then pass to the continuous case (see Chapter 8) where 'Monte Carlo' simulation is an answer to the need of exploring the space of experimental design.

7. Experimental design for uncertainty and sensitivity analysis

In this Chapter we shall be dealing with uncertainty (UA) and, specifically, *quantitative uncertainty assessment* (Bolado-Lavin *et al.,* 2008; Saltelli *et al.,* 2008; Saisana and Saltelli, 2010). The aim of this assessment should be recalled in order to truly interpret the emerging results: we would like to detect how 'robust' the computed RICI (*Regional Innovation Composite Indicator*) is, depicting an explicit ranking of the most innovative regions in Europe. In addition, a robust composite will be easier to be communicated to stakeholders and this is an essential ingredient of the usefulness of composite indicators (Saisana, 2007; Saisana and d'Hombres, 2008).

If the composite has the simple additive form:

$$CI_r = \sum_{i=1}^{n} w_i x_{ri}$$

where x_{ri} is the i-th simple index, we have to even distinguish if the weights are determined by some exogenous information or are endogenously set. In the first case w_i are used as parameters and therefore $CI = \varphi(X|w)$. Differently, in the second case $w = f(X)$ and therefore $CI = \varphi[X, f(X)]$. In this second case the composite depends on both the index variables, X, and the specification of the function $f(.)$ obtaining weights.

When we add uncertainty and let X be perturbated by a factor $\varepsilon \neq 0$, if the weights are derived from X, a perturbation of x_i would probably affect the values of w_i as well as of CI, and the extent of pervasiveness would depend on the specification of $w = f(X)$[56].

With this problem in mind – the effect of w of CI – we would like to have a composite with two desirable properties (Mishra, 2008): *i)* the first is that changes in x_r should be least reflected into changes in CI_k, with $r \neq k$, which we call *robustness*. It can be said that, to some extent, robustness implies insensitiveness of w to change in x (immunity to allochthonous changes); *ii)* the second property is that changes in x_r should best be reflected in change in CI_r, which we call *sensitiveness* (to autochthonous changes). Sensitiveness implies stronger correlation between the composite CI and the constituent simple variable x_i.

What in literature is called *pre-existing model* (Oecd–Jrc, 2008) in the present study is the 'zero option' RICI[57] as presented in section 4.2. We know that different sources of uncertainty may affect that composite: errors in the measurement of selected phenomena, omitted variables, as well as technical choices on the structure of the composite and operational selected methodologies, *i.e.* normalization, weighting, and aggregation.

[56] In addition, when $CI = \varphi(X|w) = wX$, the weight w – that is $\partial CI/\partial X$ – is constant and CI is indeed a linear combination of X. Otherwise, the weight w in general is not constant and CI results not to be a linear combination of X.

[57] Just to recall, the composite is founded on the following methodological choices: *i)* imputation of missing values (regression, plus two stages estimate); *ii)* four Pillars (instead of three); *iii)* rescaling original values with min–Max procedure; *iv)* equal weighting (two stages weighting, within Pillars and among Pillars); *v)* geometric aggregation, partially non compensatory (applied to the Pillars level).

Therefore, we want to stress the *pre-existing model* modifying many of the assumptions we have made in the previous steps, and let the RICI fluctuate in a specific 'experimental design space'.

In general – and following de Rocquigny, Devictor and Tarantola (2008) – the *pre-existing model* can be expressed as:

$$\underline{X},\underline{d} \Rightarrow \underline{z} = G(\underline{X},\underline{d})$$

where $\underline{X}$ is a vector of uncertain inputs (lack of knowledge, errors, or any other sources of uncertainty) with other inputs $\underline{d}$ considered to be known (or fixed), and G(.) represents a function. The model output $\underline{z}$ may be a scalar (in our case the composite indicator), or a vector (of composites) when we modify and compare different structural choices.

In the context of the construction and validation of a composite one main goal of uncertainty assessment is to understand the influence, and rank the importance, of uncertainties which are:

«transferred into a set of scalar input factor, such as the resulting Rank(CI) is a non-linear function of the uncertain input factors.» (OECD–JRC, 2008: 119).

Once uncertainty analysis (UA) has been developed, and the scrutinized *CI* has been judged enough 'robust' it is worthwhile to come back to the *pre-existing model* in order to improve it: provided the 'best composite' does not exist, a *robust composite* may suggest a number of improvements even in upgrading the methods of measurement, in offering a comparative performance evaluation of regions against a selected benchmark, in better defining the kind of phenomena to be monitored and data to be collected (Saisana and Munda, 2008).

Having clarified the relevance on uncertain inputs and/or structural choices, UA needs to develop the well-known *uncertainty propagation step*, that is the method to:

«transform the measure of uncertainty in the inputs in a measure of uncertainty in the outputs of the pre-existing model.» (de Rocquigny *et al.,* 2008: 10).

In order to apply the computational step, to measure the uncertainty propagation, we have to previously distinguish two different scenarios: *i)* a *deterministic setting* in which to apply a design of experiments (or other discrete techniques) from *ii)* a *probabilistic setting* in which we can run a Monte Carlo sampling (among the others), and we'll come back later to this second one (see Chapter 8).

Here we start with a deterministic setting and pass straightforward to the *design of experiment* (see Figure 7.1) where a set of methods have been chosen to define the range of variation for each of the uncertainty scores.

7.1 The design of experiments

In the deterministic setting we consider four different sources of uncertainty which are related to the structural frame for organizing data (see Figure 7.1): *i)* the main dimensions of the composite, that is the number of Pillars; and *ii)* the inclusion or exclusion of variable 1.2.1 *public R&D expenditure* which seems not correlated within Pillar 1 from the analysis of Pearson's R (see Table 3.9). The other two sources of uncertainty being: *iii)* standardization of raw data; and *iv)* weighting and aggregation methods.

In Figure 7.1 we see the tree of the different combinations which sum up to 40 different scenarios. So, the final output of the application of this *design of experiments* to the initial matrix [35,17] of raw data is an output matrix [35,40] for the

35 regions and the 40 different scenarios, among which scenario No. 32 is the previous ‘zero option’ already presented and widely commented (see § 4.2).

In order to make all the intersections possible we prefer not to have negative values and, therefore, *z-score* normalization inputs are further rescaled in the range [0,1]. We have two different occurrences for the first three factors and five different ones for the fourth (weighting and aggregation) (see Figure 7.1). All these occurrences matched up, gave birth to the 40 different scenarios here analyzed.

The result of this design of experiments can be explored both by using scores (see Table 7.1) or ranks (see Table 7.2). Table 7.1 summarizes the results of all the 40 scenarios looking at the CI_r scores. The mean column is the average by row of all the 40 CI_r computed, while the SC32 (scenario ‘zero option’) – introduced in section 4.2 – is considered as the *base line scenario* for all the comparisons carried out.

Figure 7.1 – *Decisional tree of the design of experiments*

I factor: standardization	**II factor: Pillars structure**	**III factor: Pillar 1 structure**	**IV factor: weighting/aggregation**
1: z-scores μ = 0, and σ^2 = 1	1: three Pillars a) enablers; b) firm activities; c) outcomes	1: inclusion indicator 1.2.1 Public R&D expenditures	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained
		2: exclusion indicator 1.2.1 Public R&D expenditures	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained
	2: four Pillars a) enablers; b) firm activities; c) outcomes 1 (innovation results); d) outcomes 2 (market results)	1: inclusion indicator 1.2.1 Public R&D expenditures	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained
		2: exclusion indicator 1.2.1 Public R&D expenditures	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained
2: min-MAX range of variation [0,1]	1: three Pillars	1: inclusion indicator 1.2.1	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained
		2: exclusion indicator 1.2.1	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained
	2: four Pillars	1: inclusion indicator 1.2.1	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained
		2: exclusion indicator 1.2.1	1: linear + linear
			2: linear + geometric
			3: OWA optimistic
			4: OWA pessimistic
			5: DEA constrained

We can appreciate how the two columns are similar looking at the Pearson’s R = 0.975 which is very high. We mark the different cases of min=0 (10 regions) and Max=1 (11 regions) due to the cross effect of weighting through OWA (pessimistic=0 or optimistic=1) with geometric aggregation.

Table 7.1 – *Uncertainty analysis (40 different scenarios): scores [0,1]*

Regions	min	Mean	SC32	MAX	Std	dH	dHMax
de3	0.185	0.628	0.678	1.000	0.264	0.050	0.322
de21	0.128	0.609	0.640	0.978	0.277	0.031	0.338
de12	0.153	0.600	0.641	0.974	0.266	0.041	0.333
se23	0.309	0.600	0.550	0.949	0.204	0.050	0.399
se11	0.112	0.595	0.603	1.000	0.286	0.008	0.397
se22	0.241	0.590	0.549	1.000	0.245	0.042	0.451
de11	0.091	0.551	0.513	1.000	0.285	0.038	0.487
ukh	0.157	0.522	0.466	1.000	0.274	0.056	0.534
ukj	0.151	0.514	0.473	0.943	0.255	0.041	0.470
fi19	0.107	0.510	0.435	1.000	0.289	0.075	0.565
fi18	0.092	0.496	0.437	0.967	0.282	0.060	0.530
fr1	0.079	0.465	0.406	1.000	0.302	0.058	0.594
nl31	0.002	0.459	0.403	1.000	0.322	0.056	0.597
fi1a	0.083	0.454	0.396	0.859	0.250	0.058	0.464
nl41	0.000	0.442	0.372	1.000	0.324	0.070	0.628
ukk	0.075	0.441	0.389	0.897	0.266	0.052	0.508
at1	0.001	0.435	0.400	1.000	0.325	0.035	0.600
be2	0.132	0.423	0.375	0.772	0.206	0.049	0.397
ukf	0.052	0.422	0.378	0.863	0.262	0.044	0.485
be1	0.000	0.419	0.343	1.000	0.327	0.076	0.657
at3	0.011	0.414	0.353	0.987	0.321	0.061	0.634
nl32	0.000	0.393	0.352	0.825	0.265	0.041	0.473
be3	0.013	0.384	0.347	0.837	0.266	0.038	0.491
es21	0.012	0.379	0.331	0.869	0.278	0.048	0.538
at2	0.000	0.377	0.330	0.900	0.295	0.047	0.570
es22	0.000	0.364	0.326	0.847	0.276	0.038	0.521
fr7	0.000	0.346	0.274	0.883	0.294	0.072	0.609
itc4	0.006	0.331	0.219	0.878	0.293	0.112	0.659
itd5	0.000	0.328	0.236	0.901	0.307	0.091	0.665
fr4	0.002	0.313	0.247	0.766	0.252	0.066	0.519
ite4	0.000	0.311	0.269	0.787	0.263	0.042	0.519
fr6	0.018	0.286	0.266	0.626	0.197	0.021	0.361
es51	0.009	0.270	0.248	0.588	0.188	0.022	0.340
es3	0.000	0.268	0.180	0.712	0.240	0.088	0.532
itc1	0.000	0.238	0.110	0.683	0.246	0.128	0.573
Average	**0.063**	**0.434**	**0.387**	**0.894**	**0.271**	**0.054**	**0.507**

Notes: dH is a weighted Hamming distance; SC32 is the 'zero option' depicted in § 4.2.

The score assigned by the composite indicators to a given region *(CI_r)* or *Rank (CI_r)* is an output of the uncertainty analysis, and we can compute the relative shift in the position of the whole set of regions in a single number dH (*weighted Hamming distance*).

$$dH = \frac{1}{n}\sum_{r=1}^{n}\left|(CI_r)_{ref} - CI_r\right| \text{; or}$$

$$dHrank = \frac{1}{n}\sum_{r=1}^{n}\left|rank_{ref}(CI_r) - rank(CI_r)\right| \text{; with } 0 \le dH \le 1$$

the average of the absolute differences (for all the regions) between the reference composite and the *r*-th one. We have chosen only two benchmarks among the many as reference points: the 'zero option' and the Max score/rank.

The dH index between the ‘zero option’ and the mean is close to zero (0.054) signaling a strong stability of the CI_r score (SC32) around the mean of all the forty scenarios.

The same Table has been re-calculated with ranks instead of scores (smaller number, better performance), so the min/Max column will be logically inverted (the lower, the better) (see Table 7.2). Spearman correlation (the analogous of Pearson’s R computed on ranks instead of scores) is even higher ($R^S = 0.983$) signaling that the average shift in region rankings is almost absent.

The two box plots reported in Figures 7.3 and 7.4 offer a further evidence of ‘at a glance’ robustness of CI_r. The 90% of the cases – from 5% up to 95% – are quite compact even if there is a relatively high number of outliers, mainly due to the OWA operator. Even in this case (see the box plots) the leaders and the laggards are well separated while in the middle of the distribution regions can show a relative higher total variance. This is clear in the case of RICI composite where a group of regions from Uthecht region (nl31) to Südösterreich (at2) show a greater level of overlapping (see Figure 7.2, the red rhombs).

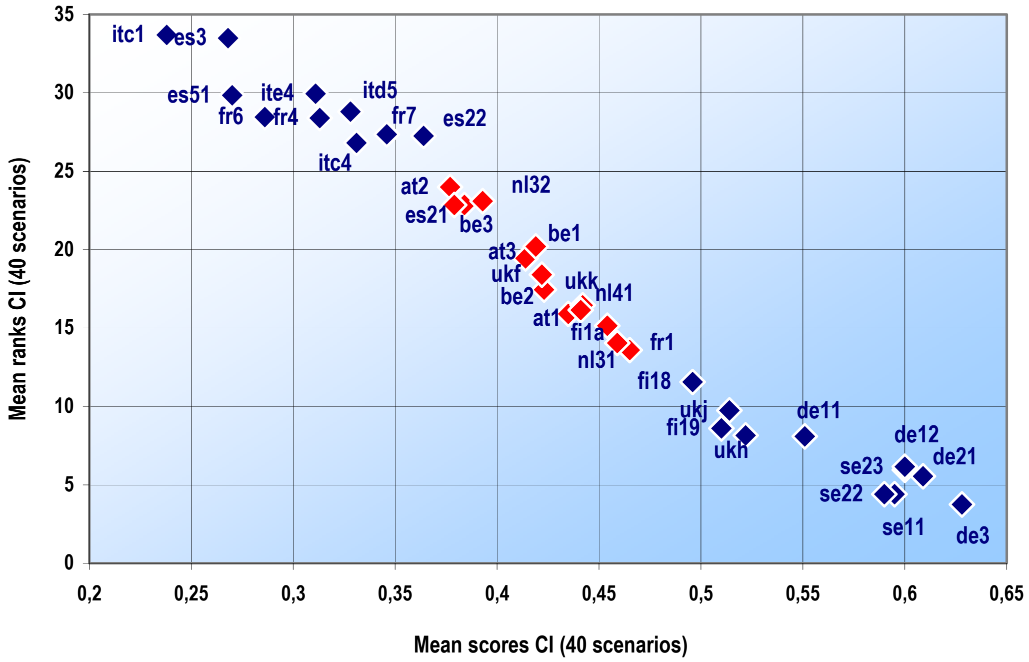
Table 7.2 – *Uncertainty analysis (40 different scenarios): ranks [1,35]*

Regions	min	Mean	SC32	MAX	Std	dH	dHmax
de11	6	8.10	7	12	2.193	1.10	5
de12	2	5.95	2	14	4.218	3.95	12
de21	1	5.55	3	13	4.646	2.55	10
de3	1	3.75	1	10	3.311	2.75	9
es21	18	22.85	24	26	2.338	1.15	2
es22	22	27.25	26	35	4.100	1.25	9
es3	31	33.50	34	35	1.377	0.50	1
es51	21	29.85	30	35	4.742	0.15	5
fr1	9	13.60	12	19	2.942	1.60	7
fr4	23	28.40	31	33	3.112	2.60	2
fr6	17	28.45	29	34	5.661	0.55	5
fr7	21	27.35	27	33	3.991	0.35	6
itc1	32	33.70	35	35	1.114	1.30	0
itc4	17	26.80	33	34	5.422	6.20	1
itd5	18	28.80	32	34	5.580	3.20	2
ite4	27	29.95	28	34	1.797	1.95	6
ukf	16	18.40	17	24	2.960	1.40	7
ukh	4	8.15	9	12	2.359	0.85	3
ukj	6	9.75	8	17	3.868	1.75	9
ukk	13	16.15	16	20	2.082	0.15	4
be1	7	20.20	23	29	7.363	2.80	6
be2	7	17.45	18	30	7.480	0.55	12
be3	18	22.85	22	27	2.704	0.85	5
nl31	6	14.05	13	24	5.909	1.05	11
nl32	18	23.10	21	28	4.113	2.10	7
nl41	5	16.45	19	27	7.271	2.55	8
fi18	9	11.55	10	15	1.934	1.55	5
fi19	4	8.60	11	11	2.489	2.40	0
fi1a	11	15.15	15	25	5.077	0.15	10
se11	1	4.40	4	10	2.744	0.40	6
se22	2	4.40	6	7	2.134	1.60	1
se23	1	6.15	5	16	5.236	1.15	11
at1	1	15.90	14	25	8.239	1.90	11
at2	19	24.00	25	26	2.660	1.00	1
at3	12	19.45	20	24	4.057	0.55	4
Average	**12.17**	**18.00**	**18.0**	**23.8**	**3.921**	**1.597**	**5.8**

Notes: dH is a wighted Hamming distance; SC32 is the ‘zero option’ depicted in § 4.2.

This result is further evident looking at Figure 7.2 were we put on the graphic the means of CI_r scores and the means of CI_r ranks for the 35 regions. The correlation (negative because of ranks interpretation, the lower the better) is almost perfect (R^S = –0.984) signaling that outliers do not affect at all the positioning of regions.

Figure 7.2 – *Scatter plot of CIr ranks and scores means – Spearmen R^s = –0.984*



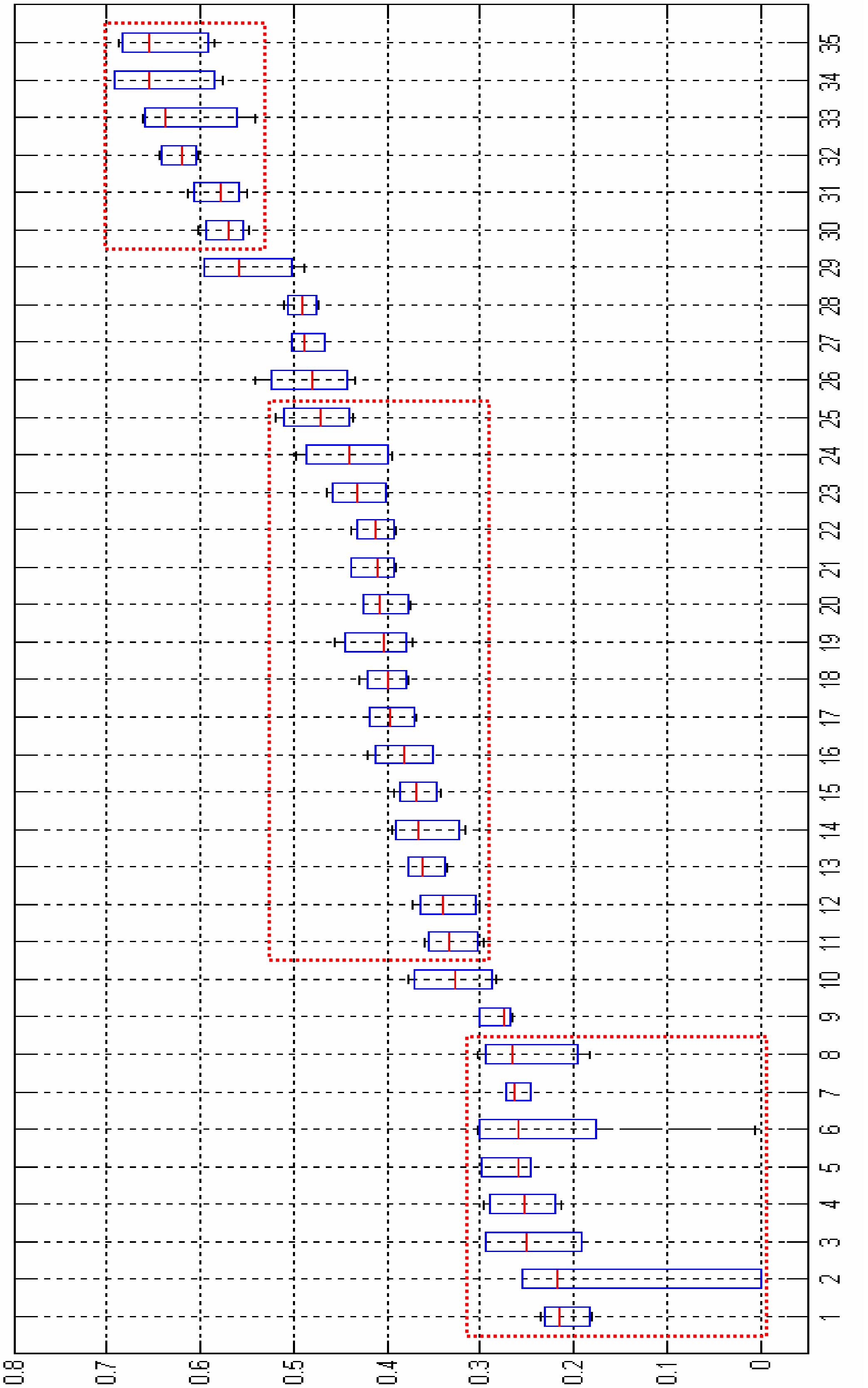
The other way to synthesize the ranks distribution is to compute a frequency matrix as already done in the previous 'zero option' (see Table 5.7). We aggregate the ranks according to a cardinality factor of three and count how many times (out of 40) a region results in the first three positions, or in the second three, and so on. Results – as percentage on the total cases – are presented in Table 7.3.

As will be explained later on, aggregation method possibly plays the greater role in determining the composite.

«If the constructors of the index disagree on the aggregation method it is highly unlikely that a robust index will emerge (…). Differently, is a well-established theoretical framework exists the resulting regions ranking could be fairly robust in spite of the uncertainties.» (Oecd–Jrc, 2008: 131).

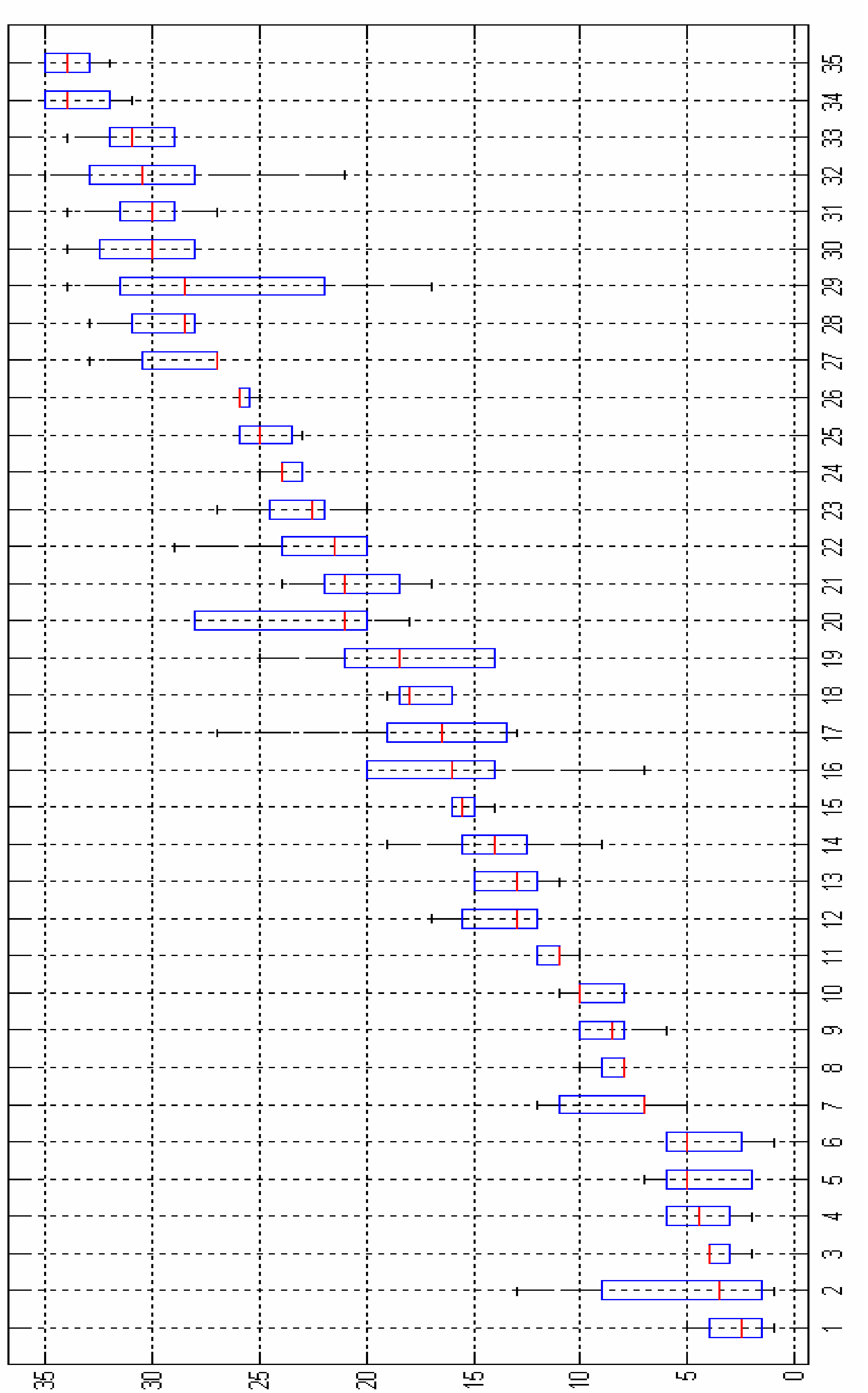
We have surely realized from the very beginning that some German Länder and Swedish regions were the most innovative milieus in Europe, but having constructed step by step the result – carefully thinking about all the plausible technical alternatives and testing for the most relevant ones – we can surely state that the final score/ranking is robust and it highlights, if anything, some major difficulties in the collection of up-to-dated data at NUTS 2 level.

Figure 7.3 – *Box plots of median scores for 40 scenarios*



Notes: 1 es3; 2 itc1; 3 itd5; 4 es51; 5 fr4; 6 itc4; 7 fr6; 8 ite4; 9 fr7; 10 es22; 11 at2; 12 es21; 13 be3; 14 at3; 15 be1; 16 nl32; 17 at1; 18 ukf; 19 nl41; 20 be2; 21 fr1; 22 ukk; 23 nl31; 24 fi1a; 25 fi18; 26 fi19; 27 ukh; 28 ukj; 29 de11; 30 se22; 31 se23; 32 se11; 33 de12; 34 de21; 35 de3.

Figure 7.4 – *Box plots of median ranks for 40 scenarios*



Notes: 1 de3; 2 de21; 3 se11; 4 de12; 5 se22; 6 se23; 7 de11; 8 ukh; 9 ukj; 10 fi19; 11 i18; 12 nl31; 13 fi1a; 14 fr1; 15 ukk; 16 be2; 17 nl41; 18 ukf; 19 at1; 20 nl32; 21 at3; 22 be1; 23 be3; 24 es21; 25 at2; 26 es22; 27 fr7; 28 fr4; 29 itc4; 30 fr6; 31 ite4; 32 es51; 33 itd5; 34 es3; 35 itc1.

Table 7.3 – *Frequencies matrix of CI ranks (percentage on 40 scenarios)*

Regions	Cod	11	10	9	8	7	6	5	4	3	2	1	0	Borda score
		1-2-3	4-5-6	7-8-9	10-11-12	13-14-15	16-17-18	19-20-21	22-23-24	25-26-27	28-29-30	31-32-33	34-35	
Berlin	de3	75,00	5,00		20,00									414
Sydsverige	se22	40,00	40,00	20,00										408
Stockholm	se11	45,00	35,00	10,00	10,00									406
Karlsruhe	de12	40,00	40,00			20,00								392
Oberbayern	de21	50,00	10,00	20,00		20,00								388
Västsverige	se23	30,00	50,00				20,00							380
Eastern	ukh		20,00	60,00	20,00									360
Stuttgart	de11		20,00	50,00	30,00									356
Länsi-Suomi	fi19		20,00	20,00	60,00									344
South East	ukj		20,00	45,00	15,00		20,00							338
Etelä-Suomi	fi18			15,00	65,00	20,00								318
Île de France	fr1			20,00	5,00	50,00	20,00	5,00						286
Utrecht	nl31		20,00		15,00	40,00	5,00		20,00					284
Pohjois-Suomi	fi1a				40,00	40,00				20,00				264
South West	ukk					50,00	30,00	20,00						252
Ostösterreich	at1	20,00				10,00	30,00	20,00		20,00				252
Noord-Brabant	nl41		20,00			20,00	15,00	25,00		20,00				246
Vlaams Gewest	be2			20,00		30,00	15,00	15,00			20,00			238
East Midlands	ukf						75,00	5,00	20,00					222
Westösterreich	at3				20,00		5,00	35,00	40,00					210
Région de Bruxelles	be1			20,00				40,00	15,00	5,00	20,00			198
Pais Vasco	es21						10,00	10,00	65,00	15,00				166
Région Wallonne	be3						10,00	10,00	55,00	25,00	0,00			162
Noord-Holland	nl32						5,00	55,00	0,00	0,00	40,00			154
Südösterreich	at2							20,00	15,00	65,00				142
Centre-Est	fr7							20,00	0,00	50,00	5,00	25,00		114
Lombardia	itc4						10,00		30,00	5,00	25,00	25,00	5,00	108
Navarra	es22								10,00	70,00			20,00	100
Est	fr4								20,00		45,00	35,00		82
Emilia-Romagna	itd5						20,00				10,00	65,00	5,00	82
Sud-Ouest	fr6						10,00	10,00	0,00		30,00	30,00	20,00	80
Cataluña	es51							10,00	10,00		30,00	30,00	20,00	72
Lazio	ite4									5,00	75,00	10,00	10,00	70
Madrid	es3											40,00	60,00	16
Piemonte	itc1											40,00	60,00	16

Notes: The Borda score is obtained multiplying the cell number (occurrences, absolute values) for the score in the first row and then summing up along the lines.

7.2 Testing hypothesis about differences in means

A useful final control of robustness on the ‘zero option’ – compared with the forty alternative scenarios – is to test the hypothesis that the means of the different box-plots (see Figures 7.3 and 7.4) are equal/different. We will use nonparametric tests (distributional-free) (see Table 7.4) which are suitable when the original data are not normally distributed[58].

[58]If data **were** normally distributed we should apply *t-test* and it would detect true differences between the two populations. But, on the other hand, using *t-test* when its assumptions are substantially violated frequently results in an erroneous observed significance level. Non-parametric tests are generally less powerful than their parametric counterparts but they are appropriate when the

Table 7.4 – *Wilcoxon signed-ranks test (sig. 0.99%, 1**)*

	es3	itc1	itd5	es51	fr4	itc4	fr6	ite4	fr7	es22	at2	es21
es3	0	0	1	0	1	1	0	1	1	1	1	1
itc1		0	1	0	1	1	1	1	1	1	1	1
itd5			0	0	0	0	0	0	1	1	1	1
es51				0	1	1	1	0	1	1	1	1
fr4					0	0	0	0	1	1	1	1
itc4						0	0	1	0	1	1	1
fr6							0	0	1	1	1	1
ite4								0	1	1	1	1
fr7									0	0	1	1
es22										0	1	1
at2											0	0
es21												0

	be3	at3	be1	nl32	at1	ukf	nl41	be2	fr1	ukk	nl31	fi1a
es3	1	1	1	1	1	1	1	1	1	1	1	1
itc1	1	1	1	1	1	1	1	1	1	1	1	1
itd5	1	1	1	1	1	1	1	1	1	1	1	1
es51	1	1	1	1	1	1	1	1	1	1	1	1
fr4	1	1	1	1	1	1	1	1	1	1	1	1
itc4	1	1	1	1	1	1	1	1	1	1	1	1
fr6	1	1	1	1	1	1	1	1	1	1	1	1
ite4	1	1	1	1	1	1	1	1	1	1	1	1
fr7	1	1	1	1	1	1	1	1	1	1	1	1
es22	1	1	1	1	1	1	1	1	1	1	1	1
at2	0	1	1	0	1	1	1	0	1	1	1	1
es21	0	1	1	0	1	1	1	1	1	1	1	1
be3	0	0	0	0	1	1	1	1	1	1	1	1
at3		0	0	0	1	0	1	0	1	0	1	0
be1			0	0	1	0	1	0	1	0	1	0
nl32				0	1	1	1	0	1	1	1	1
at1					0	0	0	0	1	0	1	0
ukf						0	0	0	1	1	1	1
nl41							0	0	1	0	1	0
be2								0	0	0	0	1
fr1									0	1	0	0
ukk										0	0	0
nl31											0	0
fi1a												0

	fi18	fi19	ukh	ukj	de11	se22	se23	se11	de12	de21	de3
es3	1	1	1	1	1	1	1	1	1	1	1
itc1	1	1	1	1	1	1	1	1	1	1	1
itd5	1	1	1	1	1	1	1	1	1	1	1
es51	1	1	1	1	1	1	1	1	1	1	1
fr4	1	1	1	1	1	1	1	1	1	1	1
itc4	1	1	1	1	1	1	1	1	1	1	1
fr6	1	1	1	1	1	1	1	1	1	1	1
ite4	1	1	1	1	1	1	1	1	1	1	1
fr7	1	1	1	1	1	1	1	1	1	1	1
es22	1	1	1	1	1	1	1	1	1	1	1
at2	1	1	1	1	1	1	1	1	1	1	1
es21	1	1	1	1	1	1	1	1	1	1	1
be3	1	1	1	1	1	1	1	1	1	1	1
at3	1	1	1	1	1	1	1	1	1	1	1
be1	1	1	1	1	1	1	1	1	1	1	1
nl32	1	1	1	1	1	1	1	1	1	1	1
at1	1	1	1	1	1	1	1	1	1	1	1
ukf	1	1	1	1	1	1	1	1	1	1	1
nl41	1	1	1	1	1	1	1	1	1	1	1
be2	1	1	1	1	1	1	1	1	1	1	1
fr1	1	1	1	1	1	1	1	1	1	1	1
ukk	1	1	1	1	1	1	1	1	1	1	1
nl31	1	1	1	1	1	1	1	1	1	1	1
fi1a	1	1	1	1	1	1	1	1	1	1	1
fi18	0	1	1	1	1	1	1	1	1	1	1
fi19		0	1	0	1	1	1	1	1	1	1
ukh			0	0	1	1	1	1	1	1	1
ukj				0	1	1	1	1	1	1	1
de11					0	1	1	1	1	1	1

data are nominal or ordinal, or when they are from markedly non normal distributions.

(Table 7.4) continued

	fi18	fi19	ukh	ukj	de11	se22	se23	se11	de12	de21	de3
se22						0	0	0	0	0	1
se23							0	0	0	0	0
se11								0	0	0	1
de12									0	1	1
de21										0	1
de3											0

Notes: in the cells **0** means the *null hypothesis* is **true** and therefore the two regions share a median that **is not** statistically different; **1** means that the *null hypothesis* **is rejected** and the two regions show a median that **is** statistically different.

es3=Comunidad de Madrid; itc1=Piemonte; itd5=Emilia-Romagna; es51=Cataluña; fr4=Est; itc4=Lombardia; fr6=Sud-Ouest; ite4=Lazio; fr7=Centre-Est; es22=Comunidad Foral de Navarra; at2=Südösterreich; es21=Pais Vasco; be3=Région Wallonne; at3=Westösterreich; be1=Région de Bruxelles; nl32=Noord-Holland; at1=Ostösterreich; ukf=East Midlands; nl41=Noord-Brabant; be2=Vlaams Gewest; fr1=Île de France; ukk=South West; nl31=Utrecht; fi1a=Pohjois-Suomi; fi18=Etelä-Suomi; fi19=Länsi-Suomi; ukh=Eastern; ukj=South East; de11=Stuttgart; se22=Sydsverige; se23=Västsverige; se11=Stockholm; de12=Karlsruhe; de21=Oberbayern; de3=Berlin.

We utilized the *Wilcoxon signed-rank test* (Wilcoxon, 1945) that, like the *paired t-test*, involves comparisons of differences between measurements. If we take two regions out of 35 – lets say *regions 1* and *region 2* – we have *2n*–observations (with $n=40$, scenarios). i denotes the particular scenario that is being referred to, and X_i the first observation measured on scenario i (the composite for *region 1* under SC1) while Y_i the second observation (the composite for *region 2* under the same SC1). For each i, X_i and Y_i should be paired together. We define:

$$Z_i = Y_i - X_i \qquad for\ i = 1,\ \ldots,\ n$$

The differences Z_i are assumed to be independent, each Z_i comes from the same continuous population and is not necessarily symmetric about a common mean θ. The value of X_i and Y_i are ordered, so the comparisons 'greater than', 'less than', and 'equal to' are meaningful.

The null hypothesis tested is $H_0 \Rightarrow \theta=0$, that is the means of the two *2n*–observations, that are not statistically different and, therefore, performance of *region 1* is not discernible from the one of *region 2*.

The alternative hypothesis H_1 is retained if the test statistic is less than or equal to the critical value based on the number of observations n, that is *region 1* and *region 2* are statistically different.

The *Wilcoxon signed rank* statistic W_+ is computed by ordering the absolute values $|Z_1|, \ldots, |Z_n|$; to each ordered $|Z_i|$ is given a rank R_i. The positive value of Z_i is denoted with φ_i. The *Wilcoxon test* W_+ is defined as:

$$W_+ = \sum_{i=1}^{n} \varphi_i R_i$$

Table 7.4 reports the *Wilcoxon test* for the 35 regions. The matrix is squared and symmetric, with the principal diagonal reporting a whole set of 0 (by definition the means of one regions with itself verifies the null hypothesis $H_0 \Rightarrow \theta=0$.

Jointly looking to the *Wilcoxon test* (Table 7.4) and to the boxplots (see Figures 7.3, 7.4) we find out important confirmations. First of all the more we depart from the principal diagonal, the more separated are (the boxplots of) the regions and, therefore, we expect to find out a *Wilcoxon test* against the null hypothesis of equal medians.

There is no doubt that the three German Länder (de12, de21, and d3) perform, on average[59], better than the two Italian regions (itc1, itd5). Around the principal diagonal there are more similar regions and here it is the *Wilcoxon test* that interestingly allows us to evaluate 'separated' or 'overlapping' neighbouring regions.

In particular, if we come back to Figure 7.3 we see three different red dotted boxes. They correspond to three blocks of regions which are well separated: for example, region 8 (Lazio, IT) is statistically different from region 11 (Südösterreich, AT) while within each block we have different cases of overlapping. In the same way, at the top of the distribution, we can't (statistically) distinguish the median of a region such as 30 (Sydsverige, SE) from the German Länder 33 or 34 (respectively, Karlsruhe and Oberbayern).

We will see later (Chapter 8) that a more 'conservative' perturbing exercise – with smaller uncertainty introduced in the distribution – allows to reach more robust results and clear-cut ranking among regions.

7.3 Sensitivity analysis[60]

Sensitivity analysis is one of the final steps in the construction of a composite (OECD–JRC, 2008) and its main goal is to assess the relative importance of different uncertainties input elements on the output of interest. It is therefore a precious instrument supporting researchers in:

> *«the study of how uncertainty in the output of a model can be apportioned to different sources of uncertainty in the model input.»* (Saltelli *et al.,* 2008:1).

Sensitivity is strictly tied with uncertainty analysis which focuses rather on quantifying the robustness of the model output. It is important to agree on the idea that uncertainty is not an 'accident' of the scientific method but its substance.

As we have already explained (see § 7) the logic of the uncertainty approach is quite simple: we modify some 'rules of treatments' of our input data[61] (sometimes even modifying the data, for example, when we check alternative ways of imputation of missing data) and run the model producing different values of the model output (the composite) for each input of observation. On the vector of output we can compute all the possible statistical measures: average, standard deviation, confidence bounds, plot of distribution, etc. Through these measures we compare the output of the set of regions under study and we can say that the output is robust if changes in the input variables x_i are moderately influencing the output CI_r under scrutiny (Saltelli and Annoni, 2010).

Having performed uncertainty analysis we can now move to a sensitivity analysis in order to determine which of the input parameters are more important in influencing the uncertainty in the model output. Obviously the more are the factors we allow to vary, the greater the variance to be expected in the model predic-

[59]On average and not 'in any case' because of the presence of some outliers (generated by the OWA weighting combining with the geometric aggregation).

[60]Sensitivity analysis is properly one of the domain in which JRC–IPSC has expressed – and is still expressing – state-of-the-art advancements. The following section is heavily rooted on the impressive stock of literature and operational sensitivity. The three main references remain the books published by John Wilew and edited by Andrea Saltelli and his research team (Saltelli *et al.,* 2000; 2004; 2008).

[61]In the context of uncertainty and sensitivity analysis an 'input' is classified as everything that can drive a variation in the output of the model.

tion. If we incorporate all uncertainties the model prediction varies so wildly as to be of no practical use. The problem becomes the right identification of a neighborhood of alternative assumptions wide enough to be 'credible':

«In 'global sensitivity analysis' a neighborhood of alternative assumptions is selected and the corresponding interval of influences is identified. Conclusions are judged to be sturdy only if the neighborhood of assumptions is wide enough to be credible and the corresponding interval of inferences is narrow enough to be useful.» (Leamer, 1990; *reported in* Saltelli *et al.,* 2008: 10).

Specifically, in composite indicators we have a number of choices which present themselves as suitable alternatives, we can evaluate the goodness of our choices even on the appraisal of the share of total variability on the final CI_r that a single factor could explain. In technical terms it is a decomposition of the overall variance of the indicator in the single uncertainties elements we have applied. This decomposition is normally run at two levels: *i)* the first one looks at 'first-order effect', that is the direct influence of the single factors on the total variance, *ii)* while the second one looks at the interactions between different factors through second– (and higher) order effects.

Despite the fact that we may assign 'equal weights' to the simple indicators, we know that usually, and luckily in a number of cases, few factor create the large majority of uncertainty and many others offer only a negligible contribution. The implication of the fact that factors assume a very asymmetric distribution – with a small number accounting for most of the output – is that a definition of importance is necessary and ordering the factors by importance may be of great advantage in the use of the model.

Following Saltelli *et al.* (2004) if we refer to the output as:

$$Y = f\,(X_1, X_2, \ldots X_k)$$

where k is the number of factors X whose variation is under scrutiny, we are interested in different f: we propagate uncertainty through different model structures or formulations and f stands for the computational code used in the production of different outputs.

We know that some of input factors are uncertain, and each of them has its specific range of uncertainty on which we know something coming from different sources (measurements, expert opinions, analogy with other case studies, etc.). Sensitivity helps in identifying the most important factor:

«This is defined as the one that, if determined (i.e., fixed in its true albeit unknown, value), would lead to the greatest reduction in the variance of the output Y.» (Saltelli *et al.,* 2004: 52).

The way through which this goal is normally pursued is using *conditional variance:*

$$V(Y|X_i = x^*_i)$$

the variance V that Y assumes when one factor X_i is fixed to the value x^*_i and the variance is taken over all factors that are not X_i. This variance offers an estimate of the direct effect of factor X_i on the overall variance but normally we do not know what x^*_i is for each X_i. So it is better to take the average of the above measure over all possible values x^*_i of X_i that is: $V(E(Y|X_i))$. In a more complete notation we can write this expression as (Tarantola *et al.*, 2009):

$$V_{X_i}(E_{X\sim i}(Y \mid X_i))$$

where $\boldsymbol{X}_{\sim i}$ denotes the vector of all the input factors but X_i, this is the top marginal variance of first order effect. The inner expectation operator means that we compute the mean of Y on all possible value of non-X_i. We can easily consider the 'sensitivity index' S_i as the normalization of conditional variance V_i by the unconditional variance $V(Y)$:

$$S_i = \frac{V_{X_i}(E_{X\sim i}(Y \mid X_i))}{V(Y)}$$

S_i is the expected fractional reduction of variance that would be achieved if X_i could be fixed.

Many times, however, we need to check for interaction among different factors. The factors are said to interact when their effect on Y cannot be expressed as a sum of their single effect on Y. The interaction of two orthogonal factors X_i and X_j on the output Y can be defined in terms of *conditional variance* as:

$$V_{ij} = V(E(Y|X_i,X_j)) - V(E(Y|X_i)) - V(E(Y|X_j))$$

The term V_{ij} is the joint effect of X_i and X_j minus the first order effects of the same factors, and is known as second-order or two-way effect.

When the factors are orthogonal the variance decomposition may be run according to Sobol's (1993) scheme[62] whereby the total output variance $V(Y)$ for a model of k factors can be decomposed as:

$$V(Y) = \sum_i V_i + \sum_i \sum_{j>i} V_{ij} + \ldots + V_{12\ldots k}$$

where:

$$V_i = V[E(Y|X_i)]; \qquad V_{ij} = V[E(Y|X_i,X_j)] - V_i - V_j$$
$$V_{ij\ldots k} = V[E(Y|X_i,X_j,X_k)] - V_{ij} - V_{ik} - V_{jk} - V_i - V_j - V_k$$

If we have a model without interactions, only the first term $V_i \neq 0$, that model is said to be additive in its factors and to compute the first-order *conditional variance* V_i is enough to decompose the model's variance.

Sobol' decomposition method belongs to a wider class of global sensitivity analysis techniques known as variance-based methods; Sobol' indexes have proved to be a powerful instrument to analyse the importance of first-order of single factors (that is the fraction of the total variance of CI_r due to any individual factor) and higher order combination.

S_{ij}, for $i \neq j$, is the second-order sensitivity index which measures the interaction effect, that is the part of the variation in CI_r due to X_i and X_j that cannot be explained by the sum of the individual effects of X_i and X_j.

Using the more complete notation the second-order sensitivity index becomes:

$$S_{ij} = \frac{V_{X_iX_j}\left[E_{X\sim ij}(Y \mid X_i, X_j)\right] - V_{X_i}\left[E_{X\sim i}(Y \mid X_i)\right] - V_{X_j}\left[E_{X\sim j}(Y \mid X_j)\right]}{V(Y)}$$

and therefore[63]:

$$\sum_i S_i + \sum_i \sum_{j>i} S_{ij} + \ldots + S_{12\ldots k} = 1$$

Anytime that first-order sensitivity indexes do not add up to one ($\sum_i S_i < 1$) it means that interacting factors are at work and higher order terms have to be included.

[62] Sobol' (1993) measure is particularly suitable because it is model-independent, that is, it works regardless of the additivity or linearity of the model, and it is able to appreciate the interaction effects.

[63] In additive models the first-order conditional variances fully decompose the model's variance: $\sum_i V_i = V(Y)$ and, equivalently, $\sum_i S_i = 1$.

Another meaningful variance-based measure is the *total effect index* (Homma and Saltelli, 1996):

$$S_{T_i} = \frac{E_{X_{\sim i}}\left[V_{X_i}(Y \mid X_{\sim i})\right]}{V(Y)} \equiv 1 - \frac{V_{X_{\sim 1}}\left[E_{X_i}(Y \mid X_{\sim i})\right]}{V(Y)}$$

S_{T_i} measures the total effect of X_i on Y (both first and higher orders) and is the expected fraction of variance that would be left if all inputs but X_i could be fixed and, therefore, for an interacting model the difference ($S_{T_i} - S_i$) is a measure of the strength of the interactions (Saltelli *et al.,* 2010). The numerator expression is known as the bottom marginal variance, or total effect and, once again, we normalised the total conditional variance $VT_i(Y)$ for the total unconditional variance $V(Y)$.

7.3.1 First-order sensitivity index in the deterministic setting

If we apply the first-order *conditional variance* and compute the sensitivity indexes S_i we obtain the data shown in Table 7.5.

Table 7.5 – *Sensitivity analysis: share of total variance explained by single factors*

Regions	Cod	I fat	II fat	III fat	IV fat	Total
Oberbayern	de21	0,0%	0,3%	0,0%	98,4%	98,7%
Région de Bruxelles	be1	0,0%	0,7%	0,0%	97,9%	98,6%
Noord-Holland	nl32	0,0%	0,5%	0,2%	97,7%	98,5%
Pohjois-Suomi	fi1a	0,0%	0,8%	0,0%	97,7%	98,5%
Vlaams Gewest	be2	0,0%	1,0%	0,0%	97,2%	98,3%
Västsverige	se23	0,0%	0,2%	0,1%	98,0%	98,3%
South East	ukj	0,0%	0,4%	0,4%	97,3%	98,2%
Noord-Brabant	nl41	0,0%	0,6%	0,8%	96,8%	98,2%
Utrecht	nl31	0,0%	0,4%	0,1%	97,7%	98,1%
Cataluña	es51	0,0%	0,6%	0,3%	96,9%	97,7%
Sud-Ouest	fr6	0,0%	0,6%	0,4%	96,5%	97,6%
Ostösterreich	at1	0,0%	1,5%	0,4%	95,5%	97,3%
Karlsruhe	de12	0,0%	0,7%	0,7%	95,7%	97,2%
Emilia-Romagna	itd5	0,0%	0,8%	0,3%	95,7%	96,8%
Comunidad Foral de Navarra	es22	0,0%	0,7%	0,1%	95,8%	96,7%
Centre-Est	fr7	0,0%	0,8%	0,0%	95,9%	96,7%
Piemonte	itc1	0,0%	0,8%	0,0%	95,9%	96,7%
Pais Vasco	es21	0,0%	0,0%	2,3%	93,7%	96,0%
East Midlands	ukf	0,0%	0,5%	0,1%	94,9%	95,5%
Südösterreich	at2	0,0%	0,0%	2,3%	93,1%	95,4%
Berlin	de3	0,0%	0,6%	1,1%	93,6%	95,3%
Sydsverige	se22	0,0%	0,9%	0,9%	93,2%	95,0%
Lombardia	itc4	0,0%	0,9%	1,7%	92,0%	94,6%
Länsi-Suomi	fi19	0,0%	1,5%	0,2%	93,0%	94,6%
Région Wallonne	be3	0,0%	0,9%	0,9%	92,5%	94,2%
Stockholm	se11	0,0%	2,2%	0,1%	91,8%	94,1%
South West	ukk	0,0%	0,1%	1,5%	92,0%	93,6%
Eastern	ukh	0,0%	2,3%	1,2%	89,9%	93,4%
Etelä-Suomi	fi18	0,0%	1,7%	1,7%	89,4%	92,8%
Est	fr4	0,0%	3,8%	0,4%	88,3%	92,6%
Westösterreich	at3	0,0%	3,6%	0,4%	87,3%	91,3%
Île de France	fr1	0,0%	4,3%	1,9%	81,3%	87,5%
Stuttgart	de11	0,0%	0,0%	6,9%	75,0%	81,9%
Comunidad de Madrid	es3	0,0%	13,5%	2,2%	54,1%	69,7%
Lazio	ite4	0,0%	6,0%	39,0%	16,2%	61,3%
	Average		**1,55%**	**1,97%**	**90,22%**	**93,74%**

The final column reports the total share of variance explained by the sum of the first-order effects. The first consideration is that the interaction effects are on average around 6%, that is quite negligible. The most of the overall variance is totally explained by direct single factors.

We recall that, according to the design of experiments (see Figure 7.1) the first factor is related to standardization (z-scores *vs.* min-Max), the second one regards the Pillars structure (three or four), the third one looks at the inclusion/exclusion of variable 1.2.1 (public R&D expenditures), and the last factor – absolutely the most relevant – is connected to weighting and aggregation.

Figure 7.5 presents the average share of the total variance explained by the uncertainty factors considered. We see that 94% is imputable to first-order effects and only 6% to interactions among factors (second and higher order effects), and among the first-order effects the 90% is related to the fourth factors (weighting and aggregation).

Figure 7.5 – *Percentage distribution of S_i first-order sensitivity indexes and share of second-order effect*

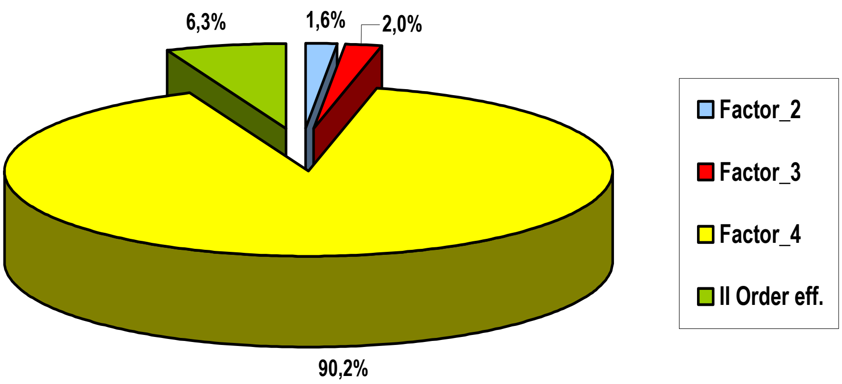


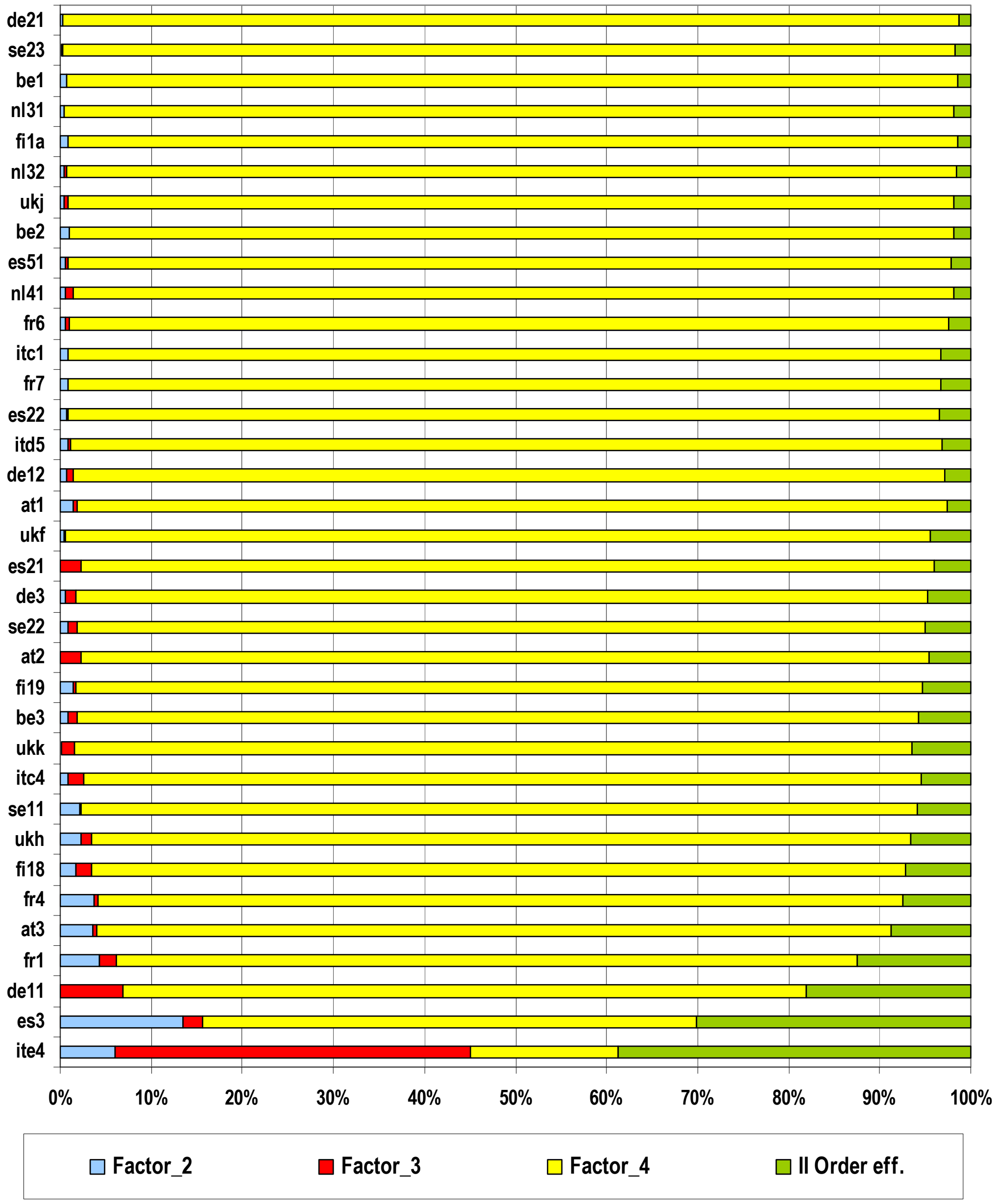
Figure 7.6 reports the distribution of the first-order sensitivity indexes across the regions adding the territorial variance to the phenomenon. Lazio (IT) is the only region, out of 35, where S_4 is not the greatest one, overtaken by S_3, the sensitivity index linked to the third factor of uncertainty (inclusion/exclusion *public R&D expenditures*). And this is not by chance. Lazio (IT), in effect, has a strong concentration of public R&D expenditures[64] and the inclusion/exclusion of this indicator makes an effective difference.

A second comment is related to the fact that the fourth factor captures the large majority of the total variance explained. This is not a surprise at all: this factor includes the weighting and aggregation choices, by and large the more relevant one as for its impact on the composite. It would have been interesting to separate the two dimensions but it has not been possible as both the OWA operators and the DEA are techniques mixing together the two steps.

As Figure 7.6 clearly shows there are 27 regions with a S_4 (first-order sensitivity index) greater than average (90%) and only one – Lazio (IT) – with a S_4 value under the 50%.

[64]In 2003 the figure was 49.5% of the whole R&D expenditures of Public Administrations in Italy, against a 17,8% of the overall R&S national expenditures (inclusive of universities and private firms).

Figure 7.6 – *Regional percentage distribution of first- and second-order sensitivity indexes*

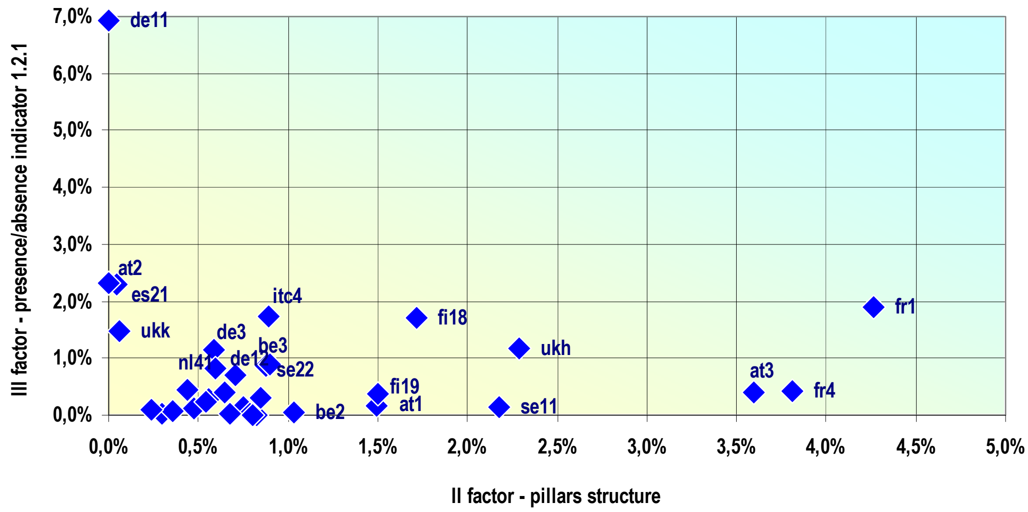


Notes: ite4=Lazio; es3=Comunidad de Madrid; de11=Stuttgart; fr1=Île de France ; at3=Westösterreich; fr4=Est; fi18=Etelä-Suomi; ukh=Eastern; se11=Stockholm; itc4=Lombardia; ukk=South West; be3=Région Wallonne; fi19=Länsi-Suomi; at2=Südösterreich; se22=Sydsverige; de3=Berlin; es21=Pais Vasco; ukf=East Midlands; at1=Ostösterreich; de12=Karlsruhe; itd5=Emilia-Romagna; es22=Navarra; fr7=Centre-Est; itc1=Piemonte; fr6=Sud-Ouest; nl41=Noord-Brabant; es51=Cataluña; be2=Vlaams Gewest; ukj=South East; nl32=Noord-Holland; fi1a=Pohjois-Suomi; nl31=Utrecht; be1=Région de Bruxelles; se23=Västsverige; de21=Oberbayern

A third comment is related to a comparative analysis between the second and third factors, here we have only a small number of regions with an out of average behaviour (see Figure 7.7).

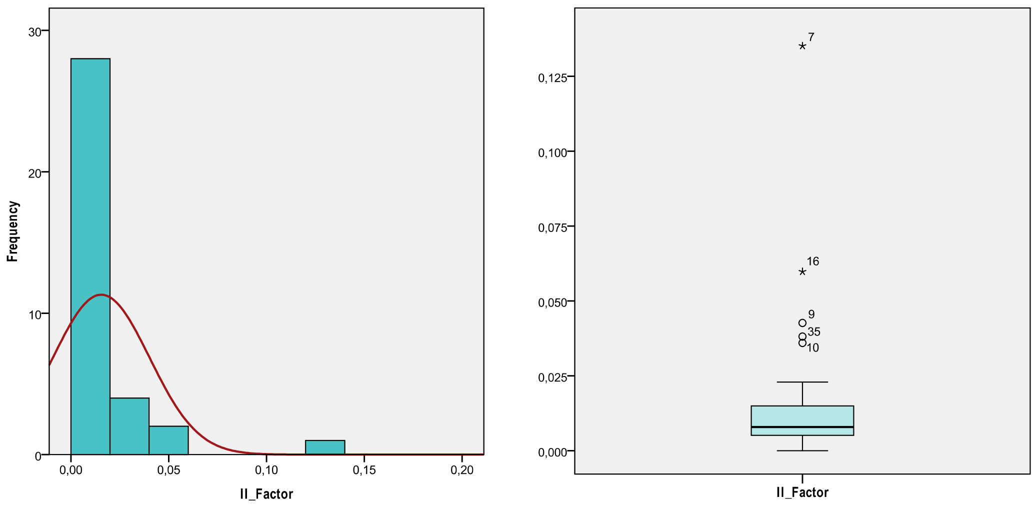
A final comment regards the first factor which actually disappears. As a matter of fact we are comparing here two different normalization procedures: the min-Max and z-scores. Due to the fact that z-scores imply also negative values we run a post-normalization, re-scaling the computed z-scores in the range [0,1] and therefore we obtain the same result in the two cases.

Figure 7.7 – *Scatterplot II factor and III factor*



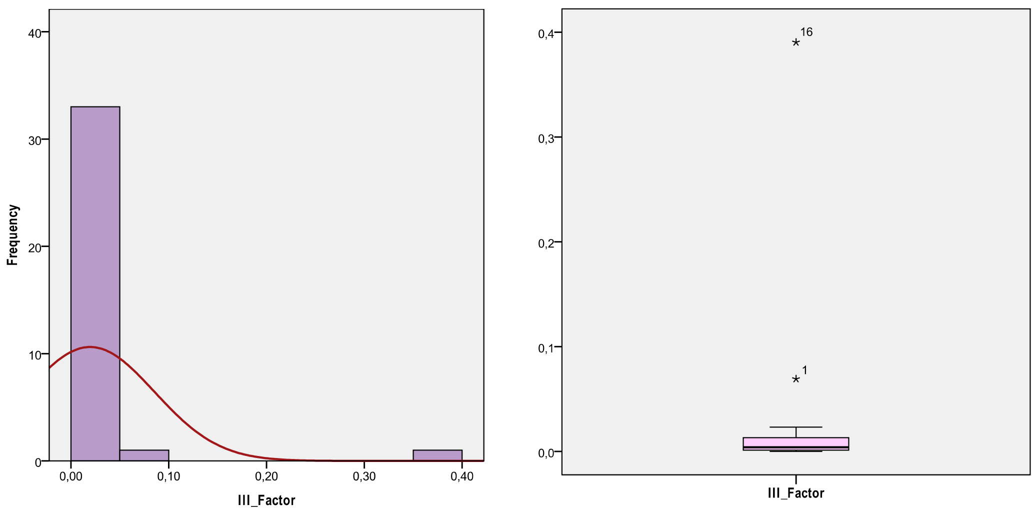
Notes: For the sake of clarity in the Figure do not appear two 'outliers': ite4 which records 39% in factor III and es3 recording 13.5% in factor II.

Figure 7.8a – *Frequency distribution and boxplot of factor II (Pillar structure)*



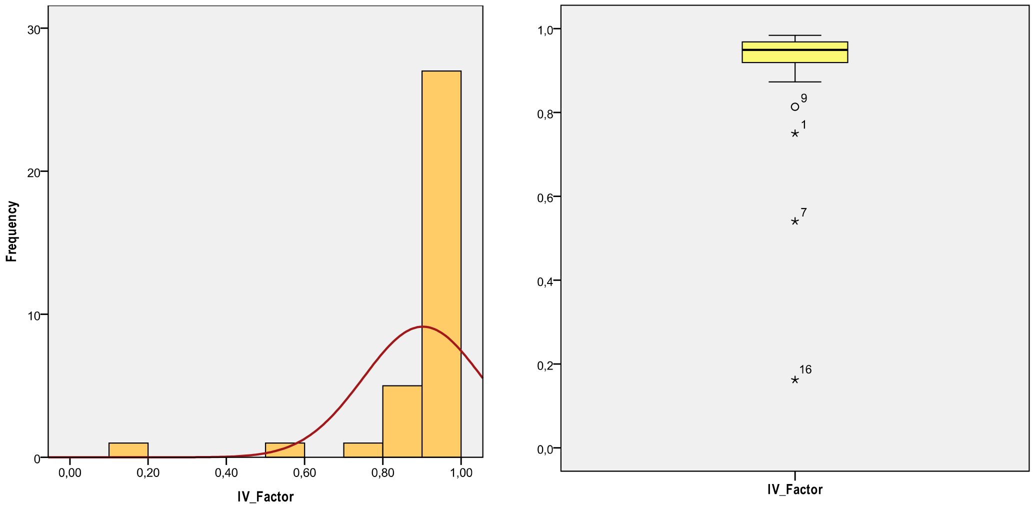
Notes: Mean = 0.015; Std.Dev. = 0.025; N = 35; Skewness = 3.746

Figure 7.8b – *Frequency distribution and boxplot of factor III (inclusion/exclusion 1.2.1)*



Notes: Mean = 0.20; Std.Dev. = 0.0657; N = 35; Skewness = 5.589

Figure 7.8c – *Frequency distribution and boxplot of factor IV (weighting and aggregation)*



Notes: Mean = 0.90; Std.Dev. = 0.153; N = 35; Skewness = –3.935

In the present case we have:

$$S_1 + S_2 + S_3 + S_4 = S_{1st} \Rightarrow 0+1.55+1.97+90.22 = 93.74,$$

where a percentage of 6.26% is related to interaction effects (second or higher order effects).

In Figures 7.8 (from *a* to *c*) we can appreciate the high skewness of the distribution of first-order sensitivity indexes which are strongly conditioned by the outliers even if the 90% of the cases (different scenarios) are very compact.

7.4 Preliminary conclusions

At the end of the reasoning within the deterministic setting some preliminary remarks are useful also for suggesting further inspections in the data.

The first one is related to the level of robustness tested. While the evidence of a relative wide dispersion of the 35 regions analysed is out of question – signalling the presence of strong and weak regions – there is still a wide area of overlapping. We have chosen a ‘base-line’ indicator (see Table 4.1), according to our vision of innovation, within the range 0.11–0.678 (the laggard and the better performer) with an average value of 0.387 and a standard deviation of 0.134 and a quite regular distribution approaching to a normal one (see Figures 4.1, 4.3).

But when we perturb the composite we obtain the results shown in Figures 7.3 and 7.4. The joint analysis of the boxplots and the non-parametric Wilcoxon signed-rank test clearly points out the existence of three distinct blocks of regions definitely separate: the low, the intermediate and the high innovative sub-set.

- In the first block we have 8 regions: Madrid (es3), Piemonte (itc1), Emilia-Romagna (itd5), Cataluña (es51), Est (fr4), Lombardia (itc4), Sud-Ouest (fr6), and Lazio (ite4), all the Italian regions, two Spanish and two French ones;
- in the high block we recognise 6 regions: Sydsverige (se22), Västsverige (se23), Stockholm (se11), Karlsruhe (de12), Oberbayern (de21), and Berlin (de3), three Swedish and three German regions;
- the intermediate block is the largest of the three with 14 regions: we have all the Austrian, the Belgian and the Dutch regions, two English ones and one region each fro Spain, France and Finland, Ostösterreich (at1), Südösterreich

(at2), Westösterreich (at3), Région de Bruxelles (be1), Vlaams Gewest (be2), Région Wallonne (be3), Utrecht (nl31), Noord-Holland (nl32), Noord-Brabant (nl41), East Midlands (ukf), South West (ukk), Pais Vasco (es21), Île de France (fr1), and Pohjois-Suomi (fi1a).

While the three blocks are clearly separated – the Wilcoxon test rejects the null hypothesis of all the pairs of regions (with a confidence level of 99%) – within the blocks we have frequently a mixed situation with a test confirming the equality of the medians of contiguous (or not) regions.

The meaning is that in some of the 40 scenarios the boxplot of *CI* of, let's say, region 17 (at1) overlaps to the one of region 18 (ukf) and the medians of the two distributions are not statistically different. The main reason for this result resides in the applied methodological choices of DEA as well as OWA weighting scheme, which are both 'extreme' solutions.

Obviously, if we carry out a more 'conservative' exercise avoiding this outermost situations, we can expect to gain a more robust ranking of the regions. So, the main conclusion is the quite obvious one: methodological choices have always interpretative implications; we can detect the existence of three main blocks of regions with a certain degree of reshuffling within blocks.

As a consequence an index-driven narrative on these regions (within blocks) should be considered only as contingent on the methodological assumptions made in developing the different scenarios.

With these results we can now move to the probabilistic setting and decide to test specifically two points: *i)* the first, not yet address up to now, is related to missing data and the imputation strategies; *ii)* the second related to weights which undoubtedly remain a major problem in the construction of composite.

8. Robustness and sensitivity analysis under a probabilistic setting

In the probabilistic setting we shift from a space of discrete choices (40 different scenarios) to a space of infinite possible combinations among which to extract an adequate sampling, offering a selected representation of the entire population.

As already pointed out in order to claim the goodness of the model we have to run uncertainty and sensitivity analysis also into the probabilistic setting. There is a widespread concern about how to use models, particularly when they should support decision making, and is not so surprising to encounter statements of the following tenor:

«Cynics say that models can be made to conclude anything provided that suitable assumptions are fed into them.» (The Economist, 1998).

In the case of composite indicators to 'conclude anything' may result from the choice of extreme procedures in order to force the final results. This is always possible and has been further 'stigmatized' by the evocative label assigned to this kind of models 'GIGO' – *garbage in, garbage out* – a way to say that a model is never better than the data it can count on (Stirling, 2000).

The two things together may have explosive consequences. That is why SA has been used also in this exercise in order to verify the degree of robustness as opposed to hazard in studying and summerizing the innovation phenomenon at regional level.

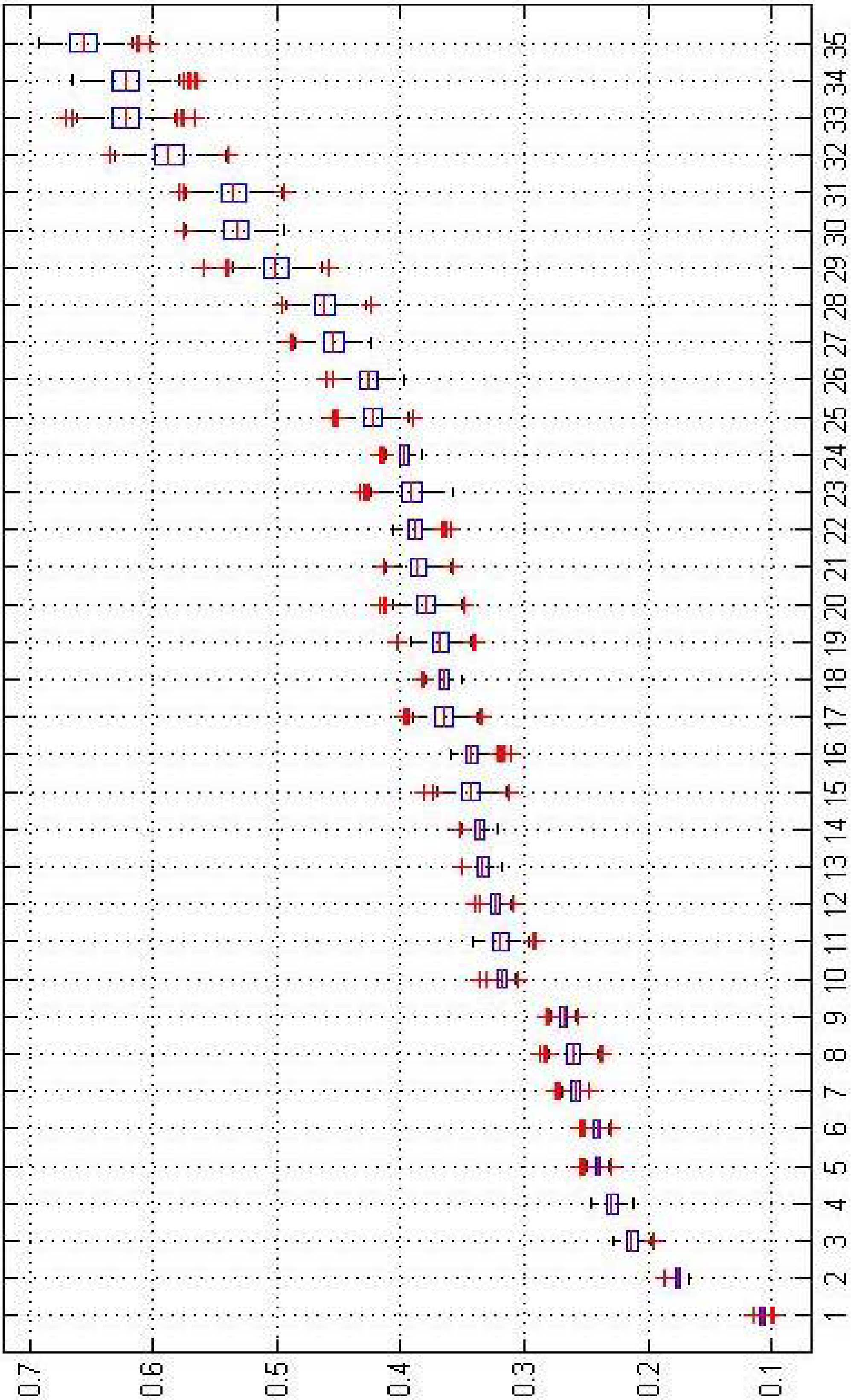
We decided to work on two different factors of uncertainty: the raw data, in order to cope with the large share of imputed data and the weighting scheme starting from the 'zero option' and considering the weights normally distributed around the central point which is the 'equal weight' figures.

Our raw data matrix [35,17] is composed by 595 data with three indicators very problematic as they are missing in 24 regions out of 35 (68,5% of missing values): 2.1.3 *non R&D innovation expenditures*; 3.2.5 *new-to-market sales*; 3.2.6 *new-to-firms sales*. The regions where they are present are: 4 Spanish, 4 French, and 3 Belgian. Other seven indicators are missing in 10 regions: 2.2.1 *SMEs innovating in house*; 2.2.2 *Innovative SMEs collaborating with others*; 2.3.1 *EPO patents*; 3.1.1 *Products and/or process innovators*; 3.1.2 *Marketing and/or organization innovators*; 3.1.3a *Resource efficiency innovator – labour*; and 3.1.3b *Resource efficiency innovator – energy*. The regions where they are missing are: 4 German; 4 Italian; 4 English; 3 Dutch; 3 Finnish; 3 Swedish and 3 Austrian.

Altogether there are 142 missing values equivalent to 23.7% of the whole data. As already reported (see § 3.3) the utilized imputation procedure was the re-proportion of the missing values on the national one according to the relative share of the region. Here we decided to substitute the imputed values with variables normally distributed and values ±10% of the central value. We extract 1,500 random values from the whole distribution, that is 1,500 matrices [35,17] and present the result in Figure 8.1 with the 35 box plots of the different regions.

The computed CI_r are the 'base line' ones: min–Max standardization, imputation of missing data as just said, equal weights, 4 Pillars, linear aggregation within Pillars and geometric among Pillars. On the vertical axis is reported the CI_r score, ranging from 0.1 of Piemonte (IT) to 0.68 of Berlin (DE).

Figure 8.1 – *Box plots of flexible missing data (scores on 1,500 runs)*



Notes: 1=itc1; 2=es3; 3=itc4; 4=itd5; 5=fr4; 6=es51; 7=fr6; 8=ite4; 9=fr7; 10=es22; 11=at2; 12=es21; 13=be1; 14=be3; 15=nl32; 16=at3; 17=nl41; 18=be2; 19=ukf; 20=ukk; 21=fi1a; 22=at1; 23=nl31; 24=fr1; 25=fi19; 26=fi18; 27=ukh; 28=ukj; 29=de11; 30=se22; 31=se23; 32=se11; 33=de21; 34=de12; 35=de3.

We find out the usual pattern (see Figure 8.1) and therefore we go straigthforward to the complete exercise summing up the two different sources of uncertainty.

8.1 The uncertainty analysis in the probabilistic setting

In order to run a sensitivity analysis on the CI_r we put together the two main sources of uncertainty which are the imputed data and the weights for the four Pillars.

Differently from the deterministic setting (see Chapter 7), instead of specific discrete values we use normal probability distributions on imputed data and Pillars' weights. The different possible combinations tend to infinity and we sample in this space using quasi-random numbers within Monte Carlo routine. The results (based on 50,000 runs) are presented in Figures 8.2 and 8.3 reporting the scores and the ranks recorded by the 35 regions.

We see in both Figures that the boxes are quite compact; the 50% of the cases – and here we have the remarkable number of 25,000 – are very compact even if we have a meaningful number of outliers (the red plus signs). This result is quite amazing considering the really huge amount of points in each plot, and it witnesses the strong robustness of regions performance[65].

The boxplots of the ranks are even more defined as we can easily appreciate also looking at the frequency matrix of the ranks, computed with cardinality three, which is shown in Table 8.1. Comparing this result with the homologous which has been run in the deterministic setting (see Table 5.4) we have a very clear cut result with very small overlapping and an absolutely well defined ranking at the hedges of the distribution (both the top and the bottom positions).

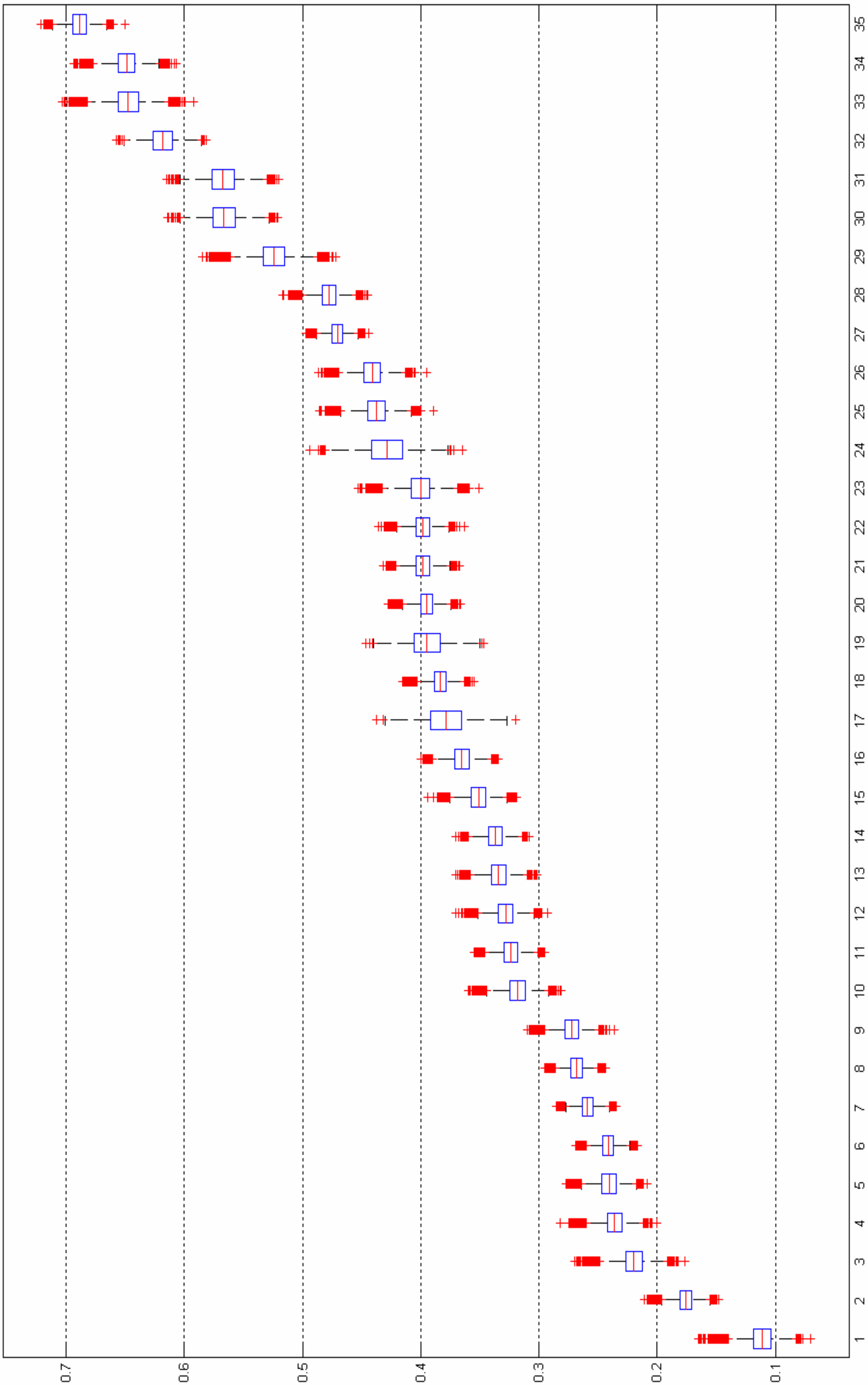
Looking at Table 8.1 we see that the first three regions – Berlin (de3), Karlsruhe (de12) and Oberbayern (de21) – always rank in the first three positions[66]. The same clear-cut patter emerges with the second three regions – Stockholm (se11), Västsverige (se23), and Sydsverige (se22) – which always rank from fourth to sixth position, and the third three regions – Stuttgard (de11), South East (ukj), and Eastern (ukh) – which, in turn, always rank from the seventh to the nineth position. The result is higly indisputable: none of the first nine regions ever ranks at 10th or higher position (out of 10,000). The same exact picture appears at the lower edge of the distribution. Piemonte (itc1) ranks 35th in the 100% of the cases, Madrid (es3) ranks 34th in the 99,9%, and Lombardia ranks 33rd in the 99,9% of the cases.

Table 8.2 reports the zooming on the ranks from 10th to 27th positions encompassing the regions from Uthecht (nl31) to Sud-Ouest (fr6). Once again the reported figures are percentage (on 10,000 runs) and in this area it is clear that the level of overlapping among regions increases. Noord Holland (nl32), for example, records a Borda score of 547 which puts it precisely behond East Midland (ukf) and in front of Vlaams Gewest (be2).

[65]We can add that differences with the previous case (see Figure 8.1) – where we consider only the data uncertainty (even if modelled differently) – are almost absent.

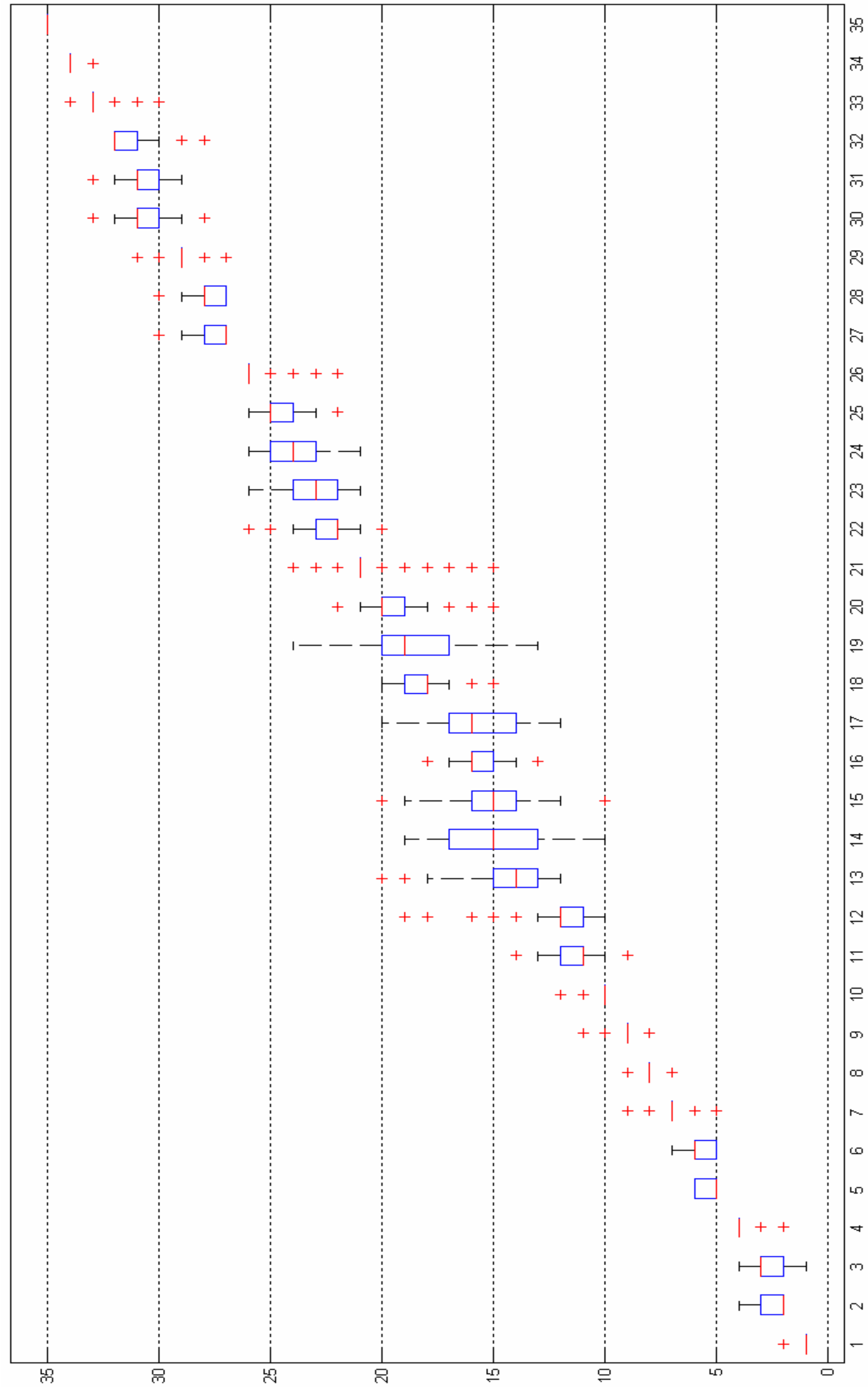
[66]The cell number is a percentage, it signals that Berlin Länder in 10,000 samples (obtained modifying data imputation and Pillars' weights) has always resulted in the first three positions. To be even more precise, Berlin always ranks in the first position, Karlsruhe ranks second 6,427 runs out of 10,000 and third in 3,573 runs, while Oberbayern is second 3,531 times and third 6,266 times.

Figure 8.2 – *Box plots of CIr (moving imputation and weights) scores on 50,000 runs*



Notes: 1 = itc1; 2 = es3; 3 = itc4; 4 = itd5; 5 = es51; 6 = fr4; 7 = fr6; 8 = fr7; 9 = ite4; 10 = es22; 11 = es21; 12 = at2; 13 = be1; 14 = be3; 15 = at3; 16 = be2; 17 = nl32; 18 = ukf; 19 = nl41; 20 = ukk; 21 = fr1; 22 = at1; 23 = fi1a; 24 = nl31; 25 = fi19; 26 = fi18; 27 = ukh; 28 = ukj; 29 = de11; 30 = se22; 31 = se23; 32 = se11; 33 = de21; 34 = de12; 35 = de3.

Figure 8.3 – *Box plots of CIr (moving imputation and weights) ranks on 50,000 runs*



Notes: 1 = de3; 2 = de12; 3 = de21; 4 = se11; 5 = se23; 6 = se22; 7 = de11; 8 = ukj; 9 = ukh; 10 = fi18; 11 = fi19; 12 = nl31; 13 = fi1a; 14 = fr1; 15 = at1; 16 = ukk; 17 = nl41; 18 = ukf; 19 = nl32; 20 = be2; 21 = at3; 22 = be3; 23 = be1; 24 = at2; 25 = es21; 26 = es22; 27 = ite4; 28 = fr7; 29 = fr6; 30 = es51; 31 = fr4; 32 = itd5; 33 = itc4; 34 = es3; 35 = itc1.

Table 8.1 – *Frequency matrix of CI_r ranks (10,000 runs)*

Regions	Cod	11	10	9	8	7	6	5	4	3	2	1	0	Borda score
		1-2-3	4-5-6	7-8-9	10-11-12	13-14-15	16-17-18	19-20-21	22-23-24	25-26-27	28-29-30	31-32-33	34-35	
Berlin	de3	100,0												1,100
Karlsruhe	de12	100,0												1,100
Oberbayern	de21	98,0	2,0											1,098
Stockholm	se11	2,0	98,0											1,002
Västsverige	se23		100,0											1,000
Sydsverige	se22		99,8	0,2										1,000
Stuttgart	de11		0,2	99,8										900
South East	ukj			100,0										900
Eastern	ukh			100,0										900
Etelä-Suomi	fi18				100,0									800
Länsi-Suomi	fi19				99,9									800
Utrecht	nl31				89,2	10,8								789
Pohjois-Suomi	fi1a				2,2	73,2	23,9	0,8						677
Île de France	fr1				5,8	52,6	36,2	5,4						659
Ostösterreich	at1				2,8	63,6	31,0	2,6						667
South West	ukk					43,5	56,5							643
Noord-Brabant	nl41					47,3	47,5	5,1						642
East Midlands	ukf						68,9	31,1						569
Noord-Holland	nl32					9,0	30,5	58,8	1,7					547
Vlaams Gewest	be2						5,4	94,6						505
Westösterreich	at3						0,1	92,9	7,0					493
Région Wallonne	be3							1,9	97,9	0,2				402
Région de Bruxelles	be1							6,9	91,1	2,1				405
Südösterreich	at2								71,2	28,7				371
Pais Vasco	es21								28,8	71,2				329
Navarra	es22								2,2	97,8				302
Lazio	ite4									67,8	32,2			268
Centre-Est	fr7									31,9	68,1			232
Sud-Ouest	fr6									0,3	99,6			200
Cataluña	es51										38,1	61,9		138
Est	fr4										44,4	55,6		144
Emilia-Romagna	itd5										17,5	82,5		117
Lombardia	itc4											99,9	0,1	100
Comunidad de Madrid	es3											0,1	99,9	0
Piemonte	itc1												100,0	0

Notes: the red box is detailed in Table 8.2

But this is true ‘on avarage’, while Noord Holland in 1% of the cases ranks thirteenth and in 0.12% of the cases even 23rd, with a complete distribution between the two extremes (see Figure 8.4).

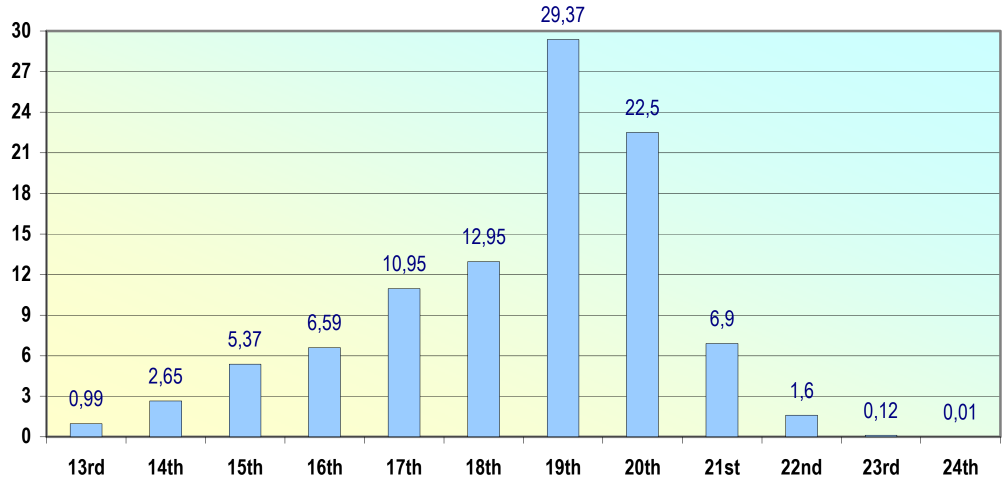
Table 8.2 – *Frequency matrix of CI_r ranks (10,000 runs): focus on 10^{th}-27^{th} positions*

Regions	Cod	10	11	12	13	14	15	16	17	18
Eastern	ukh	0,02	0,01							
Etelä-Suomi	fi18	74,91	25,06	0,03						
Länsi-Suomi	fi19	3,15	66,83	29,95	0,04					
Utrecht	nl31	21,89	8,00	59,32	6,41	3,37	1,00	0,01		
Pohjois-Suomi	fi1a			2,18	28,37	25,44	19,38	14,89	6,42	2,57
Île de France	fr1	0,03	0,10	5,68	24,80	16,10	11,71	9,49	15,78	10,93
Ostösterreich	at1			2,84	15,36	27,11	21,09	12,75	13,33	4,89
South West	ukk				0,76	9,69	33,02	46,69	9,83	0,01
Noord-Brabant	nl41				23,27	15,64	8,43	8,94	25,22	13,36
East Midlands	ukf							0,60	17,81	50,47
Noord-Holland	nl32				0,99	2,65	5,37	6,59	10,95	12,95
Vlaams Gewest	be2							0,03	0,62	4,75
Westösterreich	at3							0,01	0,04	0,07

(Table 8.2) continued

Regions	Cod	19	20	21	22	23	24	25	26	27
Pohjois-Suomi	fi1a	0,75								
Île de France	fr1	5,38								
Ostösterreich	at1	2,63								
Noord-Brabant	nl41	4,93	0,21							
East Midlands	ukf	31,11	0,01							
Noord-Holland	nl32	29,37	22,50	6,90	1,60	0,12	0,01			
Vlaams Gewest	be2	24,80	60,04	9,73	0,03					
Westösterreich	at3	1,03	17,23	74,59	5,64	1,38	0,01			
Région Wallonne	be3		0,01	1,85	59,20	37,92	0,81	0,15	0,06	
Région de Bruxelles	be1			6,89	25,02	38,60	27,43	0,87	1,19	
Südösterreich	at2			0,04	8,40	21,08	41,76	19,90	8,82	
Pais Vasco	es21				0,04	0,71	28,03	67,74	3,48	
Navarra	es22				0,07	0,19	1,95	11,34	86,45	
Lazio	ite4									67,76
Centre-Est	fr7									31,91
Sud-Ouest	fr6									0,33

Figure 8.4 – *Percentage distribution of ranks for Noord Holland region (nl32)*



This overall result is further validated by the Wilcoxon test (see § 7.2) which has been run on the medians, both of scores and ranks. Either test offers a strongly determined picture: all the cells of the triangular matrix record one, that is the null hypothesis is rejected and the medians of two different regions (adjacent or not) are statistically different[67].

This result surely tells us that the score/rank of a region is 'on average' unique and different from other scores/ranks of all the other regions.

8.2 The sensitivity analysis

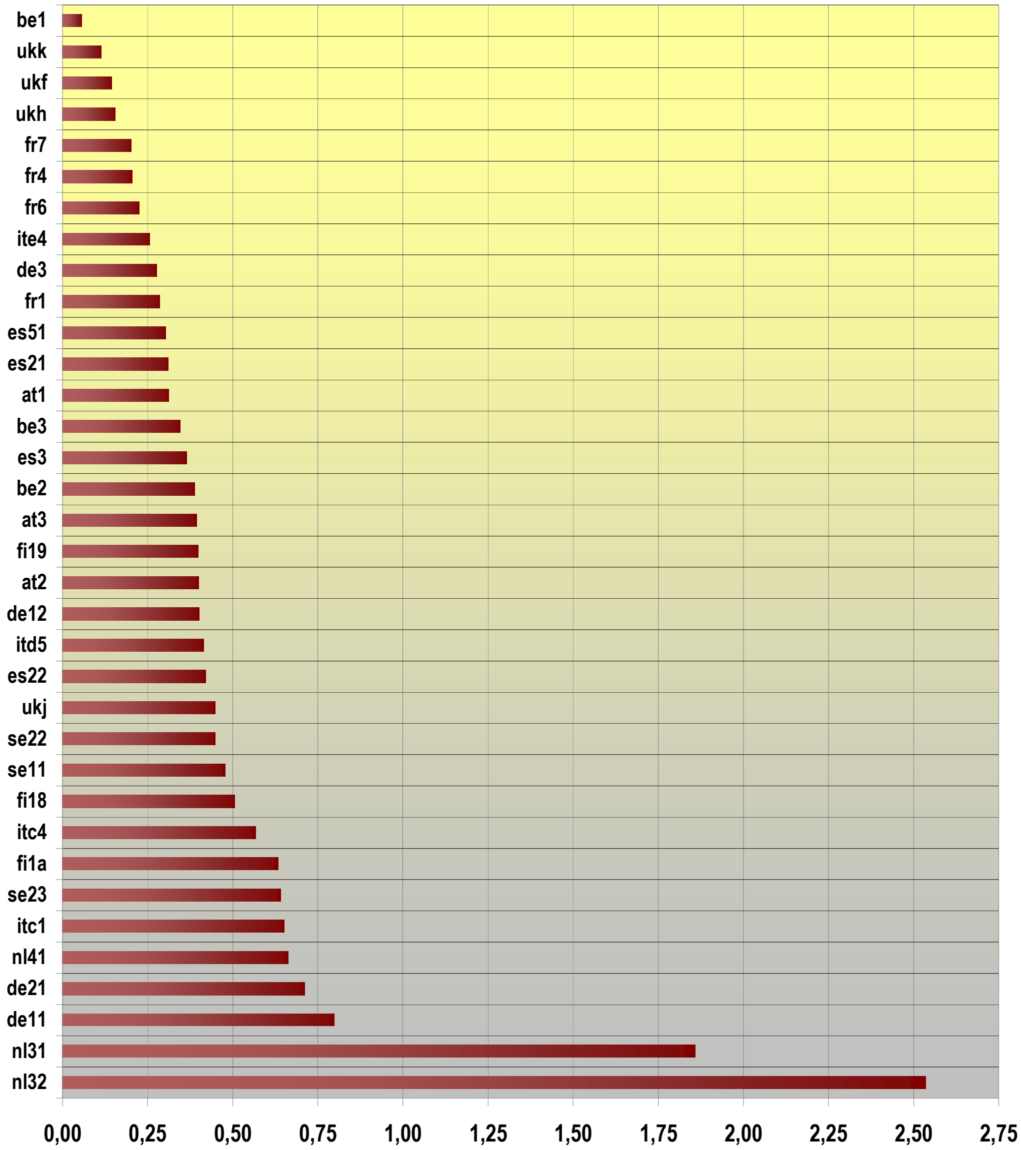
Due to the very large number of missing values, we decided to consider the problem of imputation (subject to uncertainty) as only one block of imputation. Differently from the previous exercise (see Figure 8.1) we don't consider 142 different variables (one for each imputed value) but only one randomly extracted within the interval ±10% with respect to the imputed values.

[67]We don't report the result – as we did in Table 7.4 – because of the complete and absolute homogeneity of the test: none of the 35x35 cells verifies the null hypothesis of equal medians.

The second source of uncertainty, as already pointed out, is on the weights of the four Pillars. Also here we start from the 'equal weights' situation and allow them to fluctuate within an equal range of ±10%.

We have therefore five different sources of uncertainty and we run a sensitivity analysis in order to opportionate the total variance of the CI_r to the 5 factors here considered.

Figure 8.5 – *Total variance of all the five factors: regional distribution*

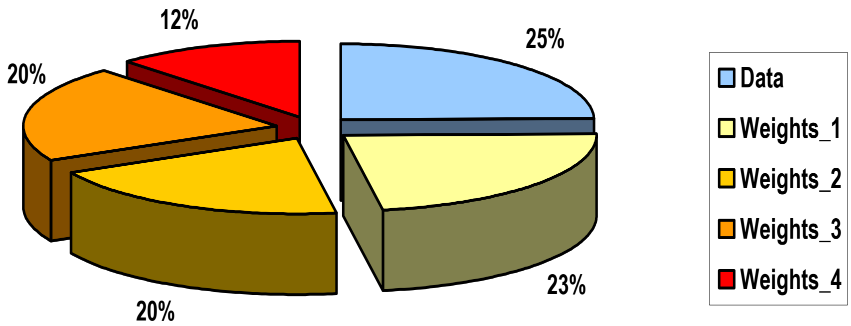


Notes: be1=Région de Bruxelles; ukk=South West; ukf=East Midlands; ukh=Eastern; fr7=Centre-Est; fr4=Est ; fr6=Sud-Ouest; ite4=Lazio; de3=Berlin; fr1=Île de France; es51=Cataluña; es21=Pais Vasco; at1=Ostösterreich; be3=Région Wallonne; es3=Comunidad de Madrid; be2=Vlaams Gewest; at3=Westösterreich; fi19=Länsi-Suomi; at2=Südösterreich; de12=Karlsruhe; itd5=Emilia-Romagna; es22=Comunidad Foral de Navarra; ukj=South East; se22=Sydsverige; se11=Stockholm; i18=Etelä-Suomi; itc4=Lombardia; fi1a=Pohjois-Suomi; se23=Västsverige; itc1=Piemonte; nl41=Noord-Brabant; de21=Oberbayern; de11=Stuttgart; nl31=Utrecht; nl32=Noord-Holland.

In Figure 8.5 we show the total variance of CI_r for the 35 regions (please remember that we have 50,000 observations for each region). The total variance is quite small with only a couple of Dutch regions above one (nl31 and nl32). Sensitivity analysis is properly to decompose this variance and attribute it to the different intervening factors of uncertainty, in this case data imputation and the four weights.

Figure 8.6 presents the on-average contribution to the total variance of the different factors named. We see a clear-cut result: one fourth of the variance in CI_r is related to objective causes (errors in the data imputation) while three-fourth depends on subjective causes (the choices of weights).

Figure 8.6 – *Shares of total variance depending on the five factors*



Among the weights, on average, the first three Pillars result quite balanced while the fourth falls behind, and the first weight – the weight assigned to the first Pillar – has the greater relative importance.

In Figure 8.7 we can appreciate the distribution of Sobol' first-order sensitivity indexes across regions with a small number of them – six regions, all among the most innovative – where uncertainty on data affects the 50%, or more, of the total variance, other 7 regions above average, and all the others with a most serious subjective problem related to weights.

We can suggest a further interpretation of the result considering the fact that a large contribution of a specific index S_i to the total variance coincides with a low performance of the region in that specific Pillar. So, for example, the last three Italian regions where S_2 (the Sobol' first-order sensitivity index of weights of Pillar 1) accounts for more that 70% of the total variance, record a very poor performance in Pillar 1 (see Table 3.2 for the single values): in the range [0,1] they all fall below 0.1.

Again, Madrid (es3) and Lazio (ite4) record a high share of S_3 (the Sobol' first-order sensitivity index of weights of Pillar 2) in explaining the total variance and jointly show low values in Pillar 2 (respectively 0.09 and 0.13; see Table 3.4), but it is not the case of South East (ukj). Regions with an important S_4 (the Sobol' first-order sensitivity index of weights 3) are mainly the Finnish ones, and again, they all show a poor performance in Pillar 3 values (see Table 3.6).

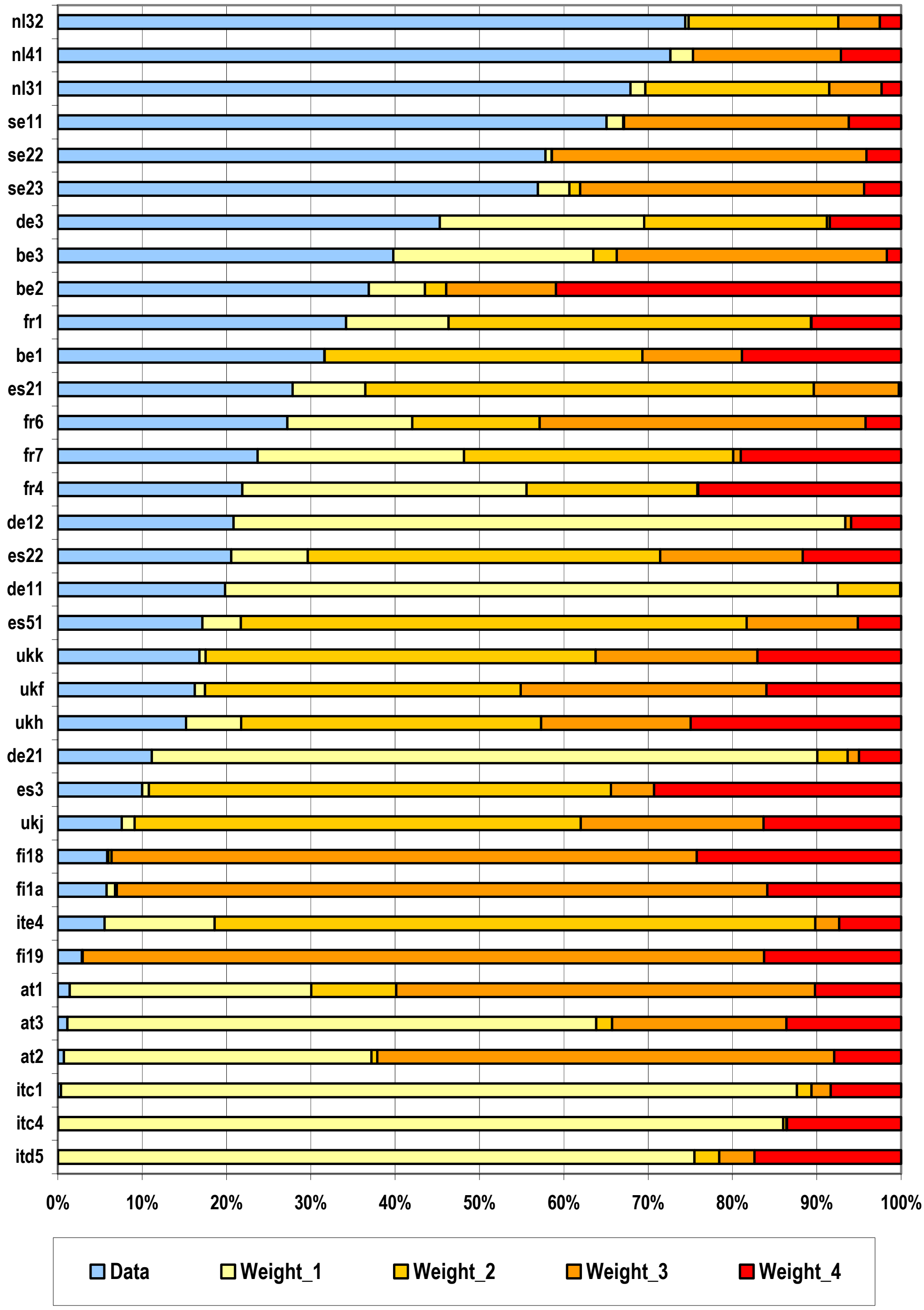
And finally, even if S_5 in not so relevant at all, (the Sobol' first-order sensitivity index of weights 4) it records above average for Vlaams Gewest (be2), Comunidad de Madrid (es3), Est (fr4), and Eastern (ukh), and punctually these regions (again, with the partial exception of ukk) fall behind in the sectors recorded in Pillar 4 (see Table 3.8).

In the study of sensitivity it is important to detect second (or even higher) order effects, which witnessed the presence of interaction among the different factors, already separately analyzed, with the first-order indexes. Among the different indexes available in literature the $S^T{}_i$ is certainly particularly interesting in exploring these interaction effects (Homma and Saltelli, 1996).

In this case the total Sobol' sensitivity index is almost equal to the sum of the first-order S_i:

$S^T = \sum_i S_i$.

Figure 8.7 – *Relative importance of the five factors of uncertainty: regional pattern*



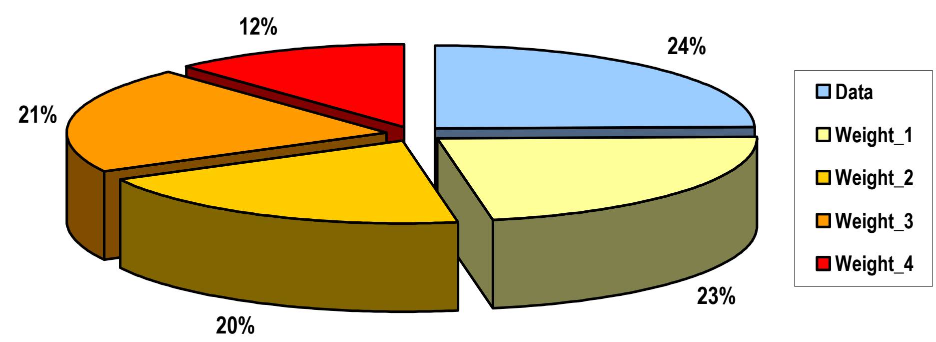
Notes: nl32=Noord-Holland; nl41=Noord-Brabant; nl31=Utrecht; se11=Stockholm; se22=Sydsverige; se23=Västsverige; de3=Berlin; be3=Région Wallonne; be2=Vlaams Gewest; fr1=Île de France; be1=Région de Bruxelles; es21=Pais Vasco; fr6=Sud-Ouest; fr7=Centre-Est; fr4=Est; de12=Karlsruhe; es22=Comunidad Foral de Navarra; de11=Stuttgart; es51=Cataluña; ukk=South West; ukf=East Midlands; ukh=Eastern; de21=Oberbayern; es3=Comunidad de Madrid; ukj=South East; fi18=Etelä-Suomi; fi1a=Pohjois-Suomi; ite4=Lazio; fi19=Länsi-Suomi; at1=Ostösterreich; at3=Westösterreich; at2=Südösterreich; itc1=Piemonte; itc4=Lombardia; itd5=Emilia-Romagna.

We have only six regions – Etelä-Suomi (fi18), Länsi-Suomi (fi19), Pohjois-Suomi (fi1a), Ostösterreich (at1), East Midlands (ukf), and South East (ukj) – with a S^T_i slightly greater than the sum of S_i.

As a matter of fact Figure 8.8 reports, on average, exactly the same contribution of the five factors (data and weights) to the total variance of CI_r.

One major conclusion is that the values obtained – and the ordering of the different regions – are highly stable under the perspectives of different methodological choices. The second important message is that 'only' one fourth of the total uncertainty is attached to data missing value and the consequent imputation procedure. So, let us say, Eurostat is responsible for 25% of the overall variance and the consequent possible misjudgment in regional innovation performances.

Figure 8.8 – *Shares of total variance depending on the five factors: S^T_i*



The large majority of the overall uncertainty is derived from the weighting scheme, and we should recognize we have been quite 'conservative' in the tested hypothesis: we start from equal weights scenario (25% each) and we allow variations within a ±10% range, that actually means a weight oscillating between 22.5% and 27.5%.

Obviously this is a motivated choice: we organized the simple indicators into four different Pillars which share on average the same importance and are expected to interact in order to improve the regions' innovation performance (here is the choice of a geometric aggregation among Pillars).

When we allow weights/aggregation to be more 'aggressive' – as we have done in the 40 scenarios test with the application of 'benefit-of-the-doubt' within DEA or OWA operators (see Chapter 6) we get a much less unequivocal result.

The robustness analysis carried out in § 7.1 (see Figure 7.3) allows to distinguish only three main blocks of regions completely separated.

8.3 Some closing comments on the previous exercises

The message being passed in the literature on the use of uncertainty and sensitivity analysis is quite widespread and accepted – to make no use of SA is like going to an orthopedist who doesn't employ X-rays – so, the need to test a model submitting the results to SA is out of question.

The problem, therefore, is not the 'if' question but, more interesting, the 'how' question: *«how to use the results on a good SA?», «How to generate suitable feedbacks on the analysis of the problem and to improve our understanding of it?»*

We know that a composite cannot be considered 'right' in the sense that a model can never be 'verified' or 'validated' but only 'confirmed' or 'corroborated' and SA may support this corroborating effort (Orekes *et al.,* 1994).

The used SA method in this exercise is a global, quantitative, model-free technique rooted on a factor-based decomposition of the output variance[68]. Following Saltelli we can easily indicate the four desirable properties of this method (Saltelli, 2002: 4):

- to cope with influence of scale and shape, *«the influence of the input should incorporate the effect of the range on input variation and the form of its probability density function»*;
- to include multidimensional averaging, *«in a perturbative approach to SA, mne computes partial derivatives: the effect of the variation of the factor when all others are kept constant at the central (nominal) value»*;
- to be model independent, *«the method should work regardless of the additivity or linearity of the test model»*;
- to be able to treat grouped factors as if they were single factors, *«this property of synthesis is essential for the agility of the interpretation of the results»*.

We have been able to rank the different factors (of uncertainty) in order of importance and this kind of exercise *«allows the identification of the factor most deserving better experimental measurement.»* (Saltelli, 2002: 6).

So, we can conclude that the weighting scheme is the most important choice which experts should agree on. While completely data-driven exercises may have a role in signalling the boundaries of the possible outcomes, they can't be taken seriously into consideration when composites should support policy decision. Here, value judgements and theoretical hypothesis should be taken in the greatest considerations.

[68]Some scholars have criticised the use of variance as a measure of the output uncertainty, suggesting alternative measure as the use of entropy (see Krykacz-Hausmann, 2001).

Second Part

Composite indicators for policy-making

by Alberto Bramanti

9. Looking at the 'national effect' and updating innovation data

This Chapter introduces the SECOND PART of this Report. While the first one (Chapters 2–8) has been entirely devoted to the methodological discussion and implementation of the *Regional Innovation Composite Indicator* (RICI 2005) – computed on 35 regions among the most innovative in Europe – here we turn our attention to new investigations with a two-fold objective.

The *first* objective is to discuss the role of the different determinant of the overall regional innovative performance, while the *second* objective responds to the need of updating the overall picture (which, in the FIRST PART, is snapped at 2005). Using the most recent data released by Eurostat (INNOMETRICS, 2011) and other international data providers we are able to grasp some deeper knowledge on what's going on in the innovation field in Europe (Huggins *et al.,* 2010; Timmer *et al.,* 2010; WIFO–ISI, 2010).

A final Chapter (see Chapter 10) concludes this SECOND PART and the whole Report leaving aside any number, focusing on the role of indicators in policymaking, and stressing the strong connection between the vision of innovation (*i.e.,* the model which is used to describe it) and the data to be collected.

A strong emphasis will be attached to innovation surveys – and CIS 2008 goes in the right direction (see also § 9.3.2) – provided that availability of data at the regional level (NUTS2) will be assured (which is not the case up to now).

The present Chapter is organized as follows. Next section (§ 9.1) looks at Countries' performance in the five-year period (2006-2010) characterized by the financial crisis and its generalized downturn of GDP per-capita in 2009. We show some first evidence of a strong correlation between innovation potential at the beginning of the period (the RICI 2005, i.e. the average between 2004 and 2006 values) and the recover registered in 2010 (see Figure 9.1).

The following section (§ 9.2) portrays a comprehensive, detailed presentation of the results obtained with RICI 2005 looking at the four Pillars and comparing the national average, for each of the studied Countries, with the average value of the four best performing regions within that Country. This section ends up with a linear regression linking Pillar 4 (the dependent variable depicting final market outcomes) with the other three Pillars considered, respectively, the contribution of NISs (Pillar 1), of RISs (Pillar 2), and of firms (Pillar 3) to the overall performance. As the first results are not very satisfying, we suggest further regression exercises, allowing us an extensive understanding of the correlation and causation issues.

Section 9.3 looks at the new dataset prepared by INNOMETRICS (2011) to monitor the Europe 2020 strategy. Twenty-five indicators are aggregated into 8 'innovation dimensions' and finally in 3 Pillars, providing a new composite (SII 2010, see Table 9.10) that is compared with the 'old RICI' (2005). The present section goes on (§ 9.3.2) commenting on the selected indicators and rising some critiques (§ 9.3.2) organized around five different points: *i)* the quest for four instead of only three Pillars; *ii)* the relevance of lifelong learning which has been dropped in the new composite; *iii)* some problems arising from ageing population and the need for immigrant workers; *iv)* the uneasiness for the emphasis placed on bibliometrics indicators, according to the view that 'big science' *is not a necessary nor a sufficient condition* to be successfully innovative, gaining market value from this innovation; and finally *v)* the use of R&D indicators which hide the frequently present 'deadweight' effects.

The following and closing section (§ 9.4) is devoted to a reappraisal of the 'old' regional data, in the absence of recent ones, and creates a bridge with the final Chapter 10.

9.1 A faint rainbow after the storm

As already argued in the Introduction of the Report (see Chapter 1), *National Innovations Systems* (NISs) represent the background on which the process of knowledge accumulation occurs. The accent is on the institutional context which involves heterogeneous agents interacting through different organizations.

Institutions are of great importance[69] (Storz and Schäfer, 2011), as they can: *i)* affect and stimulate the production of knowledge (via R&D and softer investments[70]); *ii)* facilitate the patenting process; *iii)* disseminate ideas and promote cooperation across researchers; *iv)* speed up the diffusion of scientific knowledge; and *v)* reduce uncertainty of new projects. So, institutions matter but are the result on long inter-dependent paths of accumulation, historically embedded, with the characteristics that cross-Country differences remain quite stable over time, providing differences of permanent nature.

If NISs are rooted in different combinations of institutions, organizations and policies, human capital is always their raw material as it has been authoritatively emphasized (Niosi, 2009). Human capital – as will further be described in the next Chapter (see § 10.5) – strengthens the innovation process from numerous points of view. Human capital is at the origin of rising productivity growth, it fosters absorptive capacity – the way in which firms mostly take advantages from external knowledge inputs – and speeds up the adoption of innovation.

But human capital is a mobile factor within the economy: knowledge is strongly embedded in people, it is frequently 'tacit' and very often can not be even easily codified. So, human capital is not (fully) appropriable by firms which may frequently loose their investments when skilled workers leave: as a consequence markets do not produce human capital (or demand for it) by themselves. Moreover, on its own the market usually produces a low-skilled equilibrium economy. So policies are needed to produce human capital in the right quantity and to create demand (incentives to firms) jointly with supply (Haltiwanger *et al.,* 2009; Wintjes and Hollanders, 2010; Varum *et al.,* 2011).

It is therefore quite understandable that this kind of public investment has experienced a drastic and sudden stop when economies have been severely

[69] Institutions permit to structure human interaction and, according to Ostrom (2005: 18): «*Institutions create a shared understanding by participants about enforced prescriptions concerning what actions (or outcomes) are required, prohibited, or permitted*».

[70] According to NESTA (*National Endowment for Science, Technology and the Arts,* UK) soft innovation is related to «*changes in good and services that primarily impact on sensory or intellectual perception and aesthetic appeal rather than functional performance. Soft innovation mainly concern product innovation and, with that, product differentiation (...). We identify two main type of soft innovation. The first involves changes in products in the creative industries (...). The second related to aesthetic innovation in goods and services that are primarily functional in nature, such as new furniture or a new car model.*» (NESTA, Stoneman, 2009: 4).

wounded. Unemployment hits human capital widely and seriously, with major sudden consequences on production and GDP.

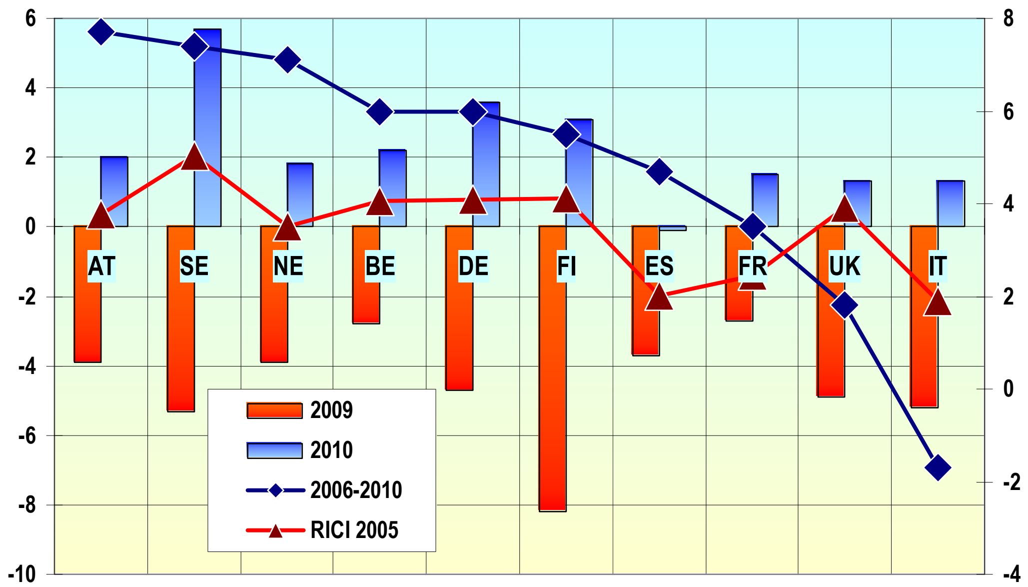
The financial crisis started in the fall of 2008 and in early 2009 became dramatically evident. No one of the ten Member States here considered, recorded a positive growth rate of real income in the black year 2009. The 'best performer' was France, with 'only' a –2.7%, while the 'worst performers' belonged to the 'deep North' with Finland recording an astonishing –8.2%, followed by Sweden with –5.3%. In the 2010 European Countries experienced a shy recovery, signing the inversion point in the major downturn suffered since the second world war (see Table 9.1).

Table 9.1 – *Real rate of growth of GDP per-capita (in PPS €)*

Countries	2006	2007	2008	2009	2010	Cumulative variation
AT	3.7	3.7	2.2	–3.9	2.0	7.7
BE	2.7	2.9	1.0	–2.8	2.2	6.0
DE	3.4	2.7	1.0	–4.7	3.6	6.0
ES	4.0	3.6	0.9	–3.7	–0.1	4.7
FI	4.4	5.3	0.9	–8.2	3.1	5.5
FR	2.5	2.3	–0.1	–2.7	1.5	3.5
IT	2.0	1.5	–1.3	–5.2	1.3	–1.7
NE	3.4	3.9	1.9	–3.9	1.8	7.1
SE	4.3	3.3	–0.6	–5.3	5.7	7.4
UK	2.8	2.7	–0.1	–4.9	1.3	1.8
EU	**3.3**	**3.0**	**0.5**	**–4.3**	**1.8**	**4.3**

Source: Eurostat [http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsieb020].

Figure 9.1 – *Annual GDP growth rate (per-capita) and RICI 2005*



Notes: Bars' scale on the left, lines' scale of the right. RICI has been multiplied by ten in order to fit the numerical scale on the right. The blue, decreasing line, reports the GDP growth rate (2006-2010).

All Countries but Spain returned to growth in 2010 even if, one of them (Italy), shows a very critical position as in the five-year period (2006-2010) it has lost real GDP, recording a negative overall performance. We should consider that with a very strong budget constraint – due to the huge accumulated public debt – and with still stagnant internal demand – due to the real impoverishment of consumers – all European Countries may catch the economic recovery provided they will be able to increase their exports (low export is first and foremost a problem of competitiveness and, secondly, of specialization).

Being competitive on a global scale, with production costs higher than most of the extra-European growing economies, implies having a valuable, market appraised, value added which, in turn, is the possible outcome of the innovation capability of the firm (Timmer *et al.,* 2010; WIFO–ISI, 2010).

It is not surprising, therefore, that the most innovative Countries in 2004-2006 according to RICI have recovered faster after the 2009 crisis. Finland, Sweden and Germany – which all record high collapse in the worst moment of the international downturn (see year 2009 in Table 9.1) – show an outstanding performance in 2010, while Spain and Italy – much more feeble in their innovative potential (RICI 2005) – do not experience such a recovery in 2010.

Figure 9.1 shows these differences quite precisely, illustrating also the correlation between the innovation in 2005 and the rate of growth in GDP per-capita in 2010, with UK being the sole Country which should have performed better in 2010 according to its stronger innovative potential in 2005.

So, these simple data call for a more in-depth looking in the articulation of the innovative potential among the different Countries in 2005, and the next section is devoted to this point.

9.2 The four Pillars of innovation at the Country level

The true functioning of the *Regional Innovation Systems* (RISs) (de la Mothe and Paquet, 1998; Los and Verspagen, 2002; Malmberg and Maskell, 2006) – which makes competitive the existing firms, and contributes to attract new ones – springs from the right balancing of internal robustness and external openness (Bramanti and Fratesi, 2009; see also § 3.1).

Territory matters, as it offers at least four ‘core’ assets in the process of generating and implementing advances in technology and innovation problem solving. Territory (and regions are here considered the government–governance ‘locus of control’ and co-ordination of the different actors operating in the socio-economic fabric) is, first and foremost:

- *«the birthplace of technology and innovation – i.e. the progress from given resource allocation processes to a collective build-up of specific resources»;*
- *«a place for co-ordinating industrial activities, a link between external territorial economies and organizational and inter-organisational firm trajectories»;*
- *«a political decision-making unit governing localization, able to create and redistribute resources, and expressing specific governance structures in the relations between actors»;*
- *«a place in which untraded inter-dependencies (means through which the actors growth technologically and organisationally, and co-ordinate themselves) form, express themselves, and evolve».* (Bramanti and Fratesi, 2009: 60).

Less innovative regions, generally, are not the outcome of temporary malfunctioning markets but rather the normal functioning of markets trapped in low-equilibrium situations. As a matter of fact the problems of unbalanced factors are always at work (as the many questions emerging on the labour market are presently teaching us: growth without employment, persisting mismatches between supply and demand; emerging of new working poor, etc.).

We can have very high skilled human capital (with peaks of participation rates for doctoral degrees) jointly with poor infrastructure and low salary (firms may be not interested in hiring the highest level educated people[71]), and, as a consequence, to experiment with a very sharp brain drain (Becker *et al.,* 2003), where brain drain still remains a major impediment to regional growth, as witnessed by a large number of regions in Southern as well as Eastern Europe. Moreover, while training and higher education can surely increase labour productivity – and contextually tend to increase people's income and life satisfaction (also independently of income levels) – tertiary education is neither the only nor an automatic source of highly skilled workers and competitiveness; skill upgrading and learning on the job can play a significant role, especially linked to labour market needs.

This is particularly evident in medium-technology sectors where the regional/spatial character of the cognitive process of interactive learning and of knowledge creation is strongly developed (Cappellin and Wink, 2009).

Innovation, as a matter of fact, is an interactive, collective process, stemming from a creative combination of generic know-how and specific competencies. This relation-based approach to innovation stresses the new concept of 'cognitive capability':

> *«The ability to manage information in order to identify and solve problems, or, more precisely in the economic sphere, the ability to transform information and inventions into innovation and productivity increases, through co-operative or market interaction».* (Camagni and Capello, 2009: 149).

Conclusively, there is a strong evidence of the incredible resilience of RISs which are heavily rooted in: *i)* the long term required in order to modify substantially some of their critical elements; and *ii)* the self reinforcing mechanisms at work, in the endless spiral bringing together information–knowledge–competence–and-creativity, contributing to the process of production, accumulation and exchange of knowledge and know-how (Bramanti and Fratesi, 2009).

What we aim at exploring are the effects that the national frame – and specifically the NISs – is likely to exert on the regional context (the RISs), as we know that there are evident linkages between the two (NISs and RISs) which are strongly intertwined, and usually share a normative and legislative frame and some research institutions. To put it more directly, we are asking if Lombardy's performance is lowered by its being plunged in the Italian NIS (or Cataluña in Spain, or Baden-Württemberg in Germany).

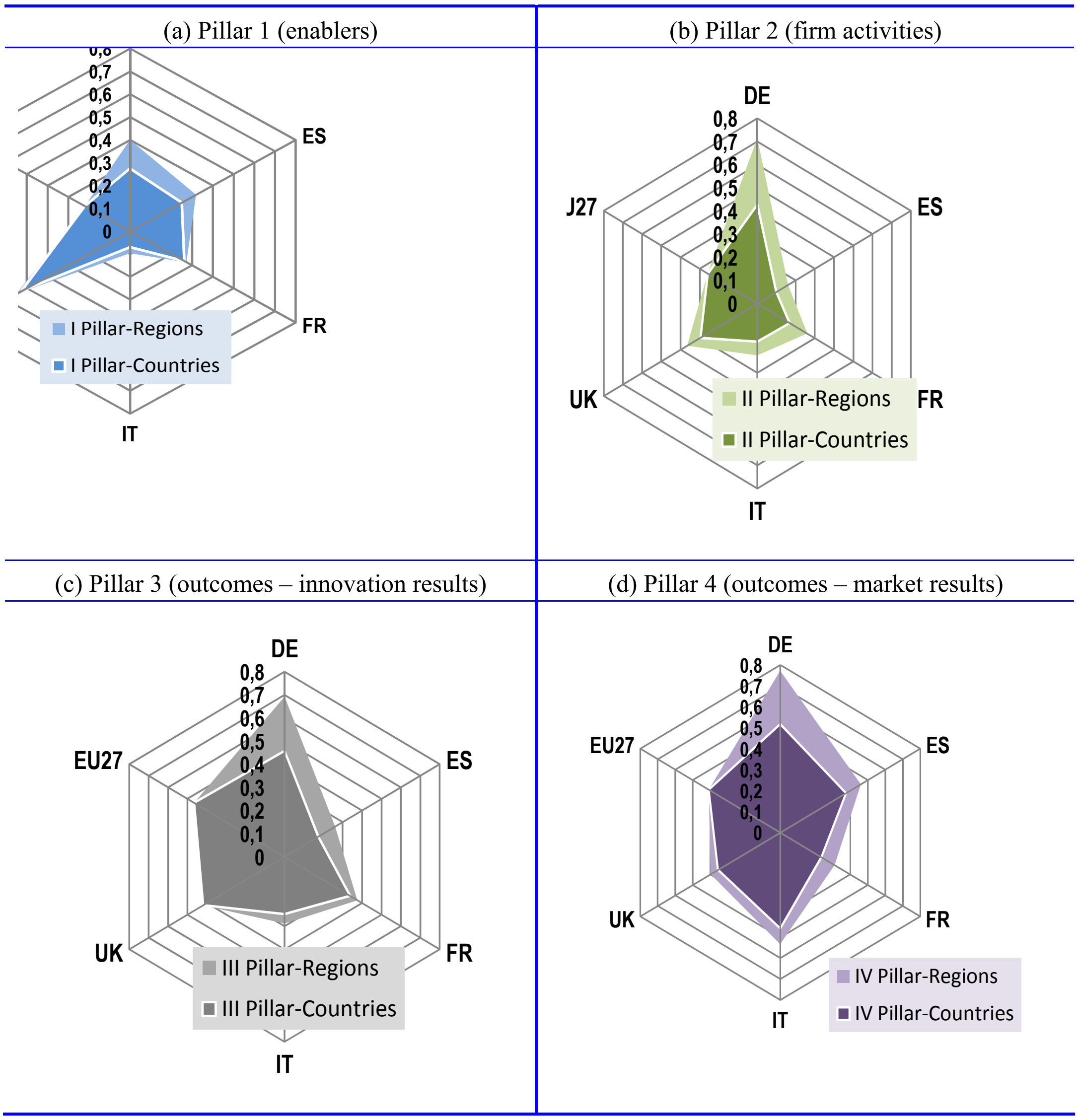
We start conducing a parallel between the national average values within the four Pillars and the average figures of the top four regions within each Country. In doing this exercise we choose to look at only the five 'big Countries' of our study, *i.e.* Germany, France, Italy, Spain and UK. The reason is simple: we want to differentiate the national average from the top regions group, but this is purely impossible where the nation is small enough that the selected regions exhaust (com-

[71] As we have already discussed, without incentives no Countries will supply (or demand) highly skilled workers. Canada and Finland – two of the most successful innovative nations within the OECD group – highly relying of human capital, have always invested very much in developing a supply policy jointly with a demand one (Niosi, 2010). Governments of those Countries have directly financed all the research activities (within and outside firms) which were strongly demanding of skilled labour.

pletely, or almost totally) their national context (i.e, Austria, Belgium, the Netherlands and, to a lesser extent, Finland and Sweden).

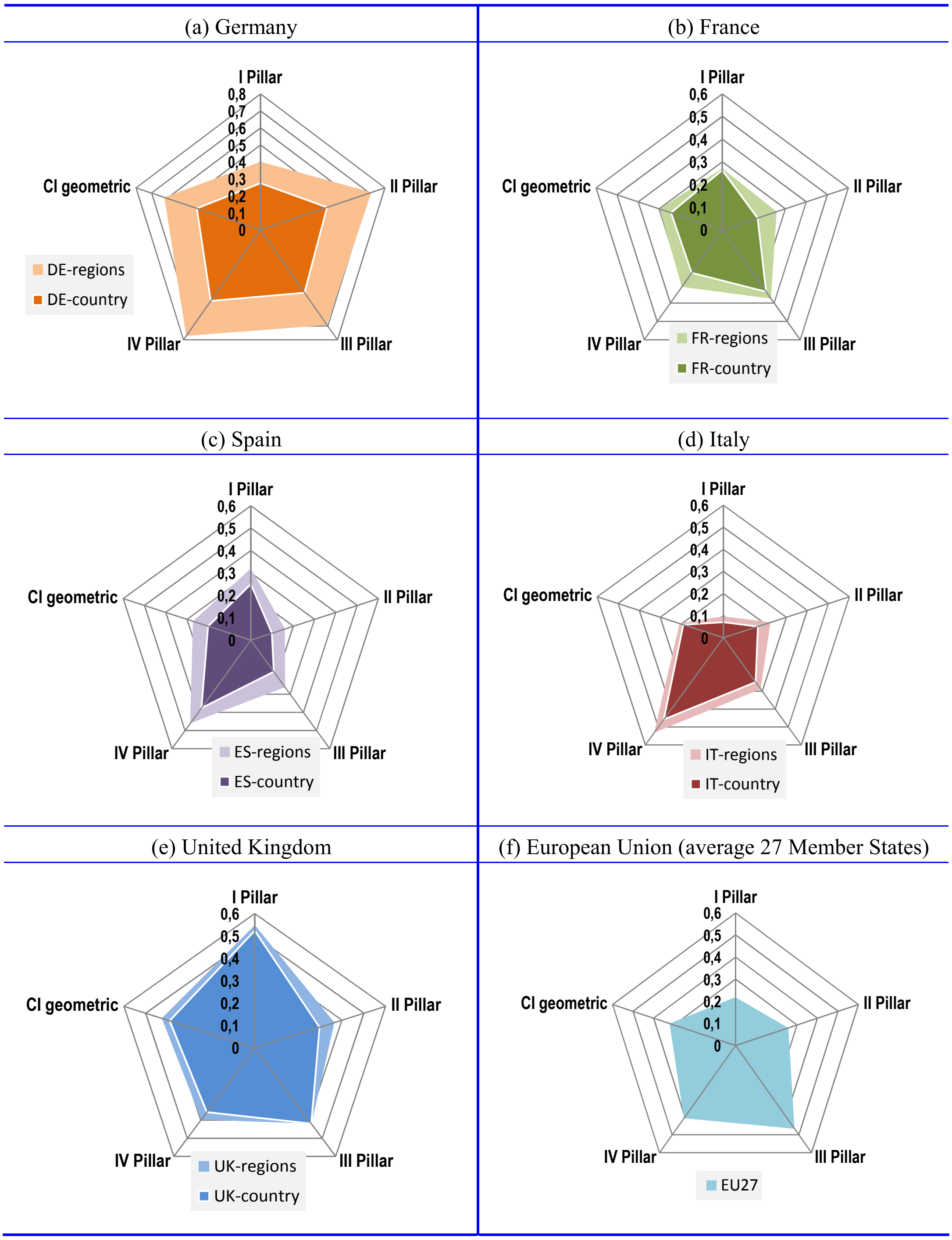
Figures 9.2–9.3 show the distances existing between 'best regions' and the national average, and they suggest some comments (obviously EU27 is represented by a single point within the 'radar graphs'), (see Figure 9.2): *i)* in Germany the four 'best in class' regions perform strongly better that the national average, and this is true for all the four Pillars; *ii)* Spain shows the same pattern but with a smaller difference between its best regions and the whole national system; *iii)* in Italy and France[72] the four top regions are much more like the national average, particularly for Pillar 1; and *iv)* in UK the distance between regions and the country is the smallest across the four Pillars.

Figure 9.2 – *Comparing 'best regions' and 'national average': four Pillars*



[72]We should not forget that in France 'regions' are defined at NUTS1 level, i.e. to a much larger grain that the standard NUTS2 regions of the other Countries. Saying it differently we are here summing up more that 4 regions (NUTS2-type) and the sum, therefore, is closer to the France average.

Figure 9.3 – *Comparing best regions and Country levels for the ‘big five’ and Europe*



Some Countries’ specificities are also evident (see Figure 9.3):

- Germany (a) excels in all the Pillars except the first, specifically due to a low performance in ‘lifelong learning’;
- France (b) is relatively better in Pillar 3 where it outperforms in the ‘efficient use of resources’ (due to innovation), both in labour and energy;
- Spain (c) and Italy (d) perform better in Pillar 4, the first counting on a relatively high share of ‘new-to-firm sales’, while the second according to a significant result in the share of ‘new-to-market sales’;

- UK (e) stands out in Pillar 1 with three indicators well above the EU average ('broadband access', 'tertiary education', and a very stellar 'lifelong learning').

In relative as well as absolute terms, Pillar 1, with the exception of UK, is the worst performer.

9.2.1 The contribution of NISs to the regional success

The idea of verifying the 'Country effect' on the regional performance is attracting but not easy to be detected.

Regional growth is not only a problem of 'best practice' but, even more importantly, of coherent knowledge combination: institutional differences may lead similar (or different) science-technology-industry structures to different (respectively same) performances. At the same time, even if local interaction has strong importance in the production of innovation, these regional interactions depend to a great extent on their national context, as these regional configurations remain primarily defined by institutions and policy implemented at the national level.

«These debates show that various scales remain possible for the study of innovation systems but the question of the relevant scale of analysis seems without immediate theoretical answer. The problems of the relevant scale can only be treated within the framework of institutional analysis.» (Carricazeaux and Gaschet, 2006: 11).

The question on how regions could substantially improve the competitive performance of their industrial system rises exactly at this level.

The competition among regions, with its benchmarking orientation, the awareness of the long time required to change some structural features of RIS, the need to capture and retain new firms and high skilled people, all have exerted a pressure on regional innovation policies.

Rough rules of thumb about what works, have been the main propellants of competitiveness-based policies rather than sound empirical evidence of the forces driving competitive performance. A possible consequence has been the rising attention devoted to benchmarking which, in turn, leads inexorably to the establishment of regional policies with similar objectives, policy concepts and instruments. This tendency for replication in regional development agendas is further reinforced by the need to be attuned to market imperatives.

Of course benchmarking all regions with respect to some 'best performer' means that we all should reach the same specific mix: *«is there any suitable different combination of factors which are better/equally good for the specific structure of our region?». «Is there some 'best practices' towards which different RISs can converge?».* Regional performances are not independent from national contexts but reasonably tied to national trends.

So, we should consider the composite indicator CI_{rj} for region r-*th* in Country j-*th* equal to:

$$CI_{rj} = \alpha + \beta_r + \delta_j + \varepsilon_{rj}$$

where α is a parameter, β_r is the effect specific to the region r-*th*, δ_j is the effect of belonging to the Country j-*th*, plus an error element ε_{rj}.

9.2.2 A linear regression exercise

In order to identify the main engines of innovative economic success of small and medium sized European enterprises, we first estimate by OLS a simple model with a time lag between dependent and independent variables (where *Pred* stands for 'Predictor', whatever it would be) at regional level, where Pillar 4 is the dependent variable to be explained[73].

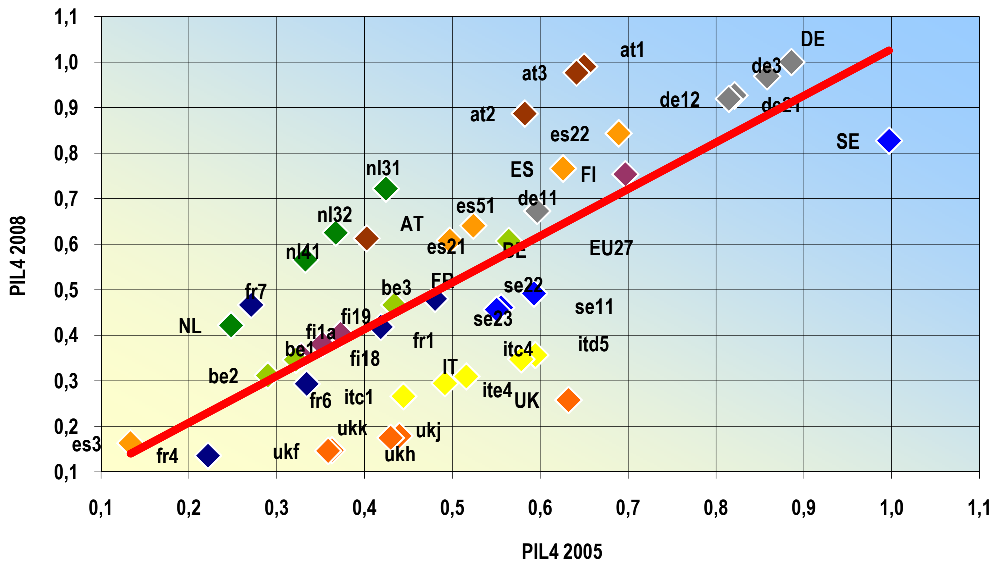
$$Pil4_{it} = \beta_0 + \beta_1 Pred1_{it-\tau} + \beta_2 Pred2_{it-\tau} + \ldots + \beta_n Pred\mathrm{n}_{it-\tau}$$

Regional data are not available from the CIS 2008 but a possible workable solution is to use the new national data available from the CIS 2008 (see § 9.3.4) giving us information on 'Pillar 4' in 2008 for the 10 Countries here considered. Starting with these data, we can estimate the regional figures for Pillar 4 in 2008, assuming that the 35 best innovative regions would have behaved as in 2005, relatively to their national context[74]; in short:

$$\frac{[Pillar4_{2005}]_{R_{j,i}}}{[Pillar4_{2005}]_{C_j}} = \frac{[Pillar4_{2008}]_{R_{j,i}}}{[Pillar4_{2008}]_{C_j}}$$

where C_j is one of the 10 Countries considered, and $R_{j,i}$ is the i-*th* region within the j-*th* Country. We construct in this way a vector containing the new values 2008 for Pillar 4 in each of the 35 regions (see Figure 9.4) that we need to describe the dependent variable in the econometric model given above.

Figure 9.4 – *Scatterplot of Pillar 4_{2005} and Pillar 4_{2008} (Pearson's R = 0.732**)*



Despite the short period considered (three years), and the fact that the EU average does not move, Countries do move and, accordingly, also regions move. As the red tendency line is almost overlapping the main diagonal of the quadrant, we can roughly say that regions above the red line have improved their performance in Pillar 4, while the opposite occurs for regions below the red line.

We may choose the independent variables for our model in different ways. The *first,* and more intuitive, way is to explore the role of the other three Pillars in

[73]It's worth recalling that Pillar 4 is composed by only two indicators referring to the innovative outcomes of the firm, as appreciated by the market (3.2.5 *«New-to-market sales as % on turnover»,* and 3.2.6 *«New-to-firm sales as % on turnover»,* see Chapter 3, § 3.2.5).

[74]This hypothesis can be easily justified also in the view of the strong persistence, in 2006-2010 period, of the 10 Countries in their positioning within the overall innovation ranking. Se later on § 9.3.3 and specifically the Pearson's R coefficient reported in Table 9.11. The year 2005 refers to the average value of CIS 2004 and CIS 2006 data.

2005 as predictors of the dependent Pillar4 in 2008. The results would hardly be meaningful as working with Pillars as regressors may add collinearity problems (as the correlation between Pillar 2 and Pillar 3 is .553, see previous Table 4.2), and, therefore, we opt for a second strategy of analysis.

Thus, instead of using the Pillars as such, we run the regression on the component resulting from applying factor analysis to the original dataset in order to extract a proper number of factors. The software (PASW Statistics, 18.0) highlights four factors, with eigenvalues greater than 1, and a total variance explained equal to 78%. We apply the extraction method of 'principal component analysis', and the Varimax rotation with Kaiser normalization to maximize the dispersion of loadings within the factors[75]. The final result is reported in Table 9.2 where we can read the rotated component matrix.

Table 9.2 – *Loadings from the principal component analysis after rotation*

Indicators	Components			
	1	2	3	4
3.1.1 Product and/or process innovators 2005	.922			
3.1.2 Marketing and/or organisational innovators 2005	.915			
2.2.1 SMEs innovating in-house 2005	.870			
Sum 3.2.1-3.2.2 High skilled employment	.647			
1.2.1 Public R&D expenditures 2005	.629		.442	
2.1.1 Business R&D expenditures 2005		.873		
2.3.1 EPO patents 2005	.311	.757		
2.2.2 Innovative SMEs collaborating with others 2005		.705	.568	
2.1.3 Non-R&D innovation expenditures 2005	.564	.588		
1.2.4 Broadband access 2005			.864	
1.1.3 Tertiary education 2005			.747	
1.1.4 Life-long learning 2005		.435	.718	
3.1.3a Resource efficiency innovators - Labour 2005				.944
3.1.3b Resource efficiency innovators - Energy 2005				.891

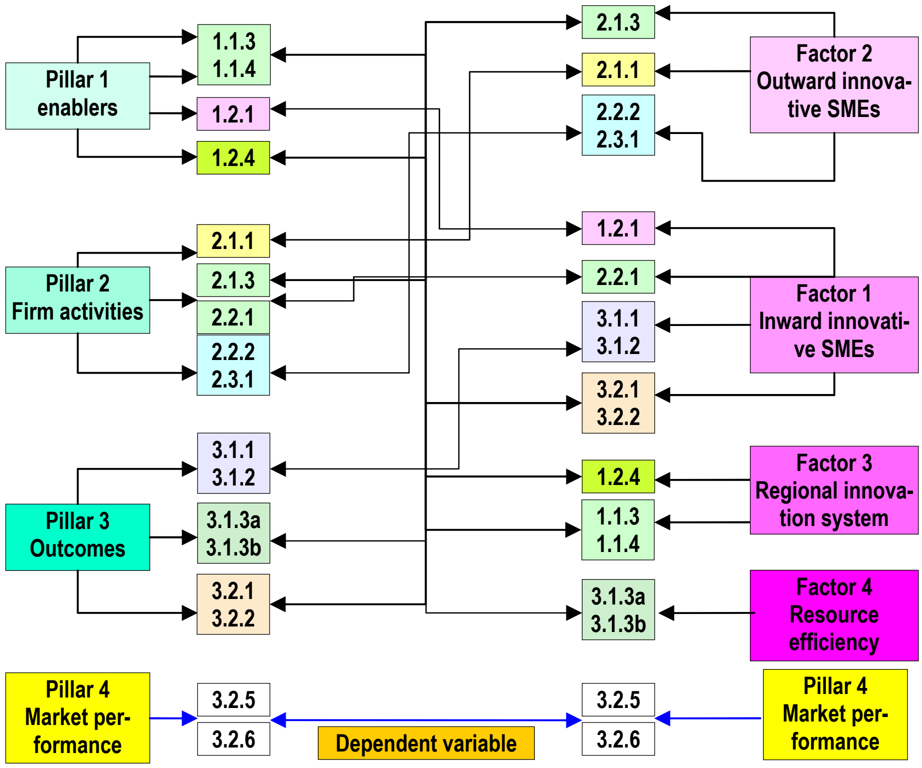
Notes: Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 5 iterations.

- the first component gathers five indicators which, broadly speaking, describe innovation process within the firm and public R&D expenditure; we name Factor 1 *«Inward-oriented innovative SMEs»;*
- the second component contains four indicators again related to firms, but this time with a more formalized effort (2.1.1 and 2.3.1) and a greater interrelation with other firms (2.2.2): we name Factor 2 *«Outward-oriented innovative SMEs»;*
- the third component contains three indicators related to skilled human capital, and broadband availability; we consider this factor specific of a regional context and we named Factor 3, even if with some approximation, *«Regional Service Economy»;*
- the final component strictly captures efficiency and appears to be a very clear-cut factor: we named Factor 4 *«Resource efficiency»*.

[75]The manifest goal of all the rotations is to achieve the simplest possible factor structure. 'Varimax' belongs to the orthogonal rotation methods and it attempts to maximize the dispersion of loadings within factor. Therefore, it maximizes the sum of the variance of the squared loadings within each column of the loading matrix, resulting in more interpretable clusters of factors. Chosing Varimax method implies we are thinking that underlying factors shouldn't be related. So, by definition, correlations among factors are null.

It is useful to compare the different aggregation operated by factor analysis with respect to the original structure based on Pillars. Figure 9.5 allows a parallel 'at a glance'.

Figure 9.5 – *Two different aggregations of indicators: Pillars vs. Factors*



Notes: The basic indicators are the following:
1.1.3 Tertiary education 2005 – 1.1.4 Life-long learning 2005 – 1.2.1 Public R&D expenditures 2005 – 1.2.4 Broadband access 2005 – 2.1.1 Business R&D expenditures 2005 – 2.1.3 Non-R&D innovation expenditures 2005 – 2.2.1 SMEs innovating in-house 2005 – 2.2.2 Innovative SMEs collaborating with others 2005 – 2.3.1 EPO patents 2005 – 3.1.1 Product and/or process innovators 2005 – 3.1.2 Marketing and/or organisational innovators 2005 – 3.1.3a Resource efficiency innovators - Labour 2005 – 3.1.3b Resource efficiency innovators - Energy 2005 – 3.2.1 Employment medium-high & high-tech manufacturing 2005 – 3.2.2 Employment knowledge-intensive services 2005.

The final significant model tested (see Tables 9.3, 9.4, and 9.5) is therefore the following:

$$Pil4^r_{08} = \beta_0 + \beta_1 Fact1^r_{05} + \beta_2 Fact2^r_{05} + \beta_3 Fact3^r_{05} + \beta_4 Fact4^r_{05} + \varepsilon^r_{05}$$

and its estimate is:

$$Pil4_{2008} = 0.433 + 0.425F1_{2005} - 0.202F2_{2005} - 0.475F3_{2005} + 0.338F4_{2005}$$

Table 9.3 – *Model summary*

Model	R	R square	Adjusted R square	Std. Error of the Estimate
1	.750	.562	.504	.205

Notes: Dependent Variable Pillar 4-2008. Observations No. 35.

The standard statistical tests show positive results, collinearity is absent by definition as the principal component are rotated, while the R square is equal to .562, and the adjusted R square is .504 (std. error of the estimate equals .205).

Table 9.4 –*Model results: Coefficients*

Model		Unstandardized Coefficients		Standardized Coefficients	t-*test*	Sig.
		B	Std. Error	Beta		
1	(Constant)	.433	.035		12.498	.000
	Factor 1	.124	.035	.425	3.520	.001
	Factor 2	–.059	.035	–.202	–1.669	.106
	Factor 3	–.138	.035	–.475	–3.935	.000
	Factor 4	.098	.035	.338	2.800	.009

Notes: Dependent Variable Pillar 4-2008. Observations No. 35.

The final result suggests a somewhat puzzling interpretation which should open to some future research. Among the predictors, three components are significantly different from zero (Factors 1, 3 and 4), but one of them has a negative coefficient. Pillar 4, *i.e.* the market performance of innovation in SMEs, responds positively to component 1 'Inward-oriented innovative SMEs' and component 4 'Resource efficiency', while negatively to component 3 'Regional service economy'. The strength of the response is offered by the estimated standardized beta coefficients.

Table 9.5 – *Residual statistics*

Residuals	Minimum	Maximum	Mean	Std. Deviation
Predicted value	.02762	.90597	.433	.2181
Residual	–.36817	.49902	.000	.1926
Std. Predicted value	–1.859	2.167	.000	1.000
Std. Residual	–1.796	2.434	.000	.939

Notes: Dependent Variable: Pillar 4-2008.

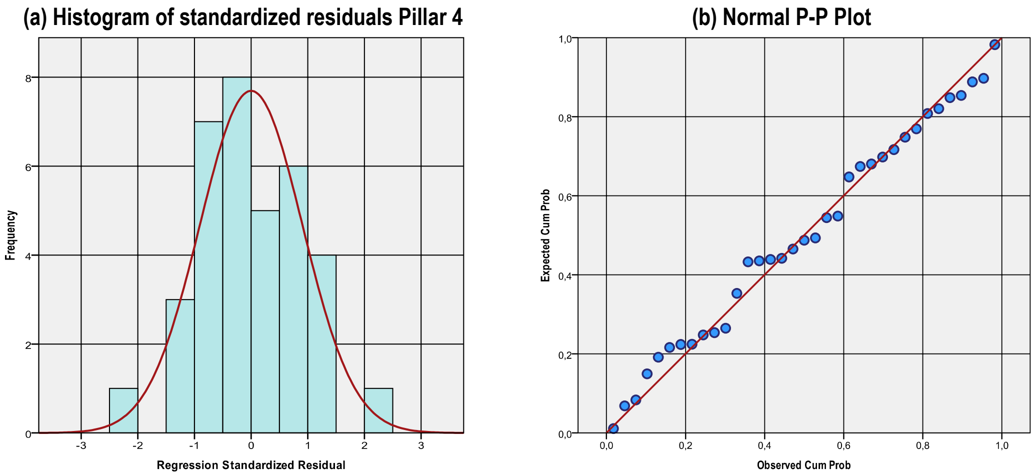
'Outward-oriented innovative SMEs' (Factor 2) and 'Innovative sales' are negatively related. This result is counter-intuitive, as one would expect that regions with firms spending more on R&D and non-R&D innovation would also generate higher shares of new products and innovative sales[76]. Part of the explanation – but just a small one – could be due to possible misallocations of innovation activities for multi-establishment enterprises with innovation activities in multiple regions. The CIS would assign all of these activities to the region of the companies' headquarter.

The negative link between 'regional service economy' and 'innovative sales' can be explained by the fact that the innovative activities of regions dominated by service activities (as reflected by high shares of tertiary educated people) are not well captured by the CIS indicator on sales of innovative *products*. The indicator on sales of innovative products is biased towards regions with higher shares of manufacturing activities. We can here stress that innovative European SMEs frequently work in medium-technology industries – which are still the dominant sectors for European exports into the global markets and the fastest-growing sector in international trade (Cappellin and Wink, 2009) – and these industries evidence a large absorption of 'secondary educated' labour, while tertiary education is much more widespread in service sectors and public administration.

[76]This result is not due to a possible sampling error related to the inclusion of only 35 of the most innovative regions. Running a factor analysis over the full set of more than 200 regions covered in the RIS produces similar (albeit slightly different) results, both for the components and the regression results.

On the contrary, the positive link between 'resource efficiency' and 'innovative sales' shows the importance of labour and energy saving innovation activities. Such activities contribute directly to reduces production costs and possibly also to increased reputation for the firms involved in such activities both contributing to increased sales of new products. In addition, we should have in mind that environmental friendly behaviours have been strongly supported at the regional level, mainly by the most advanced regions in Europe even beyond European and national support schemes.

Figure 9.6 – *Residuals' distribution*



In terms of absolute effect on Pillar 4, Factor 1 'Inward-oriented innovative SMEs' offers the greatest contribution to the final performance.

This positive Factor confirm that SMEs across Europe are able to obtain market success (high shares of sales of new-to-market/firm products) by working hard on innovation, mainly in-house. This success mostly relies on tacit knowledge and learning dynamics which seems connected with high-skilled workers. An effort which only seldom ends up with a patent outcome (it is a pity not to have the regional data on trademarks and designs – both numbers and revenues – which are now available at the Country level), (see § 9.3.1).

The predictor that has a negative impact with a meaningful beta is Factor 3 'Regional service economy', which captures education and an infrastructure element: the broadband access. We can detect a good coherence between the characteristics of the innovative small firms and their 'distance' from the ICT background outlined by knowledge-intensive services, broadband and tertiary education. The sectors in which more frequently the depicted SMEs operate are the intermediate technology ones and this is, comprehensibly, an explication of the negative sign with which indicator 1.1.3 enters in the third Factor.

In conclusion we would like to stress two main results, being conscious of some objective shortcomings of this exercise (cross sectional analysis with small sample, and delayed dependent variable estimated at one time point).

The first result is that the first three Pillars (in their original form) are not meaningful in explaining regional innovative performance (*i.e.,* market sales, as captured by Pillar 4). The second result is that the picture becomes clearer when we replace Pillars with Factors: and that 'inward oriented innovative SMEs' are determining in enhancing the performance of the most innovative regions.

9.3 What is going on? Innovation Union Scoreboard 2010 and Community Innovation Survey 2008

The fact that we can not find a meaningful impact of NISs on Pillar 4 does not mean that the national level is not important on regional performance, but more simply that we cannot appreciate its actual contribution by just looking within the different Pillars of the composite. In the following sections of the Chapter we use the most recent data available to comment on the present positioning of the different Countries analysed within the European innovation challenge.

One of the major shortcomings of the picture on innovation (of the 35 strongly innovative regions presented in the first part of the Report) is surely the lack of fresh data. We took a picture at 2005: in the light of what has been going on in the innovation field it may seem ancient history!

Even at the European level the strategy has been changed. In 2005 we were just in the middle of the 'Lisbon strategy' and a minority of European high officials still believed in those goals: *«to become the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion».* But Lisbon strategy has resolved to be a partial failure, also due to the dramatic financial crisis which crashed into our economies in the middle of 2008. Now we are deepened in the scenario traced by the new Europe 2020 Strategy, and its renewed goals need up-to-date indicators for monitoring the process.

So, following the pressing demand for adequate instruments to evaluate the national progresses towards the Europe 2020 objectives, a new set of indicators – the *Innovation Union Scoreboard* (IUS) – has been proposed with the specific ambition:

«to inform policy discussions at national and EU level, by tracking progress in innovation performance within and outside the EU over time» (InnoMetrics, 2011: 3).

9.3.1 The IUS and Summary Innovation Index 2010[77]: a new depart

The analysis carried out in this Report has used the indicators of the former European Innovation Scoreboard (EIS). New scoreboard (IUS) is largely based on the previous EIS (ProInno Europe, 2009; 2010) but introduces some changes in order: *i)* to give an answer to some major criticisms raised on the 'old EIS' (Hollanders and van Cruysen, 2008; Schibany and Streicher 2008); and *ii)* to better capture and understand the progresses made by Member States and the strengths and weaknesses in their research and innovation systems.

It is not object of the present Report to give details on the construction of the new Summary Innovation Index (SII)[78]. The general structure of that composite indicator has remained unchanged with regard to the EIS: it is still based on three Pillars, each one is divided into two or three 'innovation dimensions', articulated, in turn, in two to four different basic indicators (see Table 9.6).

[77]Just to be clear on the acronyms, IUS (*Innovation Union Scoreboard*) is the data set of 25 basic indicators collected by Eurostat for the 27 Member States, plus some extra-UE nations in order to make international comparisons possible, while the SII (*Summary Innovation Index*) is the final composite created with the IUS dataset (se Table 9.3). From the same IUS we can, therefore, compute many different SIIs, one for each set of alternative hypothesis we can adopt in the creation of the composite indicator (Hollanders and Tarantola, 2011).

[78]The reader can refer to the two publications prepared by UNU-Merit and DG JRC G3: (InnoMetrics, 2011; Hollanders and Tarantola, 2011).

Table 9.6 – *Indicators of the Innovation Union Scoreboard*

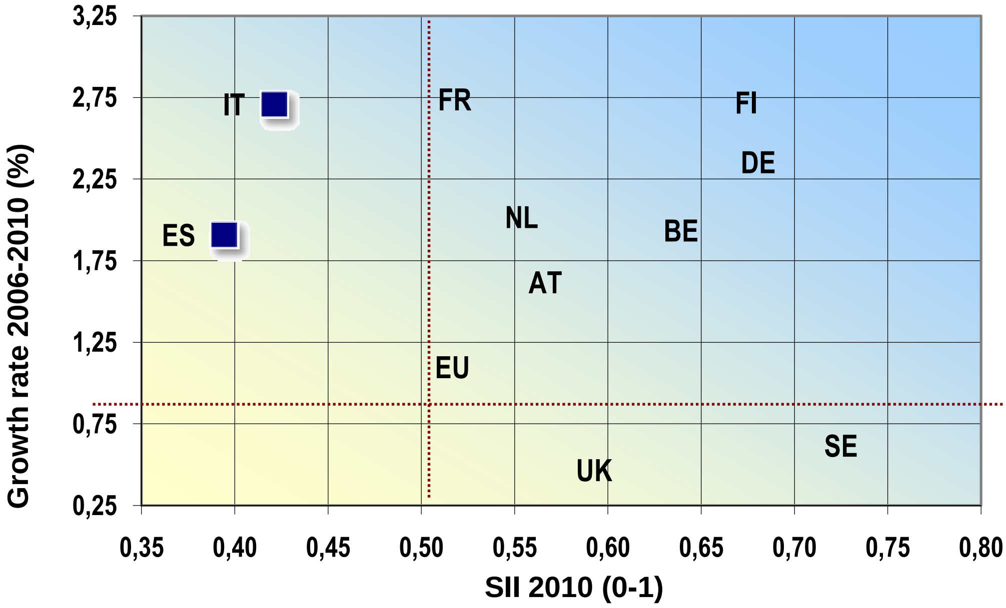
Main type/Innovation dimension/Indicator	Data source	Reference year(s)
1. Enablers		
1.1 Human resources		
1.1.1 New doctorate graduated (ISCED 6) per 1000 population aged 25-34	Eurostat	2004–2008
1.1.2 Percentage population aged 30-34 having completed tertiary education	Eurostat	2004–2009
1.1.3 Percentage youth aged 20-24 having attained at least upper secondary level education	Eurostat	2004–2009
1.2 Open, excellent and attractive research systems		
1.2.1 International scientific co-publication per million population	Science Metric/Scopus	2004–2008
1.2.2 Scientific publication among the top 10% most cited publications worldwide as % of total scientific publications of the Country	Science Metric/Scopus	2003–2007
1.2.3 Non-EU doctorate students as a % of all doctorate students	Eurostat	2003–2007
1.3 Finance and support		
1.3.1 Public R&D expenditures as % of GDP	Eurostat	2005–2009
1.3.2 Venture capital (early stage, expansion and replacement) as % of GDP	Eurostat	2005–2009
2. Firm activities		
2.1 Firm investment		
2.1.1 Business R&D expenditures as % of GDP	Eurostat	2005–2009
2.1.2 Non-R&D innovation expenditures as % of turnover	Eurostat/CIS	2004–2006–2008
2.2 Linkages & entrepreneurship		
2.2.1 SME innovating in-house as % of SMEs	Eurostat/CIS	2004–2006–2008
2.2.2 Innovative SME collaborating with others as % of SMEs	Eurostat/CIS	2004–2006–2009
2.2.3 Public-private co-publications per million population	CWTS/Thomson Reuters	2004–2008
2.3 Intellectual assets		
2.3.1 PCT patents applications per billion GDP (in PPS€)	Eurostat	2003–2007
2.3.2 PCT patents applications in societal challenges per billion GDP (in PPS€) (climate change mitigation, health)	OECD/Eurostat	2003–2007
2.3.3 Community trademarks per billion GDP (in PPS€)	OHIM/Eurostat	2005–2009
2.3.4 Community designs per billion GDP (in PPS€)	OHIM/Eurostat	2005–2009
3. Outputs		
3.1 Innovators		
3.1.1 SMEs introducing product or process innovation as % of SMEs	Eurostat/CIS	2004–2006–2008
3.1.2 SMEs introducing marketing or organisational innovation as % of SMEs	Eurostat/CIS	2004–2006–2008
3.1.3 High-growth innovative firms	N/A	N/A
3.2 Economic effects		
3.2.1 Employment in knowledge-intensive activities (manufacturing and services) as % of total employment	Eurostat	2008–2009
3.2.2 Medium and high-tech product exports as % total product exports	UN/Eurostat	2005–2009
3.2.3 Knowledge-intensive exports as % total service exports	UN/Eurostat	2004–2008
3.2.4 Sales of new to market and new to firms innovations as % of turnover	Eurostat	2004–2008
3.2.5 Licence and patent revenues from abroad as % of GDP	Eurostat	2005–2009

Source: INNOMETRIC (2011), table 1.

As Table 9.6 clearly shows, the data used for the 2010 SII are not all equally updated: the most recent available figures are related to 2007 for 4 indicators, 2008 for 10 indicators, and 2009 for 10 indicators. This means that even the SII 2010 can not fully capture the impact of the financial crisis on innovation performance.

One interesting feature of the SII exercise with the current composition of indicators is that it has been computed back in time, starting from 2006 on a yearly basis: we have therefore a five-year period to consider to assessing the growth performance of the different Countries. Two major results should be recalled: *i)* almost all Countries have experienced a meaningful increase in innovation performance in the period considered – with a European average rate near to an annual increase of 0.85%; and *ii)* an emergent convergence path where innovation followers are growing at a faster rate than the innovation leaders[79].

Figure 9.8 – *SII (Summary Innovation Indicator): 2010 value and 2006-2010 growth*



All the 27 European Countries have been divided into four groups on the basis of their average annual growth rate, over the five-year period considered. The ten Countries considered in this Report populate the following sets: *innovation leaders,* Sweden, Finland and Germany (average growth rate 1.6%); *innovation followers,* UK, Belgium, Austria, the Netherlands, and France (average growth rate 2.6%); and *moderate innovators,* Italy and Spain (average growth rate 3.5%).

Figure 9.8 illustrates clearly the three groups of innovators (leaders, followers and moderate innovators) and identifies, contextually, three different bands of rates of growth: fast growing Countries (Italy[80], France, Germany and Finland); intermediate growing Countries (Spain, the Netherlands, Austria, and Belgium); and the low growing Countries (UK and Sweden).

9.3.2 Some comments on the indicators' selection

Without going into the details of the scoreboard (see Hollanders and Tarantola, 2011), we point out only few comments on the indicators selected.

FOUR PILLARS MAY BE BETTER — The idea of having three main Pillars still holds from the EIS exercise. Within the Pillars, the indicators are well selected.

[79]The spread in innovation performance across EU27 Countries has been verified with the *sigma-convergence.* It is measured by the ratio of the standard deviation and the average performance of the Member States. This spread has been reduced over the five year period (2006-2010) even if the convergence rate is slowing down (INNOMETRICS, 2011: Annex G).

[80]Italy is growing fast but, due its current performance level, other things being equal, it will be able to reach Sweden within 28 years! While Finland and Germany remain unreachable.

However, we believe it would be useful to distinguish, within the third Pillar (Outputs) the dimension of *innovative outputs* from that of the *economic effects* they finally imply, which should represent our fourth Pillar. We note how in the new scoreboard more indicators are reflecting the economic effects of innovation with respect to the previous EIS where there were only two indicators which we considered as the four Pillar[81].

REVENUES FROM COMMUNITY TRADEMARKS AND DESIGNS — We appreciate the suggestion of indicator 3.2.5 *«Licence and patent revenues from abroad as % of GDP»* and we know that revenues from abroad, coming from community trademarks and designs, are a not jet available information. As this indicator is extremely important for firms working on 'softer' dimensions of innovation, an effort should be done by Eurostat in order to collect data on this issue.

ADULT EDUCATION & LIFELONG LEARNING — Indicator 1.1.2 *«Percentage population aged 30-34 having completed tertiary education»* is much more focussed than the old one included in the EIS, which took as reference group the population aged 25-64 and was therefore too much constrained by path-dependency, while showing a very slow pace in its improvements. Differently, the old EIS indicator 1.1.4 *«Participation in lifelong learning per 100 population aged 26-64»* has been dropped, while it is certainly still appropriate and particularly interesting also in relation to some specific policies adopted by different Member States[82].

The Lisbon Council has deeply studied human capital and its rising role in generating and supporting long term growth. Two main points should be recalled at this point. The first is widely known and well accepted: human capital endowment is positively correlated with regional prosperity (LC, Ederer *et al.,* 2011), but the most interesting thing is that, among the five principal ingredients of human capital endowment – parental education, schooling, university, adult education, and learning of the job – the last two play a fundamental role in Countries that do particularly well (LC, Ederer *et al.,* 2006).

Sweden, Denmark, UK and the Netherlands – the best performers according to the *European Human Capital Index* – are fostering adult education and learning on the job.

«Swedish 44 to 64 year spend 358 hours per year in adult educational activities with job relevance, which is almost 50% more than the German who are ranked second, and three times as much as the Spanish who are last». (LC, Ederer, *et al.,* 2006: 9).

So, the good news is that low human capital endowment might be easily and speedily reversible; the bad news is that human capital endowment will be strongly influenced, in the near future, by demographic trends (see Figure 9.9).

[81]From this point of view the proposed indicator 3.2.1 *«Employment in knowledge-intensive activities (manufacturing and services) as % of the workforce»* is not an economic outcome of the innovative process. It would be more convincinlly put within the innovation dimension 'innovators' (see Table 9.10) rather than in the innovation dimension 'economic effects'.

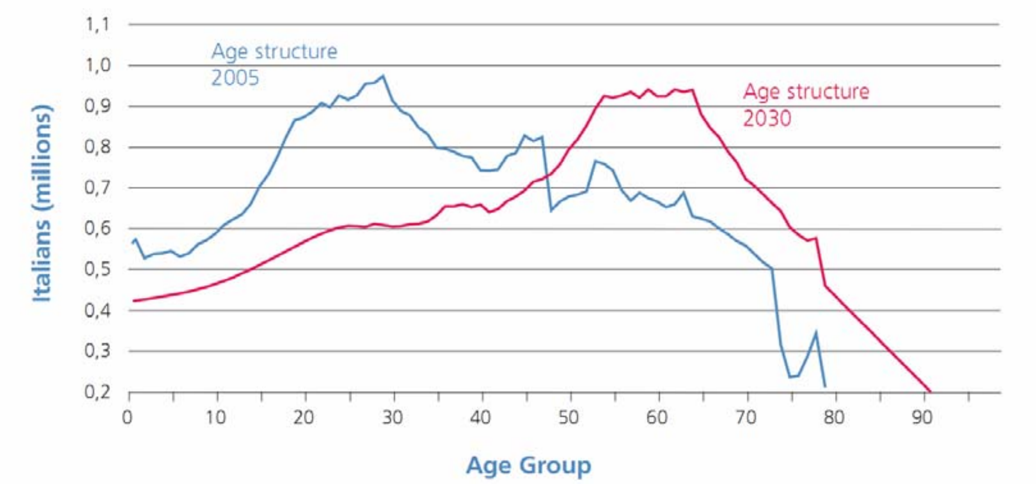
[82]Bratislava region (Slovakia) can count on a share of workers with graduate degree of 29%, well above the EU average (23%). It has significantly invested in the University of the Third Age (Comenius University in Bratislava) with a three-year programme for people over 50. The number of senior students enrolled went from 235 in 1990/1991 to more than 1800 in the academic year 2009/2010. It has been considered a beneficial initiative because: *«it assists elderly in maintaining a youthful mentality that is a pre-condition for productive utilization of this demographic group. This also increases the incentive for employers to hire and employ elderly longer.»* (LC, Ederer *et al.,* 2011, p. 21).

In Italy birth rates are far below replacement level, and the same is true in most European Countries. If current employment and immigration patterns continue, Italy will loose 3.5 million employees by the year 2030 (while Germany will loose some 5.2 million) and the only, but by no means easy, solution will be immigration.

«Can Europe attract, absorb and train 12.4 million non-European immigrants that are at least as equally endowed with human capital as the native population? Can these immigrants be persuaded to go where they are needed most or will they go places where better native demography also improves the chances for the newcomers?». (LC, Ederer, *et al.,* 2006: 16).

So, all considered, it is a pity that a measure of *lifelong learning* has been removed from the new scoreboard.

Figure 9.9 – *In Italy, 60 year olds will outnumber 20 year olds by two to one in 2030*



Source: LC, Ederer, *et al.,* 2006: 15.

BIBLIOMETRIC BIAS — Few comments also on the innovation dimension 'open, excellent and attractive research system' which catches a very 'core' dimension of future performance but in which two out of three indicators are 'bibliometric' in type. There is a wide debate on the usefulness and proper use of bibliometrics[83] as a measure for scientific production. While bibliometrics is seemingly easy to use and provides numbers that are attractive for their simplicity and factual nature:

«It involves nevertheless numerous biases. It is important to mention that in order to carry out bibliometrics in an unquestionable fashion, time, rigor and experience are necessary. It is also essential to remember that no index or set of indices alone can summarize the quality of a researcher's scientific production. Moreover, the importance of bibliometrics in some disciplines may encourage researchers to adapt their publications and even their work to the journal in which they wish to publish their articles rather than engaging in original and creative research.» (Académie des sciences, 2011: 2).

We cannot forget that some French Fields Medal winners in mathematics and Nobel laureates in chemistry and physics have surprisingly very modest bibliometric indices. Moreover, according to *Physic World* (November 2010) the two pieces of works that were rewarded with the Physic Nobel Prize in 2010 has been

[83]Bibliometrics doesn't measure the quality of researcher's work but only citations to the work. Quite naturally, in the case of equally good articles, those published in the most influential journals will be cited more often than those published in less prestigious ones.

refused twice by *Nature*. It is astonishing, and to some extent worrisome, that highly important works were not accepted for publication by *Nature*.

While many of these shortcomings attain to the accuracy of the measure, or to the way we make use of bibliometrics, and may be, therefore, improved along time, there is a second critique that is more radical.

Is not true that a supremacy in 'big science' – measured by an elevated number of publications/citations – imply technological and market success in transposing invention or discovery into innovation (this point will be elaborated in the next Chapter, please refer to § 10.3). Scientific excellence is not a sufficient nor a necessary condition to performing well in innovation's markets.

At the end, what policy makers and entrepreneurs are looking for is that kind of innovation which is able to generate new jobs, to rise revenues and profits, and to increase export shares on global markets. Considering these final ends the use of proxies such as simply counting publications/citations seems at least partially misleading. A different, and possibly more focused, indicator should be the number of technical awards gotten by innovative firms in their specific field of activity.

PUBLIC R&D EXPENDITURES AND DEADWEIGHT EFFECTS — In the same Pillar 'enablers', compares also the usual 'public R&D expenditures' which is obviously a tribute to custom. There is a growing disaffection towards this measure, which is frequently 'inflated', but, more importantly, which is in direct competition with private expenditure, generating the well known 'deadweight effects' (Lenihan, 2004; Tokila *et al.,* 2008; Brancati *et al.,* 2011).

The deadweight effect is defined as the degree at which projects would have gone ahead even without public support. So, if the investment would have been completely realised at the same time, we incur in a 'pure' deadweight which states the complete failure of the policy.

One of the major problems in evaluating the effectiveness of innovation policy, and specifically measures devoted to stimulating R&D activities, is surely the *additionality* feature of the policy. R&D expenditures – when Government doesn't finance directly public laboratories and research institutions – take mostly the way of grants offered by public to private firms to stimulate and obtain new *additional* R&D activities.

The effectiveness of the policy should be defined and measured as differences between an observed outcome and the *counterfactual situation*, *i.e.*, the outcome that would have been observed, had the policy not taken place (Martini, 2008).

Different studies have been developed throughout Europe converging towards the existence and the relevance of deadweight effects. In the Finnish case the more a firm is new and big, the more deadweight is likely to occur (Tokia and Haapanen, 2009). In the Irish case the smaller firms are, the less likely deadweight occurs (Lenihen, 2004). In the Italian case firms with higher level of turnover are more likely to display deadweight (Brancati *et al.,* 2011), in any case, one third of the Italian firms in the sample belong to the 'pure' deadweight category.

The conclusion is that the (completely) 'additionality clause' is never been respected and therefore the simple recording of public R&D expenditures may be quite misleading: a substantial part of them will be a simple substitute for private R&D expenditure. This critic suggests that it should be better to sum up private and public R&D expenditures in order to counterbalance crowding-out effects.

9.3.3 The final result: comparing RICI 2005 with SII 2006-2010

Once we agree on the list of indicators, the construction of the composite requires the usual methodological attentions which have been largely addressed in the first eight Chapters of the Report.

The final result – the SII 2010 – is a well structured composite, robust enough to deliver us a full clear-cut ranking of the European Countries. We take it for granted and go further in our comparisons.

Figure 9.10 – *Comparing the two composites: RICI (2005) and SII (2006) – Pearson's R = 0.968*

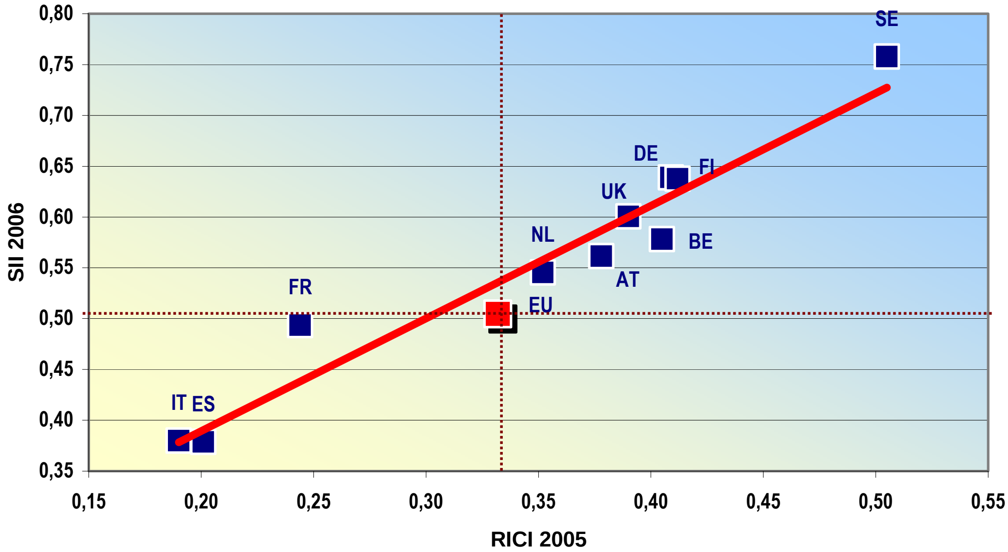


Table 9.7 – *Evolution of the SSI in the five-year period. Pearson correlation*

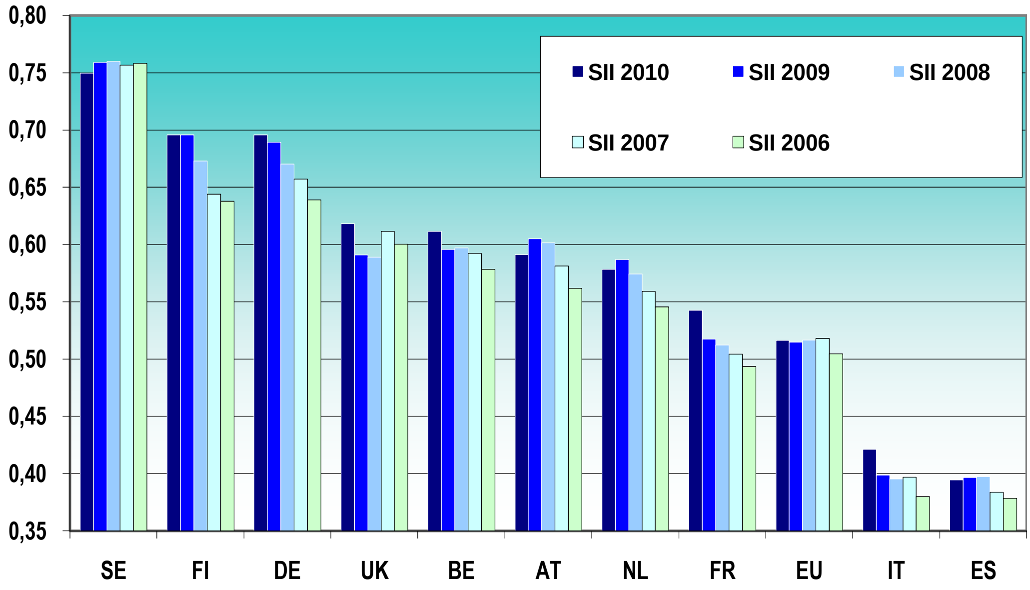
Country	RICI	Summary Innovation Index (SII)				
Year	2005	2006	2007	2008	2009	2010
Austria	0,378	0,562	0,581	0,602	0,605	0,591
Belgium	0,405	0,578	0,592	0,597	0,595	0,611
Germany	0,409	0,639	0,657	0,670	0,689	0,696
Spain	0,201	0,379	0,384	0,397	0,397	0,395
Finland	0,412	0,638	0,644	0,673	0,696	0,696
France	0,244	0,493	0,504	0,512	0,517	0,543
Italy	0,190	0,380	0,397	0,395	0,398	0,421
Netherlands	0,352	0,545	0,559	0,574	0,587	0,578
Sweden	0,505	0,758	0,757	0,760	0,759	0,750
United Kingdom	0,390	0,600	0,611	0,589	0,591	0,618
EU	**0,332**	**0,505**	**0,518**	**0,517**	**0,515**	**0,516**
Pearson R		**Summary Innovation Index (SII)**				
		SII 2006	SII 2007	SII 2008	SII 2009	SII 2010
RICI 2005		0,972**	0,975**	0,969**	0,958**	0,949**
SII 2006			0,999**	0,991**	0,983**	0,985**
SII 2007				0,993**	0,986**	0,988**
SII 2008					0,998**	0,990**
SII 2009						0,992**

Note: Correlation is significant at the: * 0.05 level; ** 0.01 level.

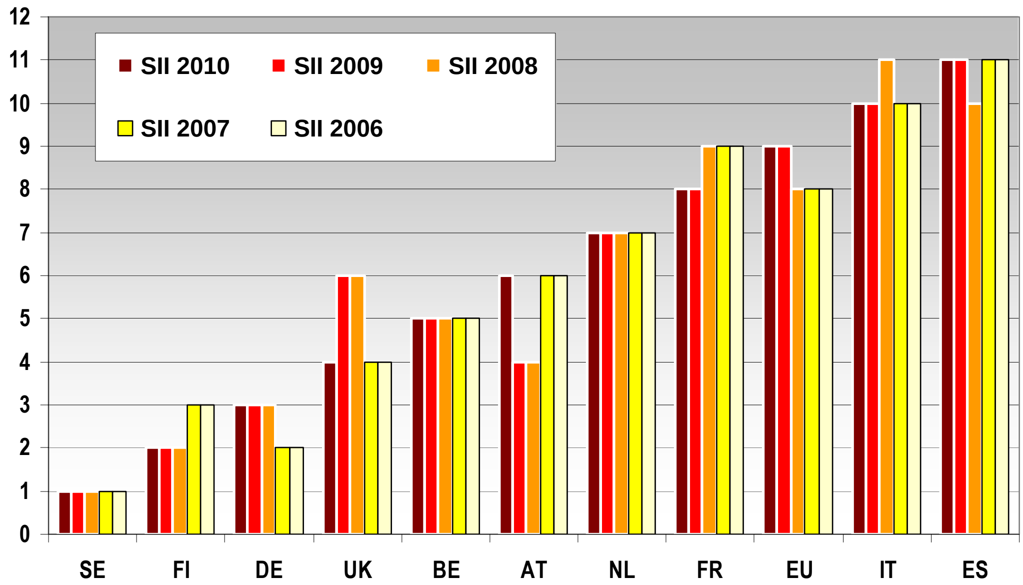
From Figure 9.10 we see a strong correlation between the two different composites, with only France (and partially Sweden) performing significantly better when computing SII instead of RICI. Within the RICI indicator, the modest performance of France is mainly due to a very poor result in Pillar 2 (firm's activities) which, in turn, is highly influenced by a very low *'non R&D innovation expenditures'* and an almost negligible *'collaboration with other SMEs'*.

On the contrary, looking at the SII 2006 we find out that France is closer to the EU average due to improvements in *'linkages & entrepreneurship'* (refer to Table 9.6) and to a high level of *'human resources'* and *'research systems'*.

Figure 9.11 – *Different SIIs, values and ranks*



(a) Indicators values [range: 0,1]



(b) Indicators ranks [range: 1,11]

Notes: Small numbers (ranks) indicate better performance.

Table 9.7 and Figure 9.11 show the strong correlation between SII and RICI existing in the five-year (2006-2010) period analysed. This result is important because it confirms the persistence of the single Country positioning within the European scenario. Even in the presence of different growth rates (allowing analysts to speak about ‘convergence’) the emerging picture is very clear-cut and stable over time.

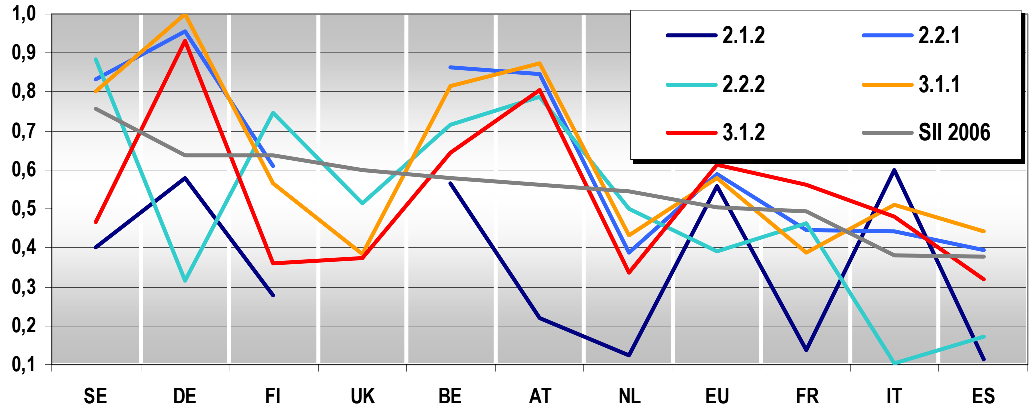
Figure 9.11 evidences the strong stability in the absolute and relative performance of the different Countries. In part (b) the ranks confirm the picture with only two pairs and a triad of overtakings: Italy and Spain in 2008; Finland and Germany in 2006–2007; Austria–Belgium–UK in 2008–2009.

The second part of Table 9.7 shows the Pearson R coefficients. The correlation is quite high, well above 0.95. It is interesting from our viewpoint that RICI 2005 is significantly and strongly correlated with SIIs: it means that we can continue to use ‘old data’ (the only ones with the regional dimension) without the risk to incur in wrong inferences.

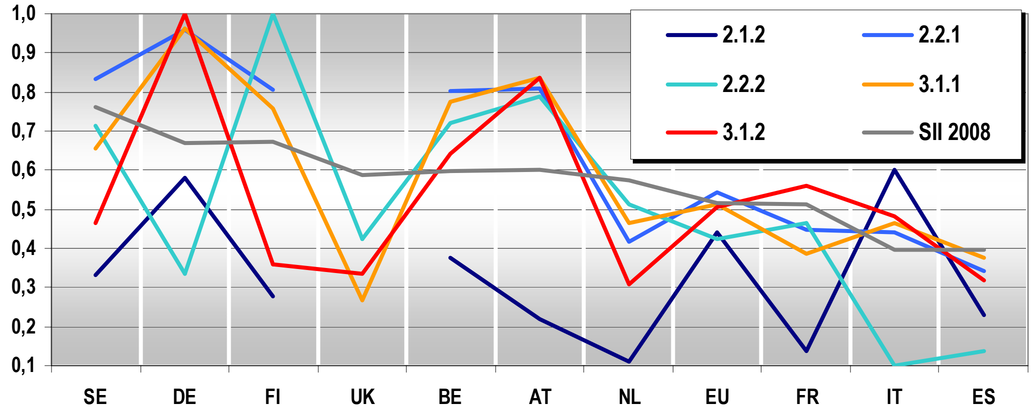
9.3.4 The CIS 2008 and its contribution to the SIIs

At the end of 2010 Eurostat released the latest *European Innovation Survey* known as CIS 2008. It is a survey on innovation activity in enterprises covering all the EU Member States, plus Iceland and Norway. This last version was launched in 2009, based on the reference period 2008, with the observation period 2006 to 2008.

Figure 9.12 – *National values of CIS indicators 2006-2008*



(a) Reference year 2006 – CIS 2006 survey



(b) Reference year 2008 – CIS 2008 survey

Notes: 2.1.2 *«Non-R&D innovation expenditures as % of turnover»*; 2.2.1 *«SMEs innovating in-house as % of turnover»*; 2.2.2 *«Innovative SMEs collaborating with others as % of SMEs»*; 3.1.1 *«SMEs introducing product or process innovation as % of SMEs»*; 3.1.2 *«SMEs introducing marketing or organizational innovation as % of SMEs»*.

Some changes were introduced to the CIS 2008 questionnaire in order to meet the third revision of the Olso Manual (2005 edition):

«This was achieved by giving greater weight to organisational and marketing innovation. However, the question on innovation expenditures is still limited to product and process innovation in order to maintain continuity with earlier version of the CIS. Furthermore, fewer questions are asked of organisational and marketing innovation than for product and process innovation.» (Eurostat, reference Metadata), [http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/inn_esms.htm].

As the CIS data are not available at regional level (NUTS2) we can just compare some information at the Country level in order to grasp the main changes occurred with respect to previous years. As already stressed in different points in the Report, the intra-national variance is normally so high that to knowing the changes registered at the national level (Country average) does not help much to infer the changes occurred in the top performing regions of that Country.

We are interested in the five indicators relating to SMEs, deriving from the CIS 2008 survey (2.1.2 *«Non-R&D innovation expenditures as % of turnover»*; 2.2.1 *«SMEs innovating in-house as % of turnover»*; 2.2.2 *«Innovative SMEs collaborating with others as % of SMEs»*; 3.1.1 *«SMEs introducing product or process innovation as % of SMEs»*; 3.1.2 *«SMEs introducing marketing or organizational innovation as % of SMEs»*.). Figure 9.12 offers a comparison between their values at 2006 and 2008. While the profile of the overall composite SII is quite smooth across Countries, the five indicators presents heterogeneous characteristics which are more evident for indicator 2.1.2.

Table 9.8 – *Rate of change of the five CIS indicators and the composite SII*

Country	2.1.2	2.2.1	2.2.2	3.1.1	3.1.2	Δ SII (2006–208)
AT	—	– 4.3		– 4.3	4.1	7.1
FI	—	32.4	33.6	34.0	—	5.5
NL	– 9.0	8.1	2.3	7.3	– 8.8	5.3
ES	100.4	– 13.7	– 19.2	– 14.8	—	5.0
DE	—	0.4	5.3	– 3.9	7.2	4.9
IT	—	—	– 2.2	– 8.4	—	4.1
FR	—	—	—	—	—	3.8
BE	– 33.3	– 6.9	0.6	– 4.8	—	3.3
EU	**– 21.3**	**– 7.7**	**8.5**	**– 11.9**	**– 17.8**	**2.4**
SE	– 17.1	—	– 19.2	– 18.1	—	0.2
UK	n.a.	n.a.	– 17.9	– 30.7	– 10.8	– 1.9

Notes: 2.1.2 *«Non-R&D innovation expenditures as % of turnover»*; 2.2.1 *«SMEs innovating in-house as % of turnover»*; 2.2.2 *«Innovative SMEs collaborating with others as % of SMEs»*; 3.1.1 *«SMEs introducing product or process innovation as % of SMEs»*; 3.1.2 *«SMEs introducing marketing or organizational innovation as % of SMEs»*. The absence of the value means a zero variation in 2006-2008. UK lacks of two indicators (n.a.)

Table 9.8 reports the percentage variation of each indicator and we see that there is also a large number of negative variation.

Lastly one point of interest is on trademarks and designs measures which are very enlightening on a specific declination of innovation sometimes considered less important than the pure R&D, but very meaningful for firms' international competition and quite widespread all around in Europe.

Figure 9.13 reports the data of standardized scores in two points in time (2006–2009) with the indication of the path of change. In general, we see four

Countries – UK, Spain, Italy and Belgium – decreasing in one of the two measures, while all the other Countries show a quite strong double increase and, specifically, Austria and Finland, quite strong.

Figure 9.13 – *Communities designs and trademarks: a moving scenario*

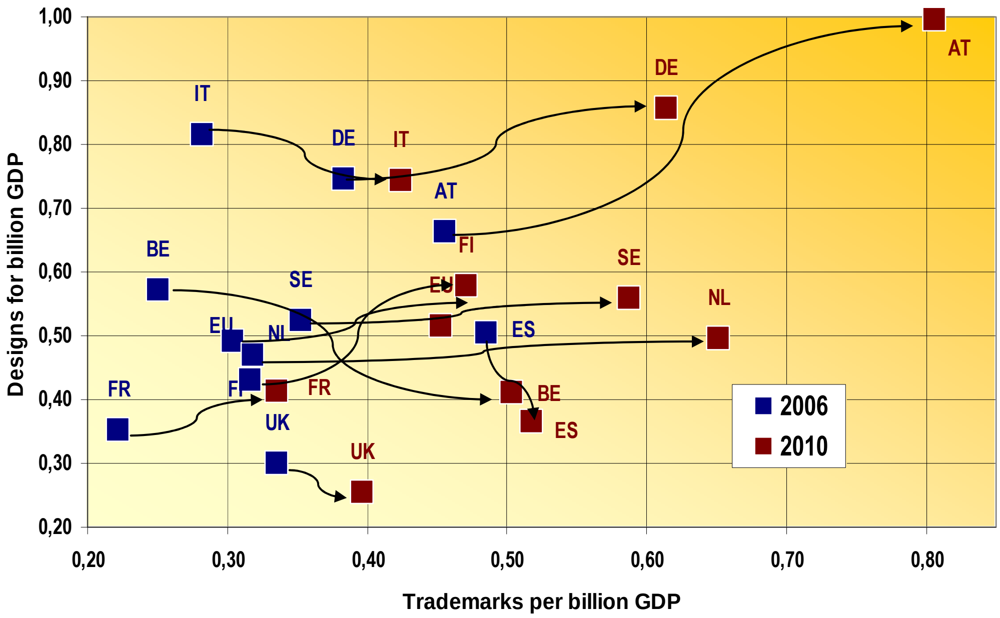


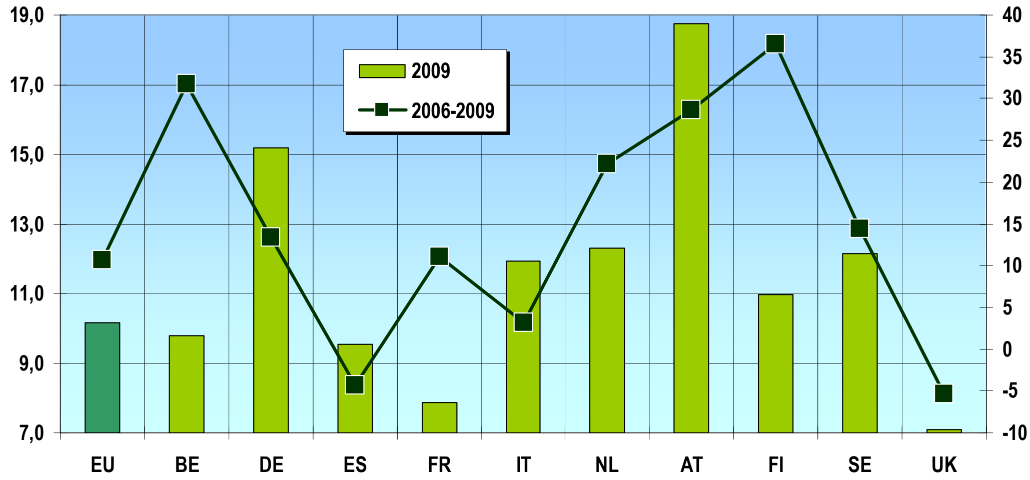
Table 9.9 – *Absolute values and rate of growth of trademarks, designs and their aggregate in the three-year period 2006-2009*

	2006			2009			Rate of growth 2006-2009		
	Trademark	Design	Sum	Trademark	Design	Sum	Trademark	Design	Sum
FI	4.41	3.63	8.03	5.63	5.34	10.97	27.65	47.24	36.49
BE	3.72	3.72	7.44	6.00	3.79	9.80	61.49	1.92	31.69
AT	7.50	7.07	14.57	9.56	9.19	18.75	27.46	29.98	28.68
NL	5.58	4.49	10.07	7.74	4.56	12.31	38.81	1.61	22.22
SE	5.63	4.97	10.60	6.99	5.15	12.13	24.06	3.48	14.41
DE	6.00	7.40	13.40	7.30	7.89	15.19	21.59	6.73	13.39
FR	3.25	3.82	7.07	4.03	3.82	7.85	24.17	0.00	11.11
EU	**4.57**	**4.62**	**9.18**	**5.41**	**4.75**	**10.16**	**18.46**	**2.94**	**10.66**
IT	4.27	7.29	11.57	5.08	6.85	11.93	18.78	–6.02	3.14
ES	5.78	4.19	9.97	6.17	3.37	9.55	6.80	–19.54	–4.27
UK	4.87	2.63	7.50	4.74	2.35	7.10	–2.58	–10.35	–5.31

Table 9.9 adds important information reporting the absolute values (number of trademarks and designs per billion GDP) for each of the two assets considered, and for their sum. We can therefore interpret the dynamics presented in Figure 9.14.

For instance, Italy experienced an increase in trademarkes jointly with a decrease in designs, but the sum of the two is still growing in the period, signaling a re-balancing of the two assets. Differently, Spain and UK registered an overall contraction of the two: for UK, both trademarks and designs are decreasing, while for Spain the slight increase in trademark can't compensate the stronger reduction of designs.

Figure 9.14 – *Sum of trademarks and designs: absolute value (2009) and rate of growth (2006-2009)*



9.4 Coming back to RICI 2005

The availability of CIS data is not unrestricted nor easy to obtain. In particular, regional data are frequently ‘out of limits’, due to the reluctance of Member States to release the information related to their regions (NUTS2). In addition we do not have a clear picture of the sampling territorial coverage and it is likely the reason for a large number of missing data as in the previous CIS 2006.

Considered all things, we can extract two main implications from the analysis carried out in this Chapter. The *first* one is that Country level show a clear-cut positioning of different nations in the last presented data (2010, remembering that it is an estimated value) which is very close to the previous 2006. Single Countries have grown, even at different pace, suggesting the idea of convergence, but generally speaking the set of the 10 advanced Countries explored here have all shifted upwards together.

We have recorded different growth rates but convergence path is still very slow and it leaves unaffected the final ranking, with Sweden, Finland and Germany well in front of the other Countries and Italy and Spain falling behind the group.

The *second* implication is that we have no fresh data at the regional (NUTS2) level and therefore – also in the light of the regression exercises run – we are convinced that top performer regions have acted not worst than the respectively Country and therefore have maintained, more or less, the same ranking explored with the RICI 2005.

Anyway, in the next Chapter in addition to many other things, we give the right attention to alternative indicators measuring innovative performance of regions.

10. Conclusions and perspectives

Innovation is surely a matter of 'life and death' in the capitalism of the twenty-first century (Baumol, 2002), and – even if the conceptual challenge to put precise demarcation lines on what constitutes innovative activity is still open (HLP, 2010) – in our complex, integrated, and hyper-competitive world, information and knowledge are preconditions to boosting and attaining sustainable development, and to meet the national and regional challenges of being innovative (Dewatripont *et al.,* 2010).

Innovation, in addition, is at the origin of the growing divergence between successful and lagging regions in the EU (Crescenzi, 2005). There are evidences (Crescenzi and Rodríguez-Pose, 2009) that this divergence reflects of the differences between *innovation–prone regions* – where there is a strong policy support for innovative firms and innovation infrastructures – and *innovation–averse regions* where relevant policy support is much less developed or backward (Rodríguez-Pose, 1999).

In this conclusive Chapter we intend to set the entire exercises developed – the construction and assessment of the *Regional Innovation Composite Indicator* – within a broader perspective on the role of innovation in the present competitive scenario (European Commission, 2007; Mettler, 2009), and the role of information systems (Oecd, 2009) as a necessary tool to monitor the process, to measure the outcomes but also, to a great and rising extent, to help policy makers in selecting goals and communicating final results (LC, Ederer, 2006; DTS, 2009; Manning, 2009; Sapir, 2009).

The Chapter is organized as follows. The first section (§ 10.1) summarizes innovation as a 'mantra' at the origin of firms' performance and their productivity (Zand *et al.,* 2011), and accordingly, territorial competitiveness and growth. In sustaining and enforcing innovation, policy matters, and it has to balance contrasting forces within the multi-level governance which characterizes the European scenario (the Union, Countries, regions, clusters and/or districts, etc.).

Next section (§ 10.2) addresses the relationship between indicators and policy models. Following Boulanger (2007) we can distinguish three models and we choose to concentrate our attention on the *discoursive-interpretative* one. Here it is more evident that the 'problem setting' is as important as the 'problem solving' effort, and the frame of the problem in highly conditioned by social, cultural and historical environment. Indicators play, therefore, a dialogical, argumentative role and 'influence' policy makers (Kirkhart, 2000), even when they are not used in a 'cogent way' (§ 10.2.1).

The Chapter goes on (§ 10.3) with reference to innovation again, in a real circular, recursive and cumulative way, stressing entrepreneurship and higher education as key drivers of the innovative process. Here territory largely matters and these assets which are the final outcome of endowments and good policy, make the difference in terms of winners and losers.

The following section (§ 10.4) stresses the role of benchmarking and the 'pedagogic' function that the construction of a composite indicator may have on policy makers as they have to answer to numerous questions compelling them to get to the bottom of the innovation issue; as the Nobel Prize Winner Amarthya Sen reminds us *«to discuss about indicators is a way to discuss about the ultimate* *goals of society»* [http://www.eco-nomist.com/debate/days/view/505], and the whole debate on ‘Beyond GDP’ is about this issue (Stiglitz *et al.,* 2008).

This section ends up putting on the table three methodological attentions we have to meet when selecting the basic indicators to appreciate innovation positioning, improvements, and policy results within a territory: *i)* regional dimension; *ii)* attention to measurement of ‘soft’ innovation; and *iii)* policy orientation of information systems.

Next section (§ 10.5) looks at two different implementation exercises, coherently with the raised attentions and proposed by authoritative institutions (HLP, 2010; LC, Ederer *et al.,* 2011). We see that the final result has to be nothing else than a compromise between the ‘best’ and the ‘reasonable good’, and on this basis we can work towards better solutions.

The Chapter and the Report concludes (§ 10.6) stressing heterogeneity in the innovative paths followed, and outcomes pursued by regions. Here the variance in territorial behaviours is strongly determined by a triad of factors which turn around human capital, they are: *i)* accessibility to knowledge; *ii)* absorptive capacity; and *iii)* diffusion of knowledge and technology. Within human capital we have still to distinguish three main dimensions closely intertwined with each others: creative entrepreneurship, good management, and highly-skilled workforce.

According to these building blocks of an innovative and performing process, we need good indicators: *i)* enabling to monitoring the system; *ii)* signaling the targets to be reached; and *iii)* evaluating the acquired results. A large part of the data needed, originate from innovation surveys, **and a major task for the near future is exactly the construction of datasets rooted in regional microdata and, possibly, longitudinal (panel data).**

At a more general level we still need to better define and measure the innovation phenomenon (*i.e.*, the most relevant process to foster and widespread competitiveness in our wealthy societies), and we know that it is not first and foremost a technical problem – obviously we need better ways of appraising the benefits of innovation – but it is mainly a shift from expert-dominated to more open, deliberative, shared and involving methods to defining the goals, the objects, and the targets to be evaluated (Henry and Mark, 2003; Stiglitz *et al.,* 2008).

10.1 Innovation policies need sound monitoring systems

Innovation is not a totally independent and market driven process. Due to externalities, spillovers, appropriability regimes, public procurements and public funding of R&D activities (Malerba and Brusoni, 2007; Boschma and Martin, 2010), innovation policy matters, at all the different scales at which competition takes place and technology is developed and applied. Europe – not by chance – has stressed its innovation-driven policies in any strategic plan for competitiveness (Dewatripont *et al.,* 2010). Under the EU’s 2000 Lisbon Agenda, great commitments have been shown to the use of scientific research to building the most competitive global knowledge-economy by 2010. ICT and the knowledge-based economy were prominently represented in the Lisbon Strategy, but Europe largely failed to translate world-class science and technology into growth and jobs.

The lesson, hardly learned, helped in shifting the governments attention towards a more ‘open model’ of innovation (Chesbrough *et al.,* 2006), a model which is strongly linked to thick networks and a strong absorptive capacity.

Later on, the current Europe 2020 Agenda[84] strongly recognizes that innovation is still to be considered the only economic vehicle which can convey the desired expansion in output, incomes, and jobs over the next decade. In this way EU reassesses its commitment to the goal of a dynamic, sustainable, knowledge–based ('smarter') economy (Hofheinz, 2009; LC, Ederer *et al.,* 2011).

Almost all Countries within the OECD group have adopted in the last decade some version of the 'knowledge economy' as an 'escape route' raising the value-added for goods and services (Bessant and Venables, 2008). The result has been a huge push down on the accelerator pedal of knowledge creation (DTI, 2004), rising – at the same time – many questions on how to get the maximum return from the money spent[85]. While in the past the term 'knowledge based–economy' has prioritized the instrumental use of scientific knowledge for competitive economic advantage (where science was a key factor of the new production as well as a traded commodity in itself), in present days the very big question among practitioners and policy makers has rapidly changed from the old one – *«how can I foster innovation?»* – towards the new one – *«how can I get value from knowledge?»* – which is a much more complex and wider task indeed, involving the understanding and organization of the innovation process (invention isn't enough) (DTI, 2004; Bessant and Venables, 2008). We deal with the ways to obtain an economic return from scientific and technological research, and it is of the greatest interest to appreciate how the different features of knowledge, its generation and utilization, can determine and shape the way in which it is capitalized. Indeed, economic and social factors are necessary conditions (even if not sufficient) to explain the capitalization of knowledge (Crescenti and Rodríguez, 2009).

The strong emphasis on increasing the percentage of GDP to be spent on R&D blurred the clear perception that:

> *«Innovation needs to be considered in all its ramification – only a few of which may be directly linked to the level of national R&D – if its real potential to support improvements in productivity is to be recognized.»* (Minshall, 2008: 138).

The American lesson is still to be metabolized. In the three-year period 2000–2003 the real GDP per hour worked grew in US of 2.6%. Seven sectors (out of 59) accounted for 85% of the whole growth and, quite surprisingly, among the top performers just one (computer and electronic products) can be considered conventionally R&D intensive. All the other six are 'traditional sectors' – retailing, finance & insurance, wholesaling, administrative and support services, real estate, and professional and scientific services – but have successfully adopted ICT and other organizational innovations within their 'non-innovating' firms.

In addition, we have to recognize that the difference in the productivity growth in US and Europe, in the past decade, should be mostly attributed to the divergence in services productivity (Bryson and Daniels, 2007), not certainly in high-tech sectors (Hughes, 2008).

In order to better understand how to get value from knowledge creation, policy makers have become (more) aware of the need of a monitoring and evaluation system (Mettler, 2009; Giovannini, 2011).

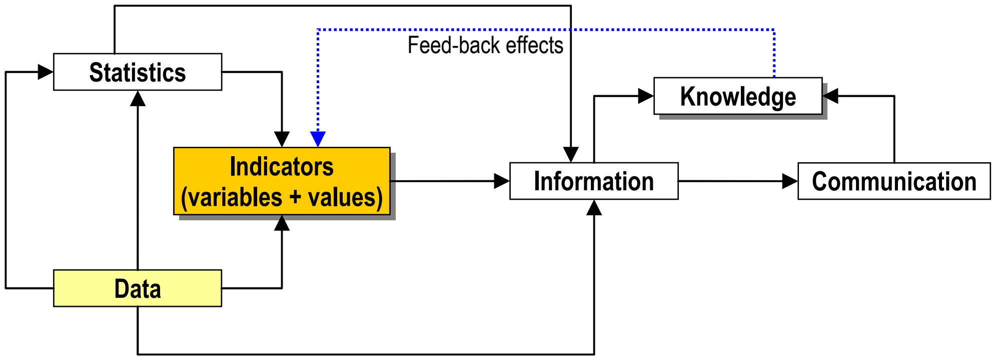
[84]*«What needed is a strategy to turn EU into a smart, sustainable and inclusive economy delivering high levels of employment, productivity and social cohesion. This is the Europe 2020 strategy.»* COM(2010) 2020 final.

[85]The very question, not jet answered in a convincing way, is that related to R&D: *«does the R&D goose really lay golden eggs?»*.

Monitoring is an ongoing process of collecting and assessing qualitative and quantitative information on the inputs, processes and outputs of programmes and policies, and the outcomes they aim to address. This is exactly what OECD calls 'indicator systems':

«Indicator systems offer regional policy stakeholders a tool for meeting two important challenges, both related to information. The first challenge has a strong vertical dimension. It involves reducing or eliminating information gap between actors at different levels of government in order to achieve specific policy programme objectives. Indicator systems contribute to meeting this challenge by complementing the contractual arrangements between levels of government. The second challenge has a more horizontal dimension. It involves capturing, creating and distributing information throughout a network of actors to improve the formulation of objectives and enhance the effectiveness the strategies employed. Here indicator systems can bring together and distribute otherwise disparate information and create a common frame of reference for dialogue about regional policy.» (OECD, 2009: 11).

Figure 10.1 – *The relationships of indicators with other 'knowledge concepts'*



Source: adapted from Gudmundsson (2009).

And we can now finally ask: *«what indicators exactly are?»* As shown in Figure 10.1 they are variables representing properties, of defined objects, to which we use to associate a value, so that we can utilize them to judge and assess those objects on the basis of the significance of the observed indicator value (Gudmundsson, 2009). According to this definition, indicators differ from both data or statistics (which are to some extent inputs of the process), on the one hand, and information or knowledge (which are interpretable as outputs), on the other hand.

Reliable and functioning indicator systems may contribute in improving the capacity to develop coordination and strategic planning, and enhancing the possibility to implement and fulfill competitiveness (Manning, 2009).

Indicator systems, in fact, may promote learning, where feed-back process result to be a major help in reaching effectiveness in the management of policies. From this point of view it is much more interesting to use indicators – even if we are conscious of the many faults they closely highlight – than to do without, only relying on humour, moods, and contingencies.

Sound policy-making, including the setting of targets, requires that the state of innovation will be adequately measured. In this way feed-backs should be used to improve both the policy and the indicator systems themselves. Even if indicators suffer evident shortcomings, they remain a precious tool for assessing progress and performance. Policy – in a clear, widespread perception – should not be based on hear-say or ideology, but rather rest on some more rooted evidence, calling for measurements and comparisons (Lehtonen, 2010).

In Table 10.1 – following Godin (2002) – we present the four different possible uses of indicators when applied to innovation issue and, specifically, to its quantitative analysis. These uses are: *i)* theoretical; *ii)* practical; *iii)* ideology-cal/symbolic, and *iv)* political.

The theoretical one is devoted to the understanding of the phenomenon, we can read behind R&D expenditures statistics, for example, the commitment and de-commitment of public and private sectors; moreover, looking at time series (if available) we can extrapolate future trends. But it is mostly for practical use that data on innovation process and outputs are gathered. The declination of this goal is presented in the second block of the Table 10.1, and it is important to remember that a control goal is frequently jointly present, specifically on the total amount of R&D and on the allocation of the public component.

Table 10.1 – *Uses of innovation indicators*

Uses and their declinations	Uses and their declinations
❶ Theoretical	**❸ Ideological/Symbolic**
Understanding and learning about science and technology	Displaying performance
Comparing Countries (benckmarking)	Objectifying decisions
Forecasting	Justifying choices
❷ Practical (controlling)	**❹ Political**
Managing (planning and allocating resources, assessing priorities)	Awakening and alerting
Orienting research	Mobilizing people
Monitoring	Lobbying for funds
Evaluating (accountability)	Persuading politicians

Source: adapted from Godin (2002).

For private sector the monitoring and evaluating perspective is all the most relevant, as entrepreneurs have to decide where to invest, and to detect and stop unsuccessful works as promptly as possible. The symbolic and potential uses belong to what is called the ‘discoursive–intepretative’ policy model and it is the object of the next section.

Within this frame composite indicators represent a step further on this line. They should not claim to have exhausted knowledge and monitoring requirements from policy makers and stakeholders, but they could contribute in speaking ‘clear and aloud’ and stressing on a more rigorous policy design[86].

Generally speaking, composite indicators (innovation scoreboards as well as many other built starting from the first decade of the new millennium) may play three different roles in policy (Arundel and Hollanders, 2008):

- they can act as ‘early warning’ to forerun potential problems;
- they can record changes in strengths and weaknesses (allowing a diachronic analysis of repeated measures);

[86]One specific contribution they can offer is to help in establishing clear objectives from the very outset of the process (Arundel and Hollanders, 2008). And we know, well defined objectives (possibly quantified) would be the first step to allowing subsequent monitoring and evaluation of the policy.

- and they can spot the light on specific question, attracting the attention of media and policy-makers[87].

10.2 Relations between information systems and alternative policy models

So, the nexus between information systems, and specifically composite indicators, and policy goals is very important to this point. In the current debate, the use of information systems and composite indicators in framing policies is abitually called ‘evidence based policy’. But this debate is frequently ‘ill fated’ by a monolithic view of policy making as rational, instrumental, linear and very mechanical problem–solving (Saltelli and Pereira, 2011).

According to Boulanger (2007) we can distinguish at least three different models for the use of statistics (and indicators) in policy: *i)* a rational-positivist; *ii)* a discoursive–interpretative; and *iii)* a strategic model.

The *first* one adheres to a simplified vision of a linear and mechanical way where decision process proceeds from measurement to indicators, and from indicators to decision. In short, policy-making as a rational problem solving, makes use of statistical indicators for the following three complementary goals: *i)* quantifying objectives; *ii)* assessing alternatives means to reach them (*ex ante*); *iii)* evaluating effects and impacts (*ex post*).

To some extent we can say that it is a ‘policy without politics’ model. Even if the rational approach seems to be very promising, we should remember that, up to now, there is no one set of indicators being, at the same time, universally accepted, rooted in a compelling theory, backed in rigorous data collection and analysis, and political influential.

The *third* one represents, to some extent, a non-normative conception of politics as a pure competition. In the words of Boulanger (2007: 20)

«there is little room for objective common knowledge and thus for reliable indicators within this model».

10.2.1 The new centrality of the ‘discoursive–interpretative’ policy model

The *second* one – the discoursive–interpretative model – seems to be the more interesting and surely complementary to the first one. Where the rational model looks at the technical problem solving, the discoursive–interpretative model[88]:

«sees it as a struggle over the definition, explanation and interpretation of public problems. The core concepts in interpretative policy analysis are the concepts of frame, discourse, narrative, meaning, story, etc.» (Boulanger, 2007: 18).

[87] One important achievement of the Lisbon Strategy – largely portrayed as a policy failure – has been the shift – in policy makers and citizens attention – from the issue of unemployment towards the concept of employment: easier to be measured and better reflecting the health and dynamism of the labour market.

[88] Following Schön and Rein (1994) arguments, people facing social problems are engaged in an activity of ‘naming and framing’. *«Policy frames are structures of beliefs, perceptions and appreciations that underlie policy positions. Because real situation are complex, indeterminate and ambiguous, people select certain features and relations they consider the most relevant characteristics of the situation and create with them ‘stories’ that describe and explain the situation.»* (Boulanger, 2007: 18).

In this frame, indicators and monitoring devices may be, and indeed they are, conditioned by social, historical, economic and local factors that intervene at every level of their production (Lehtonen, 2010).

The use of indicators cannot be purely mechanical. On the contrary, they require a massive application of judgment, vastly improving the role of discernment in decision making. If the discoursive–interpretative model reads policymaking as a struggle over the definition, explanation and interpretation of public problems, than the role of statistics and indicators within this model is a conceptual or 'enlightenment' role, where knowledge provides the information base for decisions, offers conceptual frameworks and foster different types of learning in the spirit of the Habermas' 'communicative rationality' (1984).

In the rational policy-making the setting of indicators comes on stage when objectives have been already defined. Differently, in the discoursive-interpretative model, greater emphasis is attached to the way goals are defined, and indicators play a major role in the goal-setting phase of the process.

The subjective word of values, ideas, beliefs, matters and politics has to play its role. Within this approach indicators become important components of policy discourses; they are vehicles of social learning in framing issues, developing new concepts, enhancing legitimacy in the wider political debate (Gudmundsson, 2009).

We have also to recognize that while for the researchers technical problems are of the greatest relevance (*i.e.,* the scientific quality of knowledge and, therefore, the accuracy and reliability of data is all what matters) for policy makers, contextual features are of the greatest importance, e.g. communicability, dramatization and resonance of indicators (Grob, 2003; Henry and Mark, 2003).

Along with the research path developed in this Report a first general conclusion is therefore quite obvious: there is no one best composite indicators partly depending from the goals, partly from the data, and partly from the methodological choices which will be implemented, even if this last one (technical procedures), frankly, is the most workable out of the three.

What is much more disputable are the goals which are under the direct responsibility of policy makers. In some cases, when the object of analysis and policy is charged with strong normative assumptions, we meet higher difficulties in the selection of the goals and of the basic indicators. Where the interpretative conceptual models are countless, we have no guidelines for the selection of the relevant information and therefore the offer of a 'unique number' is perceived as highly inappropriate. This is the case, for instance, of environmental sustainability issue (Rey-Valette *et al.,* 2007), as well as the 'beyond GDP' debate (Boulanger, 2007; Saltelli and Pereira, 2011).

«We are almost blind when metrics on which action is based are ill-designed or when they are not understood.» (Mairesse and Mohnen, 2010: 9).

The picture is even more blurred when the composite indicator puts together 'components' which shows evident trade-offs among themselves. Here the compensability is surely inadequate and therefore composites are not so useful to addressing the problem.

The fact that the best composite doesn't exist, can't imply, anyway, that it is useless to construct and to use them in order to learn a proper use of information, choices regarding incentives, and establishing clear objectives for the policies. Moreover, statistics and indicators may exert a great influence on policymaking (Henry and Mark, 2003), the real source of this influence being the dialogical and argumentative processes taking place in the various ‘discoursive spheres’ in which indicators are produced and used.

Table 10.2 – *Relationships between the stage of policy process, issue characteristics and role of indicators*

Policy stages			Indicators’ role
1. The emergence of the problem		➔	Discursive & rationale – enlightenment
2. Legitimisation	}	➔	Conceptual role
3. Mobilisation of the public for action}			Discursive-interpretative
4. Formation of an official plan of action	}	➔ *Consensus*	Instrumental Rational-positivist
5. Implementation of the plan		➔ *Controversy*	Strategic-political
6. Monitoring, evaluation, assessment, appraisal			

Source: adapted from Lehtonen (2010).

Social problems are not objective facts that impose themselves to societies (as many environmental questions have shown in recent years). Social problems need a legitimization; only when they have been recognized as legitimate concern, they may become a valid object of discussion and controversy in the different public arenas (Boulanger, 2007; Lehtonen, 2010).

Within the policy model we can therefore distinguish six different policy stages ordered from the emergence of the problem to the answering of that problem and the evaluation of the goodness of the solution implemented. Indicators exert different roles depending on the stage of evolution at which they are applied.

Table 10.2 reports this correspondence, recognizing that the three policy models only just discussed are more effective at different policy stages. The discoursive-interpretative model, for instance, is more useful in interpreting the legitimisation and mobilization phases, while the fourth and fifth stages (formation and implementation on an action plan) may be managed, alternatively, or with a rational-positivistic approach – when there is a large consensus among the different stakeholders – or with a political-strategic model – where the issue is still controversial or when the legitimate interests of powerful stakeholders are at stake. In this cases there is room for opportunistic behaviours (bargaining, strategic-games, log-rolling, etc.).

10.2.2 Differences between ‘use’ and ‘influence’ of indicators

The first model (the rational-positivist one) when referring to the use of indicators in policy explicitly calls for the concept of ‘utilisation’ of indicators. It is an instrumental approach where indicators provide information[89]. But looking at indicators in the light of policymaking process, falls short of giving adequate attention to the intrapersonal, interpersonal and societal change processes (Henry and Mark, 2003) through which the ‘measurement’ activity may translate into steps towards regional competitiveness improvement.

[89]During the last twenty years a large debate developed, broadening the concept of ‘use’ towards a more sophisticated and multi-dimensional construct (Cumming, 1999; Henry and Mark, 2003). It is now widely accepted to consider at least four different meanings on the term ‘use’ (Cumming, 2002): *i)* instrumental (a direct action occurred as a result of the use of indicators); *ii)* conceptual (something newly learned about the policy); *iii)* strategic (the justification of a pre-existing position); and *iv)* process (a direct action occurred, or something newly learned, as a result of participation in the construction of the indicator).

Kirkhart (2000) argues that the concept of use is too much result oriented. Despite of the relevant efforts made to enlarge its meaning, different unsatisfactoring aspects are still present. Instead of continuing to rework the concept of use, she suggests a change in focus from 'use' to 'influence'. Saying it differently, it seems more fruitful to think of the role of indicators in terms of 'influence' they can exert on policy makers:

«Indicators may not be explicitly 'used' by any stakeholders and yet they can exert powerful influence on policy, for instance through the impacts on frameworks of thought during the indicator design process or the dialogue and argumentation following the release of indicators.» (Lehtonen, 2010: 3).

The concept of 'influence'[90] (instead of 'use') allows to broaden the field of analysis also to the potential negative effects of indicator systems. The issue of performance evaluation, for example, seems to be among the most sensitive, and a numbers of shortcomings have been highlighted by practitioners (Lehtonen, 2010: 4):

«Performance measurement has been blamed for»:

- *«a closed, authoritative manner of representation, not conducive to dialogue and deliberation»;*
- *«discouraging responsibility and engendering resistance and risk aversion instead of fostering innovation, creativity and achievement»;*
- *«encouraging justification instead of improvement, potentially leading to the dissimulation and distortion of data or even lying and cheating»;*
- *«ignoring the plurality of values and point of view»;*
- *«representing a management rhetoric that is inappropriate in areas with a 'non managerial' tradition (e.g. science and technology policy); and»;*
- *«legitimizing and reinforcing the prevailing power structures».*

The message to be learnt is that we must stop the finger pointing as local Governments can't accept to be 'named and shamed' and, as a consequence, Member States frequently do not allow the publication of data considered even potentially controversial or embarrassing.

Differently, the discoursive-interpretative perspective – which better matches with the idea of indicators 'influence' – emphasizes the role of indicators as vehicles of social learning, as a tool designed to opening up perspectives and illuminating an issue from a variety of view opposed to a closing perspective of achieving convergence around a strictly shared definition of the problem (Stirling, 2008).

10.3 Entrepreneurship and higher education as key drivers of innovation

In Europe 2020 Agenda, it is absolutely clear that innovation can help to win the economic challenge to generate more products and firms (not simply to restore growth and jobs lost during the recent recession). Regions, however, need to identify their own 'smart specialization', that is to say to identify niche development strategies allowing regions to satisfy local needs and to meet global high-quality

[90] *«The term influence (the capacity or power of persons or things to produce effects on others by intangible or indirect means) is broader than 'use', creating a framework with which to examine effects that are multidirectional, incremental, unintentional, and instrumental.»* (Kirkhart, 2000: 7).

demand, in order to grow, rather than fall behind (Petrella, 2000; Crescenzi, 2005; European Commission, 2007).

We know of the existence of a meaningful connection between innovation and internationalization (Kafouros *et al.,* 2008; Cassinan and Golovko, 2011; Filippetti *et al.,* 2011): the international variables showing association are those related to inward foreign direct investments, foreign students and foreign employees[91]. When a threshold effect is reached, causal interactions from internationalisation to innovation may lead to a cumulative process affecting each other in a virtuous circle.

In addition, side by side, there is also an emerging social challenge, related to the possible use of the proceeds of growth to finance an evolving social model of welfare, healthcare and education. Within this scenario the interesting opportunities we see at the horizon are by no means guaranteed.

«How can Europe sustain its standard of live and comprehensive social system when many other competitors are able to produce goods and services at least as good as ours – and often at considerably lower costs?» The answer may be only to product outstanding goods and services that will command higher prices than anything produced elsewhere[92].

But Europe more often failed to translate its technical leadership into business and jobs[93], and even today Europe goes on sharing both the virtues and vices of maturity, it has no option but to evolve: breakthroughs centered on innovation in ICT such as superfast broadband and cloud computing, materials and nanotechnologies, mobility and robotics, mobile and remote sensors, genomics and biotechnology, all representing a wide range of growth possibilities which call for high-skilled people and the capacity to assume risks. In addition, there is a highly unexpressed potential of young innovative companies (Dewatripont *et al.,* 2010; Schuurmans, 2011). EU has fewer young firms among its leading innovators relative to the US and EU's young leading innovators are less R&D intensive than their US counterparts (Veugelers and Cincera, 2010).

This is a focal point explaining most of the differences between the old Europe and the American market. While our business environment tends to optimize existing structures, the American one has a great predilection for radical change:

«'Fail often, fail fast' is the mantra of Silicon Valley. Having tried something and failed is generally perceived as a badge of honour and as a good preparation for the next venture, whereas, in Europe, there is still a stigma associated with failure.» (Stamer, 2010: 25).

[91]Over half of the start-ups in Silicon Valley (USA) has one or more immigrants as a key founder.

[92]Even today, the world No. 1 exporter is not China but Germany – and that despite Germany's high wages and the competitive strain of a strong Euro.

[93]In the field of ITC Europe has expressed a strong leadership in the production of new ideas and innovation but not the same in the commercial exploitation. A Finn, Linus Torvalds, is the father of Linux which he started to develop as a student at the University of Helsinki around 1991. He brought the open source paradigm to its greater significance. The WWW was invented at CERN in Geneva, but the first commercial browser was created by Netscape in the US. A Swede and a Dane are the inventors of Skype which was later sold to eBay. The Fraunhofer Institute invented the MP3 codec changing music industry and allowing Apple, with iTunes, to be the only company making money from selling music on the web. Nokia, Ericsson and Siemens dominated the early days of the mobile telephony business, but it is now Apple, with iPhone, that after only three years accounts for more that 50% of all profits in the smartphone market. And the story could continue in an endless sequence of enlightening examples (Stamer, 2011).

For the future, we need players motivated to look for high-risk, high-return opportunities in high-tech businesses. Many structural deficiencies are at the origin of this gap: segmented markets; less-well functioning industry-science links; access to finance for risky breakthrough projects; the absence of a EU patent system[94]. These are all important goals on which Europe has to work hard if it want to recover against its direct competitors.

A rising consciousness is therefore emerging considering entrepreneurship combined with higher education the key drivers of innovation (LC, Ederer *et al.,* 2008), jointly with better understanding of customs, market and sales channels. Never before have skills been as central to the prosperity of regions and better life chances for individual as today (LC, Ederer, 2006; Hofheinz, 2009).

A clear-headed analysis of this point has been offered by Martin Schuurmans, chairman of the *European Institute of Innovation and Technology* (EIT) in his speech within the Lisbon Council Policy Brief for the Action Plan Europe 2020:

- *«put entrepreneurship at the heart of higher education. (…) The EU should transform the higher education landscape into one that supports and encourages the creation, production, dissemination and communication of new ideas»;*
- *«put entrepreneurship at the heart of all feature EU funding mechanisms as an enabling tool. Entrepreneurship should play a key role in all European policy programmes»;*
- *«simplify the EU programmes and instruments to achieve flexibility in support of entrepreneurship.»* (Schuurmans, 2011: 13).

Conclusively, the focus on innovation – as a broad driver for growth, inclusion and sustainability – calls for proper policies, policies which should have a privileged attention to human capital and entrepreneurship. First and foremost, the argument behind investing more in skills and human capital is fundamentally correct. Europe shall invest on the individual citizen, raising and enhancing her capabilities and allowing her to realizes her utmost potential (DTS, 2009).

We must help people – particularly the younger ones – to learn thinking creatively and to respond flexibly to global market place, where speed and innovation are as important as technical prowess (LC, Ederer *et al.,* 2008). Raising the level of education, training and employment opportunities available to all the citizens pays, both for society at large as well as for the individual. But we are still doing painfully little to take the most necessary step in this process, and particularly harmful is the high of workforce exclusion and the chronic underinvestment in education and training (DTS, 2009).

This is one on the reasons why we devoted attention to 35 regions among the most innovative throughout Europe, and even within this group we have seen outstanding differences in terms of innovative performance. But surely, all of them, devote a high and rising attention to human capital and, despite different approaches, to entrepreneurship.

The competitive advantage will shift (and it is already shifting) from big, established companies, to innovative, agile newcomers. In addition, it has been observed that the rate of innovation is increased when a specific geographical area have a higher density and diversity of people organized around a common indus-

[94] A fully integrated European patent system would create an European-wide market for technology and cooperate in cutting the huge costs of the actual, inefficient, fragmented system in which patent granted by the European Patent Office (EPO) must be managed and put in force at the national level, with the desired geographical scope for protection (27 Member States).

try (territorial clusters of innovative firms). The challenge is certainly global but the solution should be local.

The two previous point raised (human capital and clusters, as a natural seabed for innovative entrepreneurship) are two policy arenas in which local policies can have the fastest and most direct effects. Human capital is less mobile (than financial and technological capital) and therefore, factors like the availability of skilled people and the efficiency in their use, are more likely to influence the success of individual regions in the long term. Obviously there are no ready-made template or blueprint for regions seeking to device competitive-oriented policy interventions to follow. There are no cast-iron guarantee that success will follow: but regions should try. In particular, Countries performing well on human capital, always have fostered adult education and lifelong learning (Ederer, 2006). Vice versa, poor investment in adult education will lead to poor utilization of new technology and, accordingly, to lower productivity.

The possible outcome is an 'archipelago Europe' (Petrella, 2000) where the depth of cities' or regions' human capital will make the winners stand out from the losers, where the quality of the local workforce will decide the degree of their prosperity. The winners are mostly high-skilled workers in the developed world and low-skilled workers in the developing world. The losers will be low-skilled workers in the developed world.

10.4 Good indicators as a precious support in policy design and implementation

To give strength to this process we need also good indicators to monitor strategies, but these indicators call for a serious (and wider with respect to the past) engagement of stakeholders. Enrico Giovannini, the present President of the *Italian National Institute of Statistics* (ISTAT), has suggested that:

> *«Statistical indicators chosen through the involvement of stakeholders and shared by all component of the society can play a crucial role in improving policy making and increasing accountability, especially when they deal with the final outcomes that matter to people. (…) Indicators that do not relate to people's lives are seen as irrelevant or, even worse, unfaithful descriptions of what is happening»* (Giovannini, 2011: 10).

Information systems and indicators have a natural field of application related to benchmarking and its interesting implications. Benchmarking is a process by which an organization (may be a region) compare its performance (possibly using a sound metrics) to competitors, leaders, whatever other organizations identified as a 'best practice'. There are always lessons to be learnt from the way in which other regions support innovation (Minshall, 2008).

Obviously, the selection of the targets to compare with is of the greatest relevance, it involves a management work, costs and time. A main point to bear in mind is therefore that in order to make sense on a benchmarking exercise we need a focus objective – not to broad, all-embracing, and loose goal such as *«I want to become one of the top innovative regions in Europe»* – and a set of comparable competitors.

Making reference to the 35 regions chosen for the RICI construction, it is quite clear that is not particularly meaningful to compare, let's say, Burgerland (at11) with its 279 thousand inhabitants with Île de France (fr10) with its 11.5 million residents. And the same will be probably true for South West (ukk) with a GDP per-capita around 28 thousand Euros and Bruxelles (be1) with 57.3 thousand.

So, even if for European authorities a composite indicator on all their regions may be attractive and enquiring, for the single region there are two different ways to implement a benckmarking exercise.

The *first* one needs a medium-long term, and relates to the internal dynamics of the region. Having built a 10 years time series of own RICI may be very instructive to interpret the dynamics and to appreciate the impact of the policies (see § 10.6 for some further comments on this point). The *second* one is related to specific focus, as already said, for instance Lombardy region may be interested in how to improve the linkages between university R&D and small firms fabric and in answering to these questions it would be fruitful to look around to the experiences and results of other regions in Europe (but probably non the Finnish ones, too distant in terms of dimensions, industrial history, institutions, culture and national innovation systems).

From a methodological point of view it may be very instructive for regional Government to construct and to interpret a composite index on innovation. As we have seen in the various steps we have passed through, there are a number of methodological questions that draws the attention of policy makers towards having a vision on innovation, a clear idea on the undergoing process, and a sound knowledge of the regional innovation system.

In addition, looking at the strengths and the weaknesses of the region, help in selecting goals, in identifying the right structure on incentives[95], to have a strategic programming orientation capable of looking also at the medium-long term and not only to the short-term political cycle. Regional innovation policy produces outcomes that materialize over an extended period of time (OECD, 2009). Obviously in this case data collection may be costly and challenging and we are still searching for the best compromise[96].

While national statistics still play a role as contextual indicators – and they may be very useful in painting a picture on the international context – the very challenge for the future would be played at the regional level. Here a major shortcoming is always represented by available information. But even to clash with the lack of data (reliable, up-to-date, sound regional data) may give an impulse in the need for a systematic and rigorous statistical effort if we want to take informed decisions.

10.4.1 A guideline for sound indicators

In the light of the previous arguments the urgency to identify sound indicators is largely understandable; indicators which can help in measuring the state of innovative process and its progress both in time and with respect to benchmark territories; but, at the same time, the preference for considering targets in relative rather than in absolute terms. It is fundamental to bear in mind that we can't choose the same standards of success to all regions, the 'one-size-fits-all' indicator probably (and hopefully) doesn't exist.

[95] As a recent OECD study witnesses: *«attaching explicit rewards (or sanctions) to performance data can be a powerful way to encourage effort and improvement; however an explicit monetary incentive is not a sufficient condition for success.»* (OECD, 2009: 13).

[96] A very interesting experience on this point is surely that of the US *Economic Development Administration* (EDA) which has started to design and report on indicators which track outcomes three, six, and nine years after programme investments have been done [http://www.eda.gov/].

In the present Report we have worked on the RICI (composite indicator) with all the virtues and vices it has. Many other innovation measures have been proposed in the literature and, more interesting, by European institutions with the aim to overcoming the main discontents attached to the RIS one (Nauwelaers and Wintjes, 2008; DTS, 2009; Mettler, 2009). We would like to shortly reflect on two of them – among the many available – to rise some methodological questions and to stress some future path or research which is still to be done (see §§ 10.5.1–10.5.2).

As 'the best is enemy of the good' it is important to build starting from the existing proposals and to try to improve incrementally on these ones.

In doing so, we are guided by three principles which it is worthwhile to recall as a starting point because they can help in the selection process of the simple indicators.

First of all we are interested in the regional dimension (NUTS2) of innovation phenomenon. Many regions have more in common with similar areas in other Countries than they do with other regions in their own home Country. To limit to the Country level is not detailed enough for policy purposes also due to the fact that the overall innovative performance of most Countries are determined not by the performance of their leading regions, but by the size of their 'tail' of poor performers[97].

Secondly, we have in mind an eclectic and evolutive innovation model (Boschma and Martin, 2010; Bramanti and Fratesi, 2009; Malerba and Brusoni, 2007) where 'hard inputs' (R&D expenditures) are only a part of the story – not necessarily the most meaningful – and 'hard output' (patents) are not the ultimate demonstration of innovation success and in any case are very sector/technology specific (Pavitt, 1984), (while to patent is mandatory in pharmaceutics industry, in other sectors may be almost irrelevant). The emphasis on increasing R&D spending may not be the most effective way to improving European productivity, and the search for the 'optimal amount' (3% of GDP?) allocated to R&D activities is more an art that a science.

«Are we ultimately using the right indicators to measure a desired policy outcome, or are we only taking into account what can be easily measured, such as R&D spending, and using it as a simplistic proxy for assessing a complex policy phenomenon, like innovation» (Mettler, 2011: 4).

A major consequence of this idea of innovation is that more *soft factors* may be equal (and even more) interesting and, specifically, *i)* entrepreneurship (as the capacity to bear risks) and *ii)* high-skilled people (as the human capital asset on which firms may trust) are key assets for regional competitiveness.

Third, the targeting of any measurement exercise would be policy oriented: we are interest in indicator systems which may have influence on the policy making effort (distinguishing influence capacity from direct utilization, see § 10.2.1). Policy processes need tangible goalposts so that the progress evaluation can be done on comparable analysis instead of subjective, vague evaluations. This is all the most important as the Lisbon Strategy has long been considered a failure, due to the fact that it should has been monitored by a plethora of indicators agreed by a group of experts without any serious engagement of stakeholders[98] (Giovannini, 2011).

[97]An important consequence, in term of policies, is that by developing attention to the followers as to the leaders, government can drive the innovativeness of their entire economy.

[98]*«Data seem to be produced mostly for an elite target group – statisticians, policy makers, in-*

In order to fit these goals we need one (composite) or a small number of simple, easy-to-read, communicative indicators. To increase citizens awareness, to make performance more transparent, to enlarge the number of stakeholders involved in the process, all these are fundamental ingredients to meeting successful innovation process, or better, to gain the maximum from policies, devoted to foster innovation process.

10.5 Two alternative measures of innovation and human capital

Among a large set of synthetic indicators (composite, scoreboard, or more simply bulk of information) we have chosen two different ones which share some methodological features even though looking at different ends. The first one is devoted to innovation in the light of the goals of Europe 2020 strategy (§ 10.5.1) while the second one looks at human capital as a key factor for regional prosperity (§ 10.5.2).

Both address the productivity issue (Zand *et al.,* 2011) – even if in an indirect and not jet fully satisfactory way – using the proxies at hand, as the data availability constraint plays here a major role.

The *first* (HLP group) proposed a simple ‘hourly labour productivity’; the underlying idea is that innovation should ultimately be reflected on labour productivity. A more precise way to appreciate the contribution of innovation in improving global productivity would be the analysis of *total factor productivity* and indeed this is one main road to deepening research efforts in the next years.

The *second* study (LC group) measures ‘R&D and patents’ as a proxy of:

«region’s ability to attract R&D and to build confidence in the local area as a business site. Put simply, the human capital manager should focus on improving the institutional, infrastructural and social quality of the economic environment and the integration of human capital creation with the productive process – and watch for rising R&D performance as an outcome of such institutional improvements.» (LC, Ederer, 2011: 15).

What no one of the two studies does, is to look at the contribution offered to firms’ performance by management practice. There is an international evidence that the absence of professional managers is connected to poor performance and, vice versa, good management is strongly linked to good performance, and the availability of skilled people – both in management and among the workforce in general – marks an important difference between better managed firms and the rest (Collins *et al.,* 2005; Bloom and Van Reenen, 2010).

As better management practices are significantly associated with higher productivity, profitability, sales growth and firm-survival rates – and this result is not specific to Anglo–Saxon cultures (it is verified also in Continental European Countries) – the productivity issue should be probably studied with a broader scope (Homkes, 2010), looking also at the managerial practices and trying to answer to the question *«why are there so many firms which are inadequately managed?»*.

A second shared point is related to some measure of the quality of human capital not simply read with the level of attained education, but as perceived by the labour market. The two suggested alternatives are: ‘percentage of employment

tellectual leaders, academics, etc. without sufficient concern for the audience that alternatively count most, citizens and voters.» (Mettler, 2011: 9).

in knowledge intensive activities' and 'complex jobs'. The idea is the same even if the computation is slightly different (see later for any details, §§ 10.5.1–10.5.2). The other indicators are more divaricated but seem to be well coherent in their context.

Finally, one word on the 'aggregation option'. The two studies make the choice of not using a composite indicators and this suggestion seems here to be shareable. A part from the technical cautions to be considered (Arundel and Hollanders, 2008; Schibany and Streicher, 2008; Mairesse and Mohnen, 2010), the main point is that we can't select target values for a composite, we can only make comparisons with other territories or run gap analysis with respect to the 'best in class' performer. The implementation of a policy strategy, differently, needs the clear indication of a target, easy to understand and to be communicated as the 'climate change 20/20/20'[99] has widely witnessed.

10.5.1 Looking for innovation indicators within the Europe 2020 strategy

It is out of doubt that sound policy-making calls for an adequate measure of the state of innovation. Facing the Europe 2020 strategy, opens up the challenging task of suggesting and proposing a limited number of proper indicators to meet this task.

The High Level Panel on the Measurement of Innovation (HLP)[100] has proposed a short list of five indicators, finally reducen to three which are promptly available. At the very outset of the Report the HLP highlights its disapproval for the *«conceptual difficulties in precisely defining what constitutes innovative activity»* and on the *«extreme severe limitations in the availability of data»* from which the preliminary and imperfect proposal is derived[101]. The five suggested indicators are:

1. hourly labour productivity;
2. patent applications weighted by GDP;
3. percentage of employment in 'knowledge intensive activities';
4. share of fast growing and innovative firms in the economy (*data not yet available*);
5. contribution of innovative-related trade in manufactured goods to the balance of trade of goods.

The Report ends up, by presenting a further simplified scenario condensed to only three indicators directly related to the role of knowledge: the *first* on technological output (2), the *second* to the diffusion of knowledge intensity activities (3), and the *third* related to the competitive performance of innovation (5). The asso-

[99]The EU has accelerated its own policies through a comprehensive climate and renewable energy package, designed to reduce carbon dioxide emissions by 20 percent by 2020, increase to 20 percent the renewable energy share of energy mix, and improve energy efficiency by 20 percent [http://ec.europa.eu/clima/policies/brief/eu/index_en.htm].

[100]The Panel – chaired by Professor Andreu Mas-Colell – has been established by Ms Máire Geoghegan-Quinn, *European Commissioner for Research and Innovation,* and produced a Report released in its final version on September 30, 2010. Here the list of the members: M. Curley (Ireland), D. Foray (France/Switzerland), B. Hall (Netherlands/USA), H. Hollander (Netherlands), B. Huč (Slovenia/USA), H. Kagermann (Germany), F. Malerba (Italy), E. Ormala (Finland), H. Rendez (Germany), A. Salter (UK), M. Serafin (Poland), D. Vasconcelos (Portugal).

[101]The HLP has chosen to exclude a 'composite indicator' *«that would have been configured from a number of interdependent, but possibly disparate, subindicators»* (HLP, 2010: 2) according to the principles of 'simplicity and intelligibility'.

nance with the climate change target (20/20/20 target) seems to be a strengthening feature, allowing to identify a simple triadic target more easily communicable and understandable by citizens and stakeholders.

An alternative option suggested by the HLP is to simply look at the high growth innovative firms:

«A dynamic business sector is at the heart of growth, creativity and innovation. With respect to this the suggested indicator would be forward looking and compelling (young innovative firms need to grow to create employment), mobilizing (it stresses the role of business in innovation), analytically very relevant, and with strong links to policy.» (HLP, 2010: 17).

This option, to some fascinating extent, needs the immediate launch of a two-year program of data collection (and the preparatory work that this requires).

In relation to the existing measures, the 'old RIS' is considered a possible ingredient of a new 'EU wide Innovation capability Measure', provided that the composite will be based only on internationally comparable components and weights will be assigned according to a sound economic rationale. Also CIS will be surely another precious source of information but its methodology should be revised to meet higher quality standards, mostly in terms of reliability and comparability of information gathered[102] (Arundel and Kemp, 2009).

Commenting of these suggested indicators from the point of view of a 'composite indicators', we can highlight two different things.

We fully agree with the choice of the triad of indicators related to knowledge: they seem reasonably direct, easy-to-read, and policy relevant, definitely better than the 'standard input indicators' – as R&D expenditures or simple tertiary education without any further specification[103].

An unsatisfactory element is still present in the 'patent indicator' for two main reasons. *Firstly* because, as already stressed, there is a strong variance in the patenting activities among different sectors. Industrial specialization may therefore be the most important trigger for patenting.

Secondly, because the presence of patents is not a definitive measure of economic success of innovation, success which comes at the end of a more complex, articulated and less linear process. We would have preferred a joint consideration of trademarks (on which the HLP's Report has actually argued) and/or a weighted measure of patent, taking into account sectoral specialization[104].

We are rather disaffected by the national level choice – obviously understandable within the aim of supporting the Europe 2020 strategy – but not acceptable in the light of a huge and still increasing differences among European regions (NUTS2 level). Speaking about desirable properties of indicators the HLP's Report mentions: *(the indicators should be) 'decomposable',* but the regional level is hardly named and it is clear that it is totally out of the horizon of the proposed indicators. In addition, we should consider the difficulty (impossibility?) to have regional data on innovative-related trade.

The final idea we derive from the HLP's proposal is that we always need to agree on suitable, convincing compromises: in principle, all the desirable properties recalled – and the wish-list may be long enough – are shareable, but the lack

[102]And we add, the need for a stratified sample allowing to study the regional (NUTS2) level.

[103]Simply counting university graduates in a region does not tells us nearly enough about how human capital is being employed.

[104]Interestingly, some of the suggestions put forward by HLP have been adopted in the SII composite, as described in the previous Chapter 9.

of data constrain us to a smaller space of choices. While for benckmarking exercises a ‘robust composite’ may be very useful, for the sake of mobilizing stakeholders, a triad of simple indicators, perhaps, may be better.

10.5.2 The proposal of the Lisbon Council for human capital leading indicators

The Lisbon Council[105] (LC) has recently proposed a very interesting and stimulating Report devoted to human capital indicators (LC, Ederer *et al.,* 2011). There are several reasons making this exercise extremely relevant for our work.

The *first* is that it addresses regions and cities, the sub-national territorial dimension is the main focus of LC suggestions. Not only because human capital have its natural reference area in regions and cities – an interesting feature is that the same indicators *«have less predictive value at the national level than they do at the local level, due to the homogenizing effect of national statistics.»* (LC, Ederer *et al.,* 2011: 24) – but also because high-quality human capital is attracted by central region and large metropolitan area.

The *second* reason is that human capital is without any doubts a key driver of innovation process, stimulating productivity and, by this way, enhancing territorial competitiveness (LC, Ederer *et al.,*, 2006; Hofheinz, 2009).

Finally, there is a *third* reason to be remembered, human capital – and especially young people – are agents of change and evolution. But evolution in any mature system calls for mutation, selection, and replication (the Schumpeterian ‘creative distruction’ process); frequently well-off societies meet frictions and resistances towards change: evolution, in fact, may even imply shutting down and decommissioning institutions and programmes that don’t work well enough. The handless challenge of generating new knowledge, new industry and new jobs passes through a renewal of qualified human capital, and young people are at the forefront of the process.

Working on this field, the LC offers four key indicators – called *human capital leading indicators* – which shows a strong correlation with local prosperity: *i)* the number of ‘complex jobs’ in a region or city; *ii)* the number of jobs available for young people; *iii)* the ability to get the unemployed back to work; and *iv)* investment in R&D plus volume of local patent applications (a proxy for innovativeness of the region). These four indicators, taken together, explain 71% of regional differences in GDP per capita in a multivariate linear regression.

Undoubtedly, the most interesting and innovative suggestion is related to ‘complex jobs’. These are managerial positions, entrepreneurial activities or professions that typically require a university education such as engineering, law or medical services.

As human capital appears to be so important for regional prosperity, the fundamental questions we think a policy maker may ask, are the following:

- *«how can I create and empower human capital within my region?»*
- *«how can I attract high quality human capital from the outside?»*
- *«how can I use at best the human capital which my region is endowed with?»*

[105] *«The Lisbon Council for Economic Competitiveness and Social Renewal is a Brussel-based think tank and policy network. Established in 2003 in Belgium as a non-profit, non-partisan association, the group is dedicated to making a positive contribution through cutting-edge research and by engaging politicians and the public at large in a constructive exchange about Europe’s economic and social future.»* [www.lisboncouncil.net].

The concept of complex jobs brings together the endowment and the attractiveness:

«We believe complex jobs are a better magnet for talent, and offer concrete, instantly identifiable, and mutually reinforcing advantages to any human capital manager. Specifically, complex, non-routine jobs generate high economic value and are accordingly well paid. But good jobs also create more human capital via more intensive on-the-job learning than less demanding jobs, ensuring employment and high salaries and wages in the future.» (LC, Ederer *et al.,* 2011: 9).

If capital endowment is captured by complex jobs, capital utilization is appreciated by two indicators: youth unemployment (showing a 20% statistically significant correlation with regional prosperity) and long-term unemployment (which explains 18.7% of regional economic prosperity). Finally, human capital productivity – the efficiency and effectiveness with which active human capital is able to work – is measured in a more indirect way, *i.e.* through investment levels in R&D and the number of patents flowing from these investments[106].

The final steps of the LC's Report is to present a *human capital matrix* where the GDP per capita is the results of: the endowment of human capital in the region, times the human capital utilization, times the human capital productivity, plus financial capital:

$$GDP_{per\text{-}capita} = [(hc\ endowment) \times (hc\ utilization) \times (hc\ productivity)] + financial\ capital$$

In relation to our exercise we would like to stress two major points.

The *first* is the agreement with the awareness and clearness devoted to human capital. Of course there is a large accordance on the key role played by this asset on the regional chances of development, but the LC has find out three very focused and clear-cut indicators which share, in addition, all the desirable properties for becoming strong candidates in international comparisons. The check which has been done on the meaningfulness and sharpness of these indicators, in explaining regional prosperity is quite convincing and statistically reliable.

The *second* is a remark on the set of leading indicators which are all and exclusively devoted to human capital. Sustainable growth, of regions and cities, seems to be the shared meta-target of all policies – and it is here addressed in term of 'prosperity', measured by GDP per-capita. In a more complete reasoning on this issue some references to outcome indicators seem to be mandatory, and should be integrated in the LC exercise[107].

A last and general point could be rised, regarding policy implications. If we look at the data we see that manu times the most striking improvements could be obtained rising the poorest indicators (with frequently have large space of manouvre) instead of increasing the already best performing assets, which are frequently closer to the 'carrying capacity' of the system.

[106]As correctly stated, R&D is only a proxy for real productivity and therefore may be interesting to evaluate, for example, the region's ability to attract R&D from outside. Anyway, this choice does not appear to be particularly happy. Along the whole Report we have questioned on the pure quantitative dimension of R&D indicator which cannot tell us how money is spent. The risk is to transform R&D in an end in itself and to become attached to the 'research ratio' (R&D/GDP) as a kind of touch-stone of scientific success independent of the content or R&D activity.

[107]We have highly appreciated the CIS measures of innovative results of firms in terms of new products sold (the share of new-to-firm/new-to-market sale proceeds on the whole turnover), but it is possible to find out also different measures.

A sound policy implication, in the field of human capital, should be, for istance, the attention given to targeted policies in support of groups that are marginalized in the labour narket (*i.e.,* integration of immigrant and and minorities)

10.6 Back to the future: re-starting from the data

Many different points have been raised in the whole Report and a large agreed area has emerged: innovation is certainly a tool – not a goal in itself, but a powerful and effective tool – to generate socio-economic benefits and territorial prosperity. However, due to its complex, intertwined, path-dependent and cumulative functioning, a noteworthy distinctiveness of innovative paths emerge even among R&D intensive regions.

Not only innovative paths differ, but also the final results. Regions' performance, in terms of innovation outcomes, are strongly determined by three main factors:

- the *accessibility to knowledge,* which is the privileged field of all input indicators (R&D expenditures, but also 'gateway institutions' – such as universities and research centres – and networks[108], the capacity to attract external assets and innovative firms, etc.);
- the *absorptive capacity*[109] (mainly captured by intra-muros research and endowment of high-skilled workers); and

[108]The networking dimension is very important in shaping the overall innovative capacity of companies. *«The German DIW calculates a 'networking sub-indicator' which takes into account a number of factors: the degree of inter-company networking, knowledge transfer between research institutes and companies, the distribution of clusters and joint-ventures with researchers in other Countries. The results show that companies in Switzerland, Japan, and Germany place the greatest importance on networking.».* (DTS, 2009: 5).

[109]The concept of *absorptive capacity* was first defined as a firm's *«ability to recognize the value of new information, assimilate it, and apply it to commercial ends»* by Cohen and Levinthal (1990). For them, absorptive capacity depends greatly on prior related knowledge and diversity of background. The absorptive capacity is seen as cumulative, meaning that it is easier for a firm to invest on a constant basis in its absorptive capacity than investing punctually. Efforts put to develop absorptive capacity in one period will make it easier to accumulate it in the next one.

Absorptive capacity is also said to be a reason for companies to invest in R&D instead of simply purchasing the 'results' (e.g. patents). Internal R&D teams increase the absorptive capacity of a company. A firm's investment in R&D then impacts directly its absorptive capacity. The more a firm invests in research and development activities, the more it will be able to fully appreciate the value of new external information.

The concept has been further expanded by Zahra and George (2002) with a reformulation of the definition distinguishing two different absorptive capacities: 'potential absorptive capacity' and 'realized absorptive capacity'. Their new definition of absorptive capacity is: *«a set of organizational routines and processes by which firms acquire, assimilate, transforms and exploit knowledge to produce a dynamic organizational capability».*

Zahra and George go on to suggest a series of indicators that can be use to evaluate each element of absorptive capacity:

- knowledge acquisition capability (the number of years of experience of the R&D department, the amount of R&D investment);
- assimilation capability (the number of cross-firm patent citations, the number of citations made in a firm's publications to research developed in other firms);
- transformation capability (the number of new product ideas, the number of new research projects initiated);
- exploitation capability (the number of patent, the number of new product announcements, the length of product development cycle).

- the *capacity to diffuse knowledge and technology* (which we are used to measuring with patents, regulatory regimes, clusters and networks of firms, well functioning specialized labour markets).

All the best performing regions share the capacity of mastering these three factors and, specifically, exhibit: *i)* a high level of skills and effectively functioning professional networks; *ii)* the presence of knowledge spillovers from nearly technological opportunities; and *iii)* a strong interdependence among competitors. There is a well studied relation between 'absorption capacity' factors and the positive contribution they offer in explaining the level of GDP per-capita[110] (Guillamont and Jeanneney, 2006; Kneller *et al.,* 2010; Varum *et al.,* 2011).

«How can we measure all this?» In principle, a small number of indicators – we can roughly guess that ten should be enough – can give a reasonable clear picture of what is going on in this field. In practice, the severe lack of data forces to use – sometimes very disappointing – proxies, to renounce to the most powerful and clear-cut indicators, and even, as unintentional consequence, to rise the number of indicators with the idea to gathering all the available information.

Even if quantity can never be a substitute for quality in indicators selection, one point in favor of enlarging the kinds of information to be gathered, rises from the 'complementarity' issue (Polder *et al.,* 2011; Zand *et al.,* 2011).

Complementarity is related to the fact that innovation often adopts different strategies simultaneously. When this is the situation, complementarity can emerge (doing more in one thing increases returns of doing other thing). The joint adoption leads to a higher performance than the sum of the performance from their individual adoption. Complementarity may equally apply to innovation policies; the perceived obstacles to innovation can be read as an outcome of failures in innovation policy. Research suggests (OECD, 2009) that it is frequently at work and therefore governments should adopt a mix of policies to foster innovation: for instance, 'easing access to finance' *with* 'reducing regulatory burdens', or 'allowing firms to cooperate' *with* 'increasing skilled personnel recruitment'.

10.6.1 The quest for rich and well designed innovation surveys

Innovation surveys[111] are the only source of this kind of information. They are almost always very useful, providing qualitative and quantitative data on innovation activities. Anyway, there is a heavy job to be done in order to improve these surveys, particularly when we are interested in the regional level (NUTS2) of the analysis.

Apart from the essential requests for more rigorous homogeneity among different territories in running innovation survey (comparability of the sampling design, formulation of demands, etc.), the most challenging questions surely include: *i)* merging innovation survey with firm-based data on economic performance and human capital management; and *ii)* creating longitudinal datasets.

[110]This is an important element of coherence with the LC achievements: high quality human capital ('complex jobs') is conducive of high level of regional GDP per-capita, but the same human capital is the first ingredient of an effective absorptive capacity: it is the closure of the circle.

[111]The first one in Europe goes back to the '50s in Britain with the 'Science and Industry Committee' of the *British Association for the Advancement of Science,* followed in the '60s by the US with the *National Science Foundation,* and in the '70s by the *Science and Policy Research Unit* (SPRU) in Brighton (Mairesse and Mohnen, 2010).

This last suggestion is the most important, not only because of checking our own progress in time is fundamental for policymaking, but also because the attention devoted to the issue of the 'persistence of innovation' (Raymond *et al.,* 2006) is dramatically rising. This is another key question in the 'state-of-the–art' innovation research: *«do firms tend to innovate conditional on past innovation?».* The dynamics of innovation path is certainly a very challenging problem in the agenda of researchers and we need longitudinal surveys on microeconomic data (firm based) in order to grasp the real outcomes in terms of profitability and competitiveness of innovation efforts (Lööf and Heshmati, 2002; Percival and Cozzarin, 2010).

In addition, there is also a further 'technical' element in favor of longitudinal datasets: from a statistical point of view it is very difficult to infer strong conclusions regarding causality using only cross-sectional data. Accounting for individual heterogeneity may in fact reverse the conclusions of some analysis. A proper analysis of causality with innovation survey data would require structural modeling in a dynamic setting, which needs the availability of a panel data (Peters, 2006). But standard innovation surveys come in waves of cross-sectional data where the same firms are seldom surveyed wave after wave and therefore, panel data should be duly planned and performed in order to fulfill longitudinal surveys.

Closing the Chapter and the Report we cannot help recommending to improve the CIS survey which is now carried out on a two-year interval. CIS 2006 is still representing the most recent available version (and it has been used in this Report), while the CIS 2008 survey, already carried out, has not yet been released by Eurostat (at the data of closure of the present Report, June 2011, we are still waiting for the data), we should remark that it has to be substantially improved the accessibility and timeliness of the data. The urgent need for good and easily accessible indicators has never been so necessary as today.

The persisting very large intra-Countries variance – particularly on innovation issue – discourages to limiting the comparative studies only at the national level, as it is meaningless for policy purposes.

As one of the most important goals of indicator systems is to produce information elements which may improve decision making, enhance resources allocation, and increase accountability, we need that the CIS survey carefully stratifies its sample in order to guarantee an adequate and uniform coverage of NUTS2 regions.

As suggested also by practitioners (Mairesse and Mohnen, 2010), innovation surveys may have a first shared part strictly equivalent in all the European Countries – and it should be run probably yearly – and a second part, which goes in depth in the comprehension of innovation processes and results, which should be run at the regional level, maybe on a voluntary basis, every two years. We appreciate particularly non compulsory exercise because they may have a stronger effect in raising awareness of the importance of monitoring and evaluation, and on this field the political and technical challenges to implement a regional indicator system on innovation, surely enhance the regional competences in terms of designing systems, selecting indicators, achieving targets, and using explicit financial incentives.

10.6.2 The road ahead

At the very end of this Report we recall the two main points which have been emerged. The question on *«how innovation can help Europe to be competitive and* *to increase the well-being of its citizens?»* is strictly intertwined with the second one *«how can we measure innovation results?»* and *«how can these measures help the design and implementation of policies?».*

While answering to the first question is typically a policymaking problem, and all the EU is devoting its greatest efforts to this objective (LC, Ederer *et al.,* 2008; Hofheinz, 2009; Mettler, 2009), the second one seems a technical problem. Along the first eight chapters of the Report we have shown the possibility to design and compute a composite indicator on innovation activity. We have also demonstrated that the result may be robust enough, provided the construction process has respected all the methodological requirements of a consolidated technique (OECD–JRC, 2008).

Having respected all the requisites we have come out with the RICI (*Regional Innovation Composite Indicator*) which offers to the reader a non surprising well-cut rank of 35 of the most innovative regions in Europe. **Any indicator, by definition, can't be better than the data which it relies on, and this uncontestable consideration open to the point of the availability of good, reliable, timeless regional data.**

These data, to be frankly, are not still available at NUTS2 level for all the 27 Member States. Moreover, due to the vision we have embraced on innovation, the date can't be exclusively 'hard data': we need to collect 'microdata', directly gathered at the firm's level, through sound innovation surveys.

The European response to this need has been the CIS survey, certainly a good starting point on which we have to work hard in at least three directions. The *first* is the necessity of a territorial stratification of the sample in order to cover NUTS2 European regions; the *second* is to shorten the time lag[112] for the availability of the data; the third direction of improvement is a longitudinal dimension of the analysis, in order to provide panel data.

A final remark addresses directly the policy dimensions. Choosing the 'wrong' indicators means wasting valuable political (as well as financial) capital, but once the 'right' indicators have been chosen, the selection of targets is still to be done and may be as well dangerous: the 'one-size-fits-all' approach is totally inappropriate within an European scenario characterized by strong inter– and intra–Countries differences. One major point regards the identification of targets. After an endless debate on the 3% ratio (R&D/GDP) it seems much more feasible to select relative targets (for instance, in terms of rates of growth) instead of absolute ones.

The last point regards the process to be adopted in selecting and implementing the targets. **We need to establish dialogic, highly inclusive, strongly participative relationships with all the different stakeholders, and we need to correctly communicate both the process and the final goals, involving local Governments and reaching citizens**[113].

Once we have rightly selected and communicated the goals (and fixed the targets indicators) we need to reach them. A persistent mismatch between 'pious goals' and the attained results ends up in undermining participative democracy, societal cohesion and even systemic credibility, that is to say the correct identifi-

[112]In June 2011 the CIS 2008 regional data have not yet been released! This delay is quite embarrassing: delivering a black and white 'historical photo' instead of a fresh, up-to-date picture, ends up to be useless for policymaking.

[113]From this point of view the 'Lisbon strategy' seems to be a very 'worst practice', not to be reproduced in future.

cation of targets is of outmost importance. So, if we fail in achieving the goalpost, the entire policy process results in a failure: the road is marked, but the journey is still to be made.

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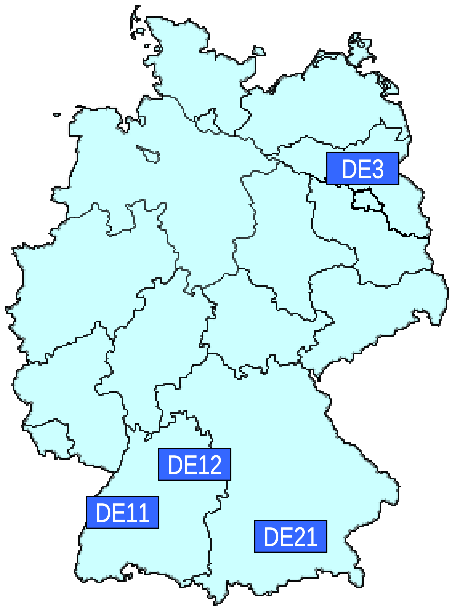
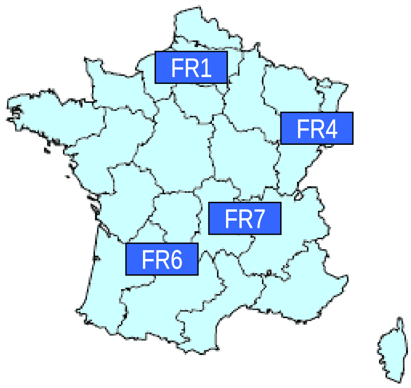
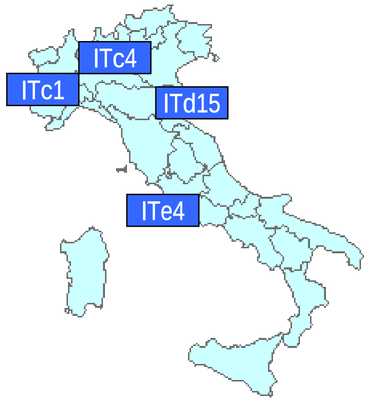
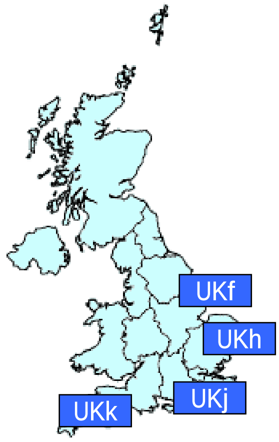
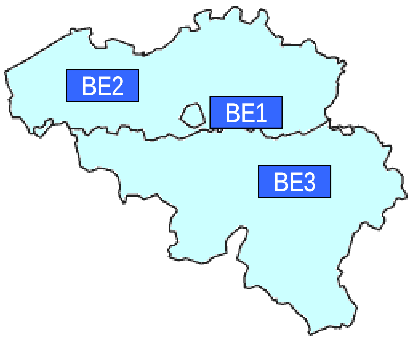
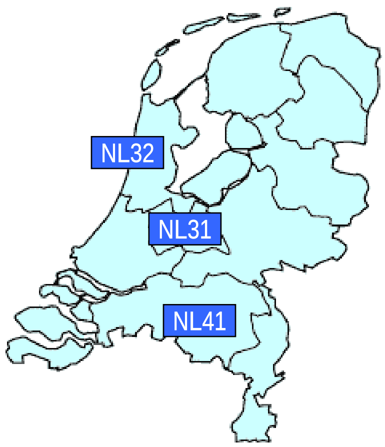
Appendix 1

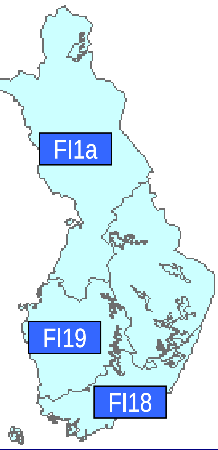
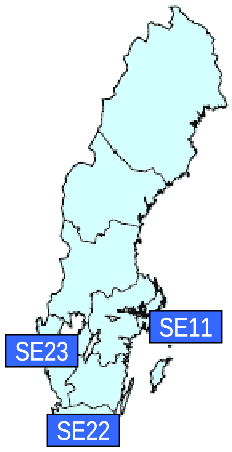
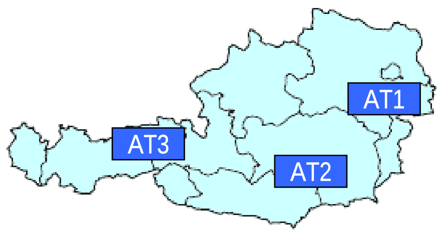
The analysed regions: a short presentation

This first Appendix report a short presentation of the 35 regions analysed in the Report. All the profiles were updated or rewritten in 2003/2004, and are taken from the Eurostat website *«Portrait of the Regions»*.

[http://circa.europa.eu/irc/dsis/regportraits/info/data/en/index.htm].

Region	Country code	Population (1.000)	GDP per-capita PPP (Euros)	Map
Stuttgart	de11	4.003	32.000	
Karlsruhe	de12	2.728	30.900	
Oberbayern	de21	4.211	39.400	
Berlin	de3	3.388	23.400	
Pais Vasco	es21	2.103	26.600	
Navarra	es22	581	26.300	
Madrid	es3	5.821	27.300	
Cataluña	es51	6.784	24.800	
Île de France	fr1	11.442	42.500	
Est	fr4	5.282	23.800	
Sud-Ouest	fr6	6.559	24.500	
Centre-Est	fr7	7.296	26.800	

Region	Country code	Population (1.000)	GDP per-capita PPP (Euros)	Map
Piemonte	itc1	4.330	26.900	
Lombardia	itc4	9.393	32.000	
Emilia-Romagna	itd5	4.151	29.700	
Lazio	ite4	5.270	29.500	
East Midlands	ukf	4.309	27.100	
Eastern	ukh	5.537	29.000	
South East	ukj	8.155	32.700	
South West	ukk	5.064	28.000	
Région de Bruxelles	be1	1.007	57.300	
Vlaams Gewest	be2	6.043	28.700	
Région Wallonne	be3	3.396	20.800	
Utrecht	nl31	1.171	37.900	
Noord-Holland	nl32	2.599	37.000	
Noord-Brabant	nl41	2.411	31.700	

Region	Country code	Population (1.000)	GDP per-capita PPP (Euros)	Map
Etelä-Suomi	fi18	2.581	34.600	
Länsi-Suomi	fi19	1.330	26.600	
Pohjois-Suomi	fi1a	632	25.800	
Stockholm	se11	1.873	45.400	
Sydsverige	se22	1.311	29.000	
Västsverige	se23	1.806	31.300	
Ostösterreich	at1	3480	31.200	
Südösterreich	at2	1.756	25.300	
Westösterreich	at3	2.966	30.300	

DE11 — Stuttgart

Geography and history

This, the largest of Baden-Württemberg's *Regierungsbezirke*, consists of 11 *Landkreise*, the *Stadtkreise* of Stuttgart and Heilbronn and 341 other *Gemeinden*. The seat of the district administration is Stuttgart.

Just over half (51.7%) of the district's 10 600 km2 is used for farming, just under a third is forested and 15% is built up or used for transport. Greater Stuttgart and its environs stretch almost 140 km from Heilbronn in the north to Tübingen/Reutlingen in the south. This, together with the Aalen-Heidenheim conglomeration, is home to 84% of the district's population. In spite of the dense settlement, there are picturesque landscapes such as the Tauberland, the Schwäbischer Wald and the vine-covered slopes of the Neckar and its tributaries.

The district is crossed by the following major European motorways: the E 70/A 81 (Eisenach-Würzburg-Zurich), die E 12/A 6 (Metz-Nürnberg-Prague-Warsaw-St Petersburg) and the E 11/A 8 (Paris-Karlsruhe-Munich-Salzburg), with the A 7 (Flensburg-Hamburg-Würzburg-Kempten) running down the eastern side.

Stuttgart and Vaihingen/Enz are on the ICE network, whilst Aalen, Crailsheim, Göppingen and Plochingen form part of the EC/IC network. Scheduled flights (including cargo and charter) connect Stuttgart directly with 112 destinations worldwide.

Industry and pig rearing

50% of the region's area is taken up by the conurbation of Stuttgart, the towns along the Neckar and its tributaries and around Aalen-Heidenheim, 21% of this area in turn being devoted to housing and transport infrastructure. The population density is 637 inhabitants per km2; 16% of the population are foreigners. The population has grown by 1.5 million people, or 76%, since 1950. Features of this industrial landscape are its major, congested motorways, power stations and power supply installations. Overall, this is an industrial area that appears to be reaching its limits.

The picture is very different in the rest of the region, which is primarily agricultural. Housing and transport infrastructure account for just 10% of the area (farming accounts for 54%). With almost a third of all pigs for fattening and 45% of breeding sows (44.91%), this is the centre of the Baden-Württemberg pig-rearing industry. The region is also famous for its wines. The centres of Würzburg, Ansbach, Ulm, Stuttgart and Heilbronn are strung around the region like pearls. The population density is 121 inhabitants per km2; 6.4% of the population holds a foreign passport. The population has risen by 170 000, or 36%, since 1950. For years, many young people left the region for training, and few returned. The entire region was thus structurally weak. However, for some years now, these areas have proved to be the most successful and dynamic in Baden-Württemberg.

Employment: Industrial growth reaching its limits

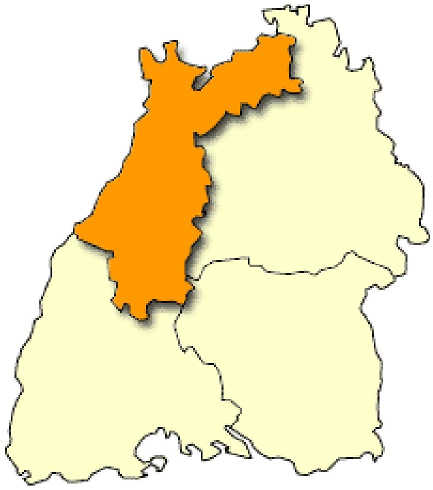
This area is most famous for its industrial products: Mercedes cars, Porsche sports cars, Bosch spark plugs, Zeiss lenses, WMF cutlery, IBM computers and Hengstenberg sauerkraut to name but a few. Around 760 000 people were employed in manufacturing in 2003. However, it seems that a limit is being reached. Employment has fallen by 165 000 since 1970. On the other hand, the tertiary sector has grown by 490 000 to almost 1.1 million employees.

Though there is a wide range of branches, 66.55% of those employed in manufacturing in 2003 were in machine and automobile construction or in the office machinery/computer industry. The dominance of mechanical engineering and automobile construction means a high level of dependency on suppliers. The Stuttgart district, accounting for 21% of all jobs in the high-tech sector, heads the European league table for the regions, though this does mean that services are less well represented.

Despite high earnings, industry is finding it particularly difficult to hire employees to work in the major urban centres, basically because of a shortage of housing and high rents. However, in terms of regional policy, the housing shortage, the labour shortage and the lack of cheap business premises do have their good sides. Industry is spreading more evenly across the area, to the benefit of areas that were previously structurally weak. The loss of green areas to development and the fear of further environmental problems have sometimes caused major projects to founder on popular resistance. This is why the region's portion of GDP fell by 0.8% between 1991 and 2001.

DE12 — Karlsruhe

Geography and history



In terms of area, the *Regierungsbezirk* of Karlsruhe is the smallest in Baden-Württemberg. In addition to the urban districts of Mannheim, Heidelberg, Pforzheim, Karlsruhe and Baden-Baden, it has 7 *Landkreise* and a further 206 *Gemeinden*. The seat of the district administration is Karlsruhe. 38% of the district's 6 900 km2 is used for agriculture, 45% is forested and 15% is built up (residential and transport infrastructure).

In addition to the conglomerations of Mannheim/Heidelberg and Karlsruhe, there is the built-up area around Pforzheim. These together account for 83% of the district's 2.7 million inhabitants. To the east, the hills of the northern Black Forest rise from the Rhine plain, giving way to the hills of the Kraichgau and the Odenwald. Mannheim, the *Land*'s busiest port, is at the confluence of the Rhine and the Neckar.

The district is also crossed by some of Europe's most important thoroughfares - the E 4/A 5 (Stockholm-Frankfurt-Lausanne) intersects at Heidelberg with the E 12/A 6 (Metz-Nürnberg-Prague-Warsaw-St Petersbourg) and at Karlsruhe with the E11/EB (Paris-Munich-Salzburg).

Mannheim, Heidelberg, Karlsruhe and Baden-Baden are connected to the German ICE network, as is Bruchsal via 'special services'. Pforzheim and Weinheim are on the IC/EC and European rail networks. The nearest airport is Frankfurt am Main. The regional airport of Karlsruhe/Baden-Baden can be used by smaller aircraft.

Sustained structural change

This district is home to one of Germany's most famous university towns, Heidelberg. With its castle ruins, this is for many the very quintessence of Germany. What is less well known is that this area was industrialized at a very early stage. As early as the mid-19th century, good transport connections meant that the area around Mannheim and the neighbouring town of Ludwigshafen had an established industry in raw materials and production goods. The working class and a critical middle class were the source and vector respectively of revolutionary thinking. Something of this remains until this day.

The recent structural changes in the secondary sector have meant the loss of 110 000 jobs in industry since 1970. This has been offset by the creation of a third of a million new jobs in the tertiary sector. The German Constitutional Court, the Federal Court and other federal and *Land* authorities, together with 21 universities and Fachhochschulen show how high-profile the public sector is.

The shift from the secondary sector and its trade tax to the public service, which yields less income, has hit many municipal coffers hard - Mannheim, for instance, recorded a debt of 435 000 million Euro in 2002. A structural change is also beginning to make itself felt in tourism: the celebrated northern Black Forest is showing negative growth rates. Attempts are thus being made to stimulate the interest of young people in the area, to "win over the guests of tomorrow". Urban tourism has seen a postive development.
In spite of a strong showing by services, the region's contribution to Baden-Württemberg's GDP grew by just 0.3% between 1991 and 2001.

The district with the greatest development disparities

This district shows a particularly heterogenous picture. The entire Rhine plain, together with the valleys in the lower reaches of the Murg, Alb and Neckar and the area around the "gold and jewellery" town of Pforzheim are amongst the more densely developed areas or are adjacent to them. These built-up areas, which account for 51% of the district in area terms, are home to 80% of the population and 85% of jobs. The high population density (668 inhabitants per km2) is particularly evident around Mannheim and Heidelberg, and the rising tide of development is already lapping at the slopes of the Odenwald. In 2003, 62% of employees were in the private services sector and the civil service.

The picture is quite different in the Odenwald and the northern Black Forest, the rural parts of the district. Here there are 147 inhabitants per km2 . Whilst the population of the Odenwald has been stagnant for the past 20 years, that of the northern Black Forest is growing dramatically. Not only is it in the Stuttgart catchment basin - it is also chosen by many as a place to retire. In both areas, the deep-cut valleys, most of which run north to south, hamper communications, this being another reason for the low level of industrial development. The dynamic axes of development are on the borders of the district, bypassing the hills.

DE21 — Oberbayern

Geography and history

Upper Bavaria is bordered to the south by the Alps and flanked in the north by the glaciated foothills of the Alps. The Alps and their foothills with their lakes (Chiemsee, Königssee and Starnberger See) constitute one of Germany's most important tourist regions. The northernmost part of Upper Bavaria actually extends beyond the Danube at Eichstätt into the terraced relief of the Franconian Stufenland.

Upper Bavaria is central Europe's gateway to Italy and the southeast. The motorways from Ulm via Munich to Salzburg and from Nuremberg via Kiefersfelden/ Kufstein to the Brenner pass are two of Germany's busiest traffic routes. Munich's new airport, opened in 1992, ensure that Upper Bavaria is well equipped to serve as a meeting place between southern and eastern Europe. In 2001 Munich handled 26 million passengers, which made it Germany's busiest airport after Frankfurt am Main.

Administratively, Upper Bavaria is divided up into three *kreisfreie Städte* (Munich, Ingolstadt and Rosenheim), 20 rural districts and 497 municipalities. Almost the half of Bavaria's area of 17 530 km² is used for agricultural purposes, one third is woodland and 10.2% is built up.

Employment

In 2002 the number of employed persons in Upper Bavaria came to 2 287 000. In the same year there were 582 400 jobs in the industry sector, or 3% less than in 1995. In the services sector 219 000 new jobs were created between 1995 and 2002 to give a total of 1 646 100 in 2002. Employment increased over this period by 15%. In 2000, 25% of those in employment were working in industry and 72% in the services sector.

In 2001, unemployment in Upper Bavaria was the lowest in Bavaria with a rate of 3.1%; long-term unemployment affected 47% of those out of work. The unemployment rate in parts of the Munich conurbation in particular was actually under 2% (Starnberg rural district). By contrast, the *kreisfreie Städte* of Ingolstadt and Rosenheim had the highest unemployment rates in the *Regierungsbezirk*.

DE3 — Berlin

Geography and history

Berlin is the capital of the Federal Republic of Germany and, in accordance with the decision taken by the German *Bundestag* on 20 June 1991, is also the seat of government and of parliament.

Berlin was given the dual status of Land and city under the terms of its constitution which entered into force on 1 October 1950 and is still valid today. Berlin is sub-divided into 12 districts (*Bezirke*), each of which has its own administration and district assembly (*Bezirksverordnetenversammlung*). Alongside the regional government, the Senate (*Senat*), and the regional parliament, the House of Representatives (*Abgeordnetenhaus*), the districts play their part in the development of the city.

Situated within the *Land* of Brandenburg, Berlin is not just the capital city but also acts as a focal point for the region as a whole.

The *Land* of Berlin today covers an area of around 892 km2 and stretches for 45 km from east to west and 38 km from north to south. Its population density is around 3 800 inhabitants per km2. The extensive wooded areas and bodies of water within the city are a feature worth mentioning, as these make up almost one-quarter of the total surface area.

German metropolis in the heart of Europe

With the unification of Germany on 3 October 1990, Berlin also regained its status as a single unit, after decades in which the two halves of the city had existed side by side as separate entities. Berlin in the 1990s was still, however, marked by major structural disparities between the two halves of the city, which have yet to be fully eradicated in the new millennium.

Employment

Around 2.43 million Berliners, or a little over 70% of the total population, are of working age of between 15 and 65. Some 50% of the workforce is made up of women. Less than two-thirds of the active population are actually in employment, so Berlin has a considerable reserve of manpower with a generally high level of training, although there are some problem groups. Of the one-third of the active population which is not in active employment, less than half are unemployed.

Focus on services

The vast majority of the working population is employed in the various branches of the service sector. Out of a total of 1.5 million persons in employment, 1.27 million are currently engaged in the provision of services, in the broadest sense of the term. The total proportion of those employed in these branches has risen from around 73% (1992) to 82% (2002), although the absolute number has only risen slightly.

The hotels and restaurants sector, which forms part of the services sector, did record a significant increase in numbers employed over the last decade (around 35%), as a result of the boom in tourism in Berlin.
As one would fully expect of a capital city, agriculture plays no role in the employment figures at less than 0.5% of the total.

Around 20% of the working population were employed on a part-time basis in 2002, with a slight upward trend. This form of employment in Berlin is still very much the domain of women, although the rate for men has risen somewhat in recent years. Almost 70% of part-time employees are women.

Continuing differences in earnings between the two halves of the city

Although unification took place over 10 years ago, there are still differences in earnings in Berlin between the former East and West of the city, in addition to the traditional differences between the earnings of manual and non-manual workers, men and women or individual branches of the economy. In the eastern part of the city, for example, manual workers earn 14% less and non-manual workers 8% less than their colleagues in the western districts. In so saying, integration in this field too is much more advanced than between the new and old *Länder*, where the difference in earnings between manual and non-manual workers is still round about the 30% mark. These differences also reflect structural disparities. There is less variation between comparable activities in comparable economic sectors.

Levels of earnings in Berlin are about the same as in the old *Länder*, more so for manual workers than for non-manual workers. Earnings are much higher than average in Berlin in the banking and insurance sectors, energy and water supply and mechanical engineering. Hotels and restaurants and the distributive trades are at the lower end of the earnings scale.

ES21 — País Vasco

Geography and history

The Basque country is one of the most distinctive regions of Spain in terms of traditions, culture and language. At the same time, together with Catalonia, it was the cradle of the industrial revolution in Spain and is one of the main centres of private banking in the country. Washed by the Bay of Biscay, it adjoins France and Navarre to the east, Rioja to the south, and Castile and Leon and Cantabria to the west.

Its main rivers, the Nervion, Urumea, Bidasoa and Orio, do not carry much water, since in orographic terms the region lies at the edge of the Cantabrian range to the west and the Pyrenees to the east.

Its climate is moist and temperate. Forests cover 54% of the total area, and there is a substantial proportion of pasture land.

Communications with the rest of Europe, through France via Irun, and with the centre and south of the country and the Ebro valley, are adequate. The official languages are Spanish and Basque, the latter a non-Indo-European language and one of the oldest in Europe.

Industrial tradition and geographical situation: two advantages for the development of the region

Factors in favour of growth are the strategic position as a bridge to the rest of Europe and its situation at the western end of the growth belt of the Ebro Valley, an established and diversified industrial fabric, a dynamic entrepreneurial tradition and a skilled labour force, and an adequate level of services. Also worthy of mention is the development of tourism, already well established, in view of the, natural resources, the beaches and the scenery.

The main obstacles to the sustained growth of the Basque economy are the relative dearth of natural resources — particularly energy — the serious damage to the environment in certain areas with a high concentration of industry and population, the excessive proportion of industry in sectors of low demand, and the persistence of outdated industrial and commercial structures which hamper the industrial changes which are needed to adapt to the single market.

Employment: industry’s important share

Of the total population 70.7 % were of working age in 2000, i.e. between 15 and 65 years, and employment was about 881 000 in 2002 (+24.2 % between 1996 and 2002). The employment rate for this year was 60.6 % and was higher for men (73.8 %) than for women (47.4 %). Both male and female activity rates increased between 1990 and 2002.

In 1999, 38.6 % of the workforce was employed in the industrial sector (one of the highest shares with Navarra and La Rioja) and 59.4 % in the service sector which is under the national average. The share of the workforce employed in agriculture and forestry was the lowest amongst the regions with only 2 %.
During the 1990’s, the female employment has been constantly increasing, and although it decreased for male, the global employment has risen as well. In 2001, the activity rate in the region was somewhat higher than the national average especially due to the rate of women.
The employment structure shows that the region is one of the most industrialized in Spain. Of the branches of industry, metal products and minerals provide the most employment, followed by construction, vehicles, paper and foodstuffs. From 1985 onwards it was above all the energy sector, food, drinks and tobacco, and construction which started to make up for the jobs lost in the previous years. Employment in services has increased substantially (particularly in the distributive trades, hotels and catering), with 86 100 new jobs between 1995 and 2001.

Relatively high labour costs

Earnings in the Basque country have traditionally been amongst the highest in Spain, and in 1999 average wages per person employed were currently 21.6% above the national average.

In 1999, the average wages per person employed in agriculture were the highest amongst the regions. In industry they were 16% over the national average and 14% over the national average for the services sector.

ES22 — Navarra

Geography and history

Situated in the north-east of the Iberian peninsula, Navarre is an autonomous community comprising a single province of 10 421 km2. The western Pyrenees form a natural frontier with France, in the region's north. The river Ebro crosses Navarre in the south, and provides it with an extensive system of canals. Like the countryside, the climate is one of contrasts, snow-covered mountains, cool mountain valleys, rain forest in the north-west, temperate green in the centre of the region, and fertile market gardening country in the south, where the climate already verges on the continental.

Navarre lies at the crossroads between the Cantabrian coast, the Mediterranean and the heart of the Iberian peninsula, but access has traditionally been difficult because of poor communications. Efforts are now being made to improve the situation, in particular by the construction of motorways and expressways linking the regional capital, Pamplona, with Saragossa, Madrid and San Sebastian. The region is linked to the main continental traffic routes via Irun.

An independent kingdom for many centuries, Navarre has traditionally enjoyed a good measure of independent authority, as is witnessed by its local laws. The region's official language is Castillan Spanish, though Basque is spoken in the areas bordering the Basque country.

A solid base for development, with local problems of access

Most of the Navarre region lies in the broad valley of the Ebro, and its geographical position allows access from the Atlantic seaboard to the Ebro corridor, fronting directly on to the single market.

The region's chief assets lie in its superb countryside, its wealth of forests and rivers, and its agriculture; a reasonably skilled work-force and substantial industrial base; together with a cultural heritage, particularly in Romanesque art, which grew up with the streams of pilgrims crossing the region on their way to Santiago de Compostela. These assets, taken together with lengthy experience of administrative and economic independence, put Navarre at an advantage compared with other Spanish regions.

Amongst the weaknesses and barriers to development, the most important remain the problems in road and rail communications. These are particularly difficult in transport within the region, because of the difficulties of access to the region's north. The lack of an industrial base is the only weak card in an otherwise excellent capacity for generating and attracting investments. And the small average size of Navarre's businesses means that, from the points of view of production, marketing and finance, they are ill-equipped to challenge their larger rivals in the single market.

Employment trends better recently, short-term employment on the increase

Of the total population 68.3 % were of working age in 2000, i.e. between 15 and 65 years, and employment was about 236 500 in 2002 (+19.6 % between 1996 and 2002). The employment rate for this year was 64.2 % and was higher for men (78.8 %) than for women (49.1 %). Both male and female activity rates increased between 1990 and 2002.

In 1999, 7.9 % of the workforce was employed in agriculture and 52.2 % in the service sector which is largely under the national average. The share of the workforce employed in the industry was one of the highest amongst the regions with 39.9 %.

The activity rate has progressed between 1990 and 2001, up from 46.8% to 51.8%. There were 235 thousands active persons in 2001, of which 61% of male. The working population has grown considerably in recent years.

ES3 — Madrid

Geography and history

The autonomous community of Madrid is composed of a single province of 7995 square kilometres and is the capital of the country. It may be divided into four areas: the (highly urbanized) metropolitan area; the Sierra in the north; the heavily industrialized Corredor del Henares in the east; and the basically agricultural area in the south. 84% of the land lies at an altitude of over 600 metres, and heights of more than 2 000 metres are reached, giving rise to a dry, continental climate with major variations in seasonal temperatures.

Its central location places Madrid in a privileged position in terms of accessibility from anywhere in Spain and also makes it an important centre for international air traffic, Barajas Airport being an important gateway to Europe for Latin America. The Madrid region thus lies between the most developed regions on the Ebro and Mediterranean axes, forming a small island of economic power at the heart of inland Spain.

Madrid: nerve centre of the Iberian Peninsula

Its central position and the role of the city of Madrid as the political and administrative capital, enables the region to act as a linchpin between the underdeveloped regions and the more developed areas of the country. This pivotal role also holds true in relations with abroad, acting as it does as a centre for the reception and retransmission of innovative ideas from the rest of Europe. Madrid is a part of the global system of cities which, thanks to air travel and information technology, is increasingly less concerned by physical distances. Moreover, the Madrid region is not only strong in advanced services, but is also the second most important industrial area in Spain (or the first in the case of high technology), the result of which is a combination allowing a sounder development than that based on services alone.

These positive aspects are counterbalanced by:

- inadequate infrastructure for transport to and within the metropolitan area;
- the deterioration of the natural environment due to pollution and the production of enormous quantities of industrial and urban waste;
- the existence of marginalized groups resulting from the high unemployment rate in some areas.

Strong concentration of economic activity and population

93% of the region's population is concentrated on only 24% of its surface area. This fact, which is common to all the capital regions in Europe, is particularly striking in Madrid, where the fall-off in population density is very pronounced (15 000 inhabitants per km2 in the centre of the city, whilst 20 km away there are some communities with less than 10 inhabitants per km2). The imbalances affect the sitting of businesses in relation to residential areas, which leads to a great deal of commuting.

The specialization in the services sector of the so-called 'central core' has led to 45% of all jobs being concentrated in this area, the figure rising to 75% for financial services and 60% for public administration.

Job creation buoyant

There has been an increasing trend of the employment during the end of the 1990's. Between 1996 and 2002, an increase of 578 300 persons took place in employment, representing an rise higher than the national average. Of the total population 70.1 % were of working age in 2000, i.e. between 15 and 65 years, and employment was about 2 318 200 in 2002 (+33.2 % between 1996 and 2002 which is one of the highest increase amongst the regions). The employment rate for this year was 62.8 % and was higher for men (76.3 %) than for women (49.8 %). Both male and female activity rates increased between 1990 and 2002.

Substantial income from property counterbalanced by a high tax burden

The Madrid region enjoys one of the highest household per capita disposable incomes in the country, although increases in recent years have been lower than the national average due to the high tax burden shouldered by this region, 8.4% of resources being set aside for the payment of taxes on income and wealth (24.8% if social security contributions are included), as opposed to 6.2% for Spain as a whole. At the same time, as might be expected of a developed region, the amount received in social security benefits is 70% that of contributions paid, whilst property and entrepreneurial income is much higher than the national average. Thanks to an economy dominated by services and industry, wages and salaries and gross operating surplus make an important contribution to income, both of them exceeding the Spanish average.

ES51 — Cataluña

Geography and history

Catalonia is situated in the north-east corner of the Iberian peninsula, bordered by France and Andorra to the north and the Mediterranean to the east and has an area of 31 930 square kilometres.

In general, the region has good communications with central Spain via Aragón and with south and south-east Spain via the Mediterranean motorway, which links up with the southern French motorway system. It also has good air and sea links, the latter mainly via the port of Barcelona being one of the largest in the Mediterranean.

The region comprises four provinces (Gerona, Tarragona, Lérida and Barcelona), and its official languages are Castilian and Catalán.

A strategic position for the extension of European development to the south

Catalonia's main advantages lie in its strategic location in the western Mediterranean, its good communications with the rest of the Iberian peninsula and its position along one of the vectors of growth from the countries of central and western Europe to the south of France and the Mediterranean.

Other factors in its favour are its long-standing industrial tradition, the wide diversification of its production structure, the development and soundness of its services sector, and the relatively high quality of its social infrastructure and amenities.

Its main problems include the great divide between highly developed areas and disadvantaged areas which have difficulties of access and poor infrastructure; the technological backwardness of some of its traditional industries (textiles, non-electrical machinery, footwear, leather goods and furs, metal products); the relatively few innovative industries; the deterioration of some of its rivers and coasts and of some urban areas (especially air pollution); and the constraints imposed on industrial and urban development by the scarcity of water resources.

Highly industrialized areas alongside rural farming

The province of Lérida is twice the size of the others, covering 37.7% of the region. On the other hand, 76% of the population lived in the province of Barcelona in 2001. The city of Barcelona had a population of 1.5 million at the first of January 2002, and there are eight other towns with more than 100 000 inhabitants (Hospitalet de Llobregat, Badalona, Sabadell, Tarrasa, Sta Coloma de Gramenet, Mataró and the two provincial capitals, Lérida and Tarragona).

Disregarding the administrative districts, the region is divided into industrialized areas which, although they were the hardest hit by the crisis in the 1980s, can be regarded as developed (the Llobregat valley, the Ripoll-Vic complex and the Barcelona metropolitan area), and the depressed areas of the interior (districts of Garrigues, Priorato, Tierras Altas and part of Ribera del Ebro). To this group can be added the mountain areas, which have the additional handicaps of natural obstacles to agricultural and industrial activities and a lack of towns of sufficient size for proper development.

Employment

In 2001, the activity rate of the total population of Catalonia was the third highest in the country after the Baleares and Comunidad Valenciana and the second in the case of the female population.

Of the total population 68.6 % were of working age in 2000, i.e. between 15 and 65 years, and employment was about 2 769 100 in 2002 (+22.8 % between 1996 and 2002 which is slightly under the national average). The employment rate for this year was 64.6 % and was higher for men (77.3 %) than for women (51.8 %). Both male and female activity rates increased between 1990 and 2002.

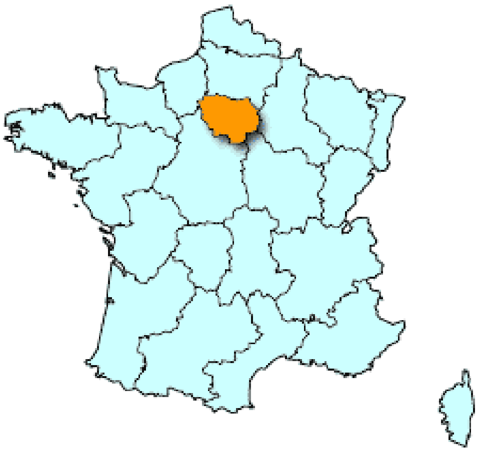
In 1999, 36.5 % of the workforce was employed in the industrial sector and 60.1 % in the service sector which is largely under the national average. The share of the workforce employed in agriculture and forestry was one of the lowest amongst the regions with 3.5 %.

There is very little part-time work compared with the national average. Its universities and the good standard of its general education and vocational training infrastructure mean that Catalonia can count on a generally well-qualified labour force.

Wide range of labour costs with a skilled workforce

In 1999, average wages per person employed in Cataluna were over the national average. For this year, the average earnings per person employed in agriculture were just under the national average while in industry they were 7.6 % over the national average and 1% over the national average for the services sector. Between 1995 and 1999, the increase of the average wages per person employed in Cataluna were slightly under the national average.

FR1 — Île-de-France



Geography and history

Nestling in the hollow of the vast natural amphitheatre formed by the Paris Basin, the Île-de-France has an area of 12 000 km2.

The relief takes the form of a gently undulating base plateau of generally calcareous rock, overtopped by a few intersected hills in the north and a larger range of higher elevations to the west of Paris. Towards the southwest, these hills become more substantial and gradually open out onto the plateau of Beauce with its covering of fertile silt, and Brie on the other side of the Seine. The Seine, the Oise and the Marne flow through all these plateaux along wide, meandering, entrenched valleys, which are mostly open.

As the climate of the region is subject to both oceanic and continental influences, it is neither monotonous nor prone to extreme conditions. The winters are not cold and very hot spells are infrequent and short-lived, even in summer.

Employment

The region accounts for one fifth of employment in metropolitan France. 5 042 000 persons were employed in Île-de-France in 1999. Between 1990 and 1999 employment in the region fell slightly (-0.1% per year), whereas in the provinces it increased by 0.5%.

At beginning of 2001 5 371 000 persons were employed in Île-de-France. The region has greatest number of employees and proportionally the second highest employee rate, after Alsace. This means that the region has the second lowest self-employed rate in France: 5.9% of the working population, compared to the national average of 9.1%.

Between 1996 and 2001 employment increased at roughly the same rate as in the provinces: 1.6%. Over the same period, the annual average growth rate of employees in the region was below that of the average for the provinces with 1.7% against 2.2%. Whereas the number of self-employed decreased in all the other regions of metropolitan France, it remained stable in Ile-de-France (+0.3% per year).

The activity rate of people between 15 and 65 years old is the highest of all the regions, at 60.9% in 2001. There are fewer young people aged between 15 and 25 on the labour market, since a large number were still at school or college. Thus the activity rate for 15 to 24 years old is the lowest in France, at 26.8% in 2001. The activity rate for 50 to 64 years old is the highest in France (66.1%); this is also true for women aged 50 or more (60.6%). Over the age of 25, the female activity rate is higher than the national average.

The proportion of foreigner workers in the working population is much higher than in any other region with 13.1% compared to the average for the provinces of 3.5%.

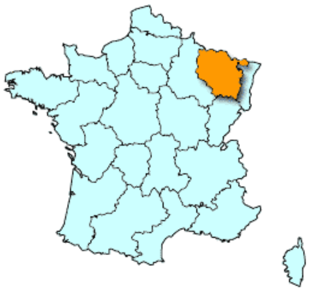
Services accounting for nearly 83% of all jobs

With the services sector accounting for nearly 83% of all jobs in the region in 2001 Île-de-France has the highest proportion of employment in services in metropolitan France. Employment in services increased by an average of 2.7% per year between 1996 and 2001. The presence of the capital city and the high level of urbanisation can explain the region’s move to the services sector. The driving force for employment is still the market services sector. The business services sector in the region employs proportionally the highest share of all employees in services with 25.3% compared to the national average of 18.5%. Since 1990 the business services sector of the region created on average 13 000 jobs per year. Île-de-France has also the highest proportion of employees working in transport (7.1%), financial services (6.1%), and real estate (2.5%). On the other hand the region has the lowest proportion in metropolitan France of employees working in distributive trades (15.4% against the provincial average of 18.5%).

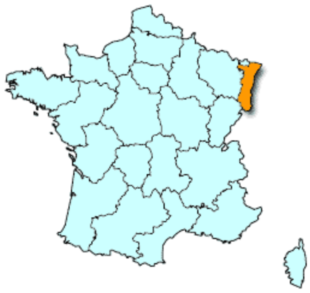
Of non-market services, Île-de-France has proportionally the lowest share of employees in education, heath and social services: 17.2% compared to the national average of 24.1%. It also has the second lowest share of employees working for public administration: 14.7% compared to national average of 16.9%.
The share of jobs in industry is below the national average (12.2% against 17.5%). Employment in industry decreased between 1996 and 2001 (-2.1% per year). The majority of employees in the industrial sector of the region work in the production of consumer goods. At the beginning of 2001, 34% worked in the production of consumer goods, which is the biggest proportion of jobs in this sector in all the other regions of France. A quarter of employees in the region worked for the production of intermediate goods; this being the smallest percentage among the regions of France.

The construction industry in Île-de-France accounts for the smallest share of regional employment compared to the proportion of jobs generated by this industry in the other regions of France. In 2001 the building trade only accounted for 4.6% of total employment in the region. Between 1996 and 2001, employment in construction in the region decreased by an average 3.1% per year, whereas for the provinces employment decreased on average by 1.8% per year.

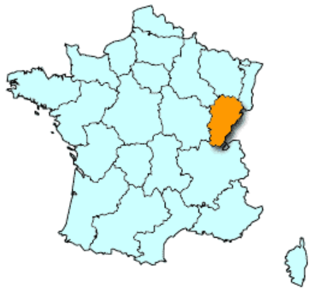
FR4 — Est [Lorraine–Alsace–Franche Comté]



FR41 (Lorraine)



FR42 (Alsace)



FR43 (Franche Comté)

FR41–Lorraine: geography and history

Lorraine comprises four départements (Meurthe-et-Moselle, Meuse, Moselle and Vosges) and occupies 23 547 km2 in a regular-shaped and well-balanced whole. The region thus matches fairly well the average French region.

The Lorraine region is divided by relief into two distinct parts: the plateau of Lorraine, occupying some five-sixths of the land area, and the Vosges mountains in the east, rising to almost 1 400 m.
The region's climate is continental and wet. Lorraine is rich in watercourses, the most important of which are the Meuse and the Moselle.

With 36.7% of the region under trees, Lorraine has a considerable and diversified wealth in forestry. Situated on France's borders, Lorraine borders Germany, Belgium and Luxembourg. Its geographical location is today a considerable asset, after a tumultuous past. Lorraine has been invaded countless times, and remained a divided patchwork until very recently. A late addition to pre-Revolutionary France, twice annexed by Germany, at scarcely any time in history had Lorraine been united until the recent creation of France's regions. The region has known three very different periods after the Second World War. From 1945 to 1962 the region was one of the greatest industrial regions of France and enjoyed considerable growth. Then the three main industries, steel, mining and textile brought the region 30 years of crisis and decline both on the economic and demographic scale. The nineties seem relatively calm even if compared to other regions Lorraine seems less dynamic.

The Moselle département maintains specific jurisdiction in certain fields, and its linguistic borderline, with Germany, runs well inside the département's frontier.

The role of regional capital is shared between Nancy and Metz. This sharing is both an asset and a liability. If the two cities add together their potential and their complementarity, the resulting conurbation may claim to be an urban region of European dimension. Taken separately, neither represents much more than an intermediate-scale urban centre.

The Meuse département, Luneville, the western flank of the Vosges and Sarrebourg tend to be more isolated and more rural. They appear rather fragile, with the problems of rural exodus and an ageing population.

Employment

The activity rate of the population aged 15 years and over is above the average for metropolitan France at 55.9% in 2001. The activity rate for 15 to 24 year olds is higher than for metropolitan France as a whole, whereas for those aged 25 and over the activity is slightly lower. The same is true for the activity rates of women.

Job creation is still below the national average. The weight of the industrial past is still a burden in Lorraine. Between 1996 and 2001 the annual average growth rate of employment in Lorraine was the lowest with the regions of Champagne-Ardenne and Picardie: 1.1%. Whereas, the annual average growth rate of employees in the region was +1.4%, the number of self-employed was -1.8%. Indeed, a feature of the region is that there are few self-employed (in farming or elsewhere). The share of self-employed, which is below the national average, fell from 8.0% in 1996 to 6.9% in 2001.

Beginning 2001, the industrial sector still offered many jobs, accounting 22.3% of all employment in the Lorraine. The share of industry is above the national average (17.5%) and above the average for the provinces (19.3%). Between 1996 and 2001, employment in industry decreased by 0.6% per year. Over the past decades the composition of industrial production has changed, with the traditional ones being replaced. The steel and clothing-textile industries now only represent 2.2% and 1.3% of jobs. New industries such as the car industry, electrical and electronic, and plastic manufacturing have taken their place. This redeployment was notably possible because of the setting up of local sites by foreign companies. Lorraine is among the first regions of France for job creation by foreign companies.

At the beginning of 2001 most employees (53.6%) of the industrial sector worked in the production of intermediary goods. This is above the average for the provinces (48.5%). 15.9% worked in the production of consumer goods, 14.4% in the car industry and 16.0% in the production of capital goods.

Employment in the construction and agriculture sectors are proportionally less important than in the provinces as a whole. In 2001 they accounted respectively for only 6.1% and 2.6% of jobs in Lorraine.
Over the decades the services sector has become the largest provider of employment. Beginning 2001, two

thirds of jobs were in the services sector. Employment in the services sector is lower than the national average (72.8%), but is roughly the same as for the provinces. Between 1996 and 2001 employment in the services sector of the Lorraine increased by 2.0% per year, whereas in the provinces as a whole it increased by 2.5%. At the beginning of 2001 the share of employees working in the market services sectors was slightly below the average for the provinces for all sectors except transport for which it is the same. The sector where the difference is the biggest is for services to households: 9.3% in Lorraine against 10.6% in the provinces as a whole. Consequently, in the Lorraine the share of employees working in non-market services is above the average for the provinces. Between 1990 and 1999 Lorraine reinforced its specialisation in public administration services, creating more than 20 000 jobs.

A consequence of the low level of job creation in the region is that the inhabitants of the Lorraine have looked beyond the region's borders. The Luxembourg and German job markets offer many jobs to the inhabitants of Lorraine. The number of cross-border workers has grown considerably, especially the number working in Luxembourg. From 18 600 in 1982, the number of cross-border workers grew to 31 000 in 1990 and 65 000 in 1999. For the year 2001 the number is estimated at 78 000.

FR42–Alsace: Geography and history

Situated in the southern part of the Rhine valley, which divides the Vosges massif (mountain region) from the Black Forest in Germany, it is bordered to the east by the Rhine, which forms the border with Baden-Wirttemberg.

To the west, the eastern slopes of the Vosges, the highest point of which is the Ballon de Guebwilier (1 424 m) are cleft by deep valleys. Passes are almost as high as the ridges and not readily accessible. The mountains are bordered by hills, with limestone slopes which are good for wine-growing. In the plain, the marshy, wooded Ried alternates with fertile terraces covered with silt. In the north, the region extends to the Lorraine plateau, an area of grass and cereals, and to the south towards Switzerland and the Belfort Gap. Alsace has a continental-type climate, with the Vosges sheltering it from the damp west winds, and the Rhine valley frequently bathed in sunshine.

Criss-crossed by trade routes, Alsace has kept its own identity, a feature of which is its German dialect which is still widely spoken.

The advantages of mixed development

Alsace presents to the world a finely balanced, harmonious landscape whose overall unity disguises different types of development in different areas.

Strasbourg (427 245 inhabitants in 1999) has important industries (mechanical engineering and agrifood), but is mainly known for its services activities (distributive trades and public services) and as the seat of European institutions. Mulhouse, on the other hand, has always been an industrial centre, with a varying economic fabric woven by successive waves of industrialization.

Alongside these major centres, a number of medium-sized towns has grown up, some of them around industries which have been brought to the area and others as dormitory towns.

With the population tending to concentrate in these urban centres, outlying rural areas are becoming disadvantaged. A further result is an army of commuters, whose daily journeys to and from work are made easier by a well-developed internal communications network.

Only a small part of the territory is directly affected by cross-border movements, but these have a substantial effect on the labour market as a whole: Basle to the south and Karlsruhe to the north are poles of attraction for workers from Alsace.

Employment

Over the nineties the Alsatian active population increased by an annual average of 1%; this is twice the national average. Three-quarters of this new working population are women. Alsace is the second region of France in terms of activity rate (58.6% in 2001) and has the most important activity rate for persons between 15 and 24 years old (40.6% in 2001). This is also true for the activity rate of women between 15 and 24 years old (38.8%).

In 2001 the most important sector in the employment is the services sector representing 67.4% of the total employment followed by the industry and construction sector representing respectively 24.2% and 6.3% of the total employment. The agriculture sector only represents 2.1% of the total employment in 2001 and has faced a decrease between 1996 and 2001 with an annual average rate of -0.6%.
The services sector has seen the highest number of jobs created from 1996 to 2001 with an average annual growth rate of 2.8%.

The construction and industry sectors have also faced a positive development since 1996 with an annual average growth rate of respectively 1.5% and 0.4%.

In areas close to the French border, the highly qualified workforce is much in demand by German and Swiss employers. The employment situation is frequently even more favourable in the regions of other countries bordering Alsace: both Baden and Switzerland have little unemployment. 70 000 persons commute across the region's borders every day, and this is a considerable advantage for the region's labour market. The economic fabric of Alsace is also highly diversified and dynamic, which generates new jobs.

FR43–Franche Comté: Geography and history

Franche-Comté is a small region with an area of 16 200 km2, representing 3% of the surface area of France. It comprises three départements of similar size (Doubs, Jura and Haute-Saône) and a fourth (Territoire de Belfort), which covers less than 4% of the region's area.

Sinkholes, long underground passageways, resurgences and grottoes all bear witness to a predominantly limestone soil and subsoil. 43% of the land area is covered by conifers and deciduous trees, making Franche-Comté the most wooded region of France along with Aquitaine. The remainder is mainly grassland, with 59% of cultivated land being given over to livestock.

The relief rises gradually from west to east, from the plain of the Saône to the Jura massif with its three tiers and moderately high skyline (1 400 to 1 700 m) along the Swiss border. Its border with Switzerland runs along 230 km.

The climate is of the continental type, with rather cold, snowy winters and warm summers. Although there is considerable rainfall, particularly on the uplands, the region is relatively sunny and not very windy. Franche-Comté is situated on the borders of the Germanic, Latin and French-speaking areas, and its roots endow it with a remarkable cultural diversity.

There are numerous development opportunities in this still relatively wide-open but nevertheless cultivated region, since although the countryside comes right to the very edges of the towns, it is never allowed to run wild. Its main assets include technical know-how, a skilled workforce and a youngish population with an efficient technical training system at their disposal.

The valley of the Doubs forms the demographic and economic backbone of the region. In the north-east, heavy industry is concentrated in the Belfort-Montbéliard conurbation, which is trying to consolidate its services sector and diversify its activities. In the centre, Besançon, the administrative capital and a university town, has to play the part of a true economic and commercial metropolis by giving fresh impetus to its development.

The Jura and the plateaux enjoy a certain degree of vitality based on craft industries, small and medium-sized firms and tourism.

Employment

The number of jobs in the region, at 451 000 at the beginning of 2001, is increasing more slowly than the increase in the working population, which has seen it ranks grow with more women. The services sector has developed and offered new jobs, especially for women, but the number of new jobs is still insufficient to employ the increasing working population and make up for the loss of jobs in agriculture and industry.

Between 1967 and 1973, employment increased at a faster rate in Franche-Comté than in the country as a whole, despite the job losses in agriculture. The first oil-price shock in 1974 affected industry. But the region came out of it relatively well; temporarily taking advantage of a productive structure that was spared more than others, the services sector making up for the job losses in industry. The effects of the second oil-price shock and the automation of production processes were more painful. The expansion of the services sector cannot make up this deficit entirely, especially as agriculture continues to decline.

Between 1996 and 2001 the annual average growth rate of employment in Franche-Comté was 1.5%, below the national average (1.7%). Whereas, the annual average growth rate of employees in the region was 1.9%, the number of self-employed was -1.3%. The share of self-employed has fallen from 10.0% in 1996 to 8.7% in 2001.

The activity rate of the population aged 15 years and over in 2001 was just above the average for metropolitan France with 55% in Franche-Comté. The activity rate for 15 to 24 years old is close to the metropolitan rate, whereas as the activity rate for 24-49 year olds is 1 percentage point higher than the metropolitan average. For women between 25 and 49 years of age the activity rate is slightly higher than for metropolitan France as a whole.

Industry is a big employer

Industry is more important in this region than in any other region of France. In 2001 it represented 27.8% of total employment. The region is highly specialised in car manufacturing and metal work which employ 43% of employees in the region's industrial sector, and generate employment in subcontracting activities too. The main employment areas are often highly specialised: for example, car manufacture in Montbéliard and Vesoul, mechanical engineering in Haut-Doubs, and electrical and electronic engineering in Belfort. Employment in industry in the region is mostly in SMEs. 21.4% of all industrial establishments employ between 100 and 499 employees, with the share of employees working in these establishments being one of the highest of all the regions in France with 45.7%. Only 1.4% of establishments employ more than 500 employees, and these account for 17.9% of all employees in industry.

The construction industry on the other hand is not a big employer. In 2001 it represented only 5.6% of total employment in the region. This is the second lowest share of the metropolitan regions, after Ile-de-France.

This high degree of industrialisation has its corollary: employment in the services sector is proportionally lower than in the national economy. With only 62.7% of total persons employed working in the services sector of the region, Franche-Comté has the lowest percentage of all the regions of France.

The proportion employed in agriculture is roughly the national average: 3.9% in 2001. Employment in agriculture in Limousin declined by an annual average rate of 1.7% from 1996 to 2001.

A region determined to improve training

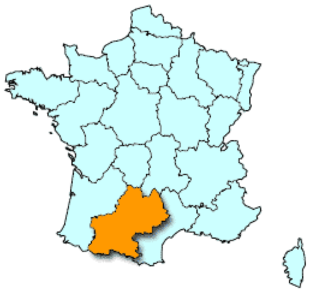
Franche-Comté has the highest share of unskilled manual workers in its total workforce of the private and semi-private sector: 14.3% compared to the national average of 10.4% in 1999. But it also has the highest share of skilled manual workers of all the regions of France: 29.7% against the national average of 22.3%.

he labour force is becoming increasingly well trained. The percentage of baccalaureates obtained by the new generations is above the average of metropolitan France (63.4% against 61.7% in 2000), and even slightly higher in the case of technological subjects. Two engineering colleges at Besançon and Belfort, specialising in training courses in optics, and the timber and dairy industries, and the technological university of Sévenans are all known and recognised outside the region's boundaries.

The number of craftsmen per 10 000 inhabitants is above the national average: 142 against 137 in 2000. 7.1% of the region's craftsmen were specialised in metalwork, representing (on a par with the region Champagne-Ardenne), the second highest proportion of craftsmen in this field.

FR6 — Sud-Ouest [Aquitaine–Midi-Pyrénées–Limousin]

FR61 (Aquitaine)



FR62 (Midi-Pyrénées)

FR63 (Limousin)

FR61–Aquitaine: Geography and history

Aquitaine comprises five départements: Dordogne, Gironde, Landes, Lot-et-Garonne, Pyrénées-Atlantiques. It has an area of 41 300 km2 (the equivalent of Denmark or the Netherlands), covering 7.5% of the country.

The relief is that of a sedimentary basin traversed by the alluvial channel of the Garonne, several kilometres wide with its banks a patchwork of market gardens, orchards and vineyards. The eastern part of the region is bordered by hills and dales, the southern part by a section of the Pyrenees range. The centre and west are covered by the vast pine forest of the Landes, stretching right to the 250 km-long, straight coastline of the Bay of Biscay.

The climate, of the southern oceanic type, is characterized by moderate temperatures with occasional heat waves. The prevailing winds, which sometimes blow up into gales, are from the west and are accompanied at times by heavy rainfall, which is evenly distributed throughout the four seasons. The winters are mild and spring comes early.

A strategic situation

Aquitaine has an outlying geographical situation in the European Union. However, it has a strategic position between the northern countries and the Iberian Peninsula. Its future depends on the improvement of its communication network towards the south and on the development of multimodal transport, an issue already planned in the development programme of the region.

Employment

In 2001 the activity rate was of 52.4%, under the average of metropolitan France (54.7%).

The 9.3% increase in jobs between 1996 and 2001 can be attributed to the rise in the number of employees, whose number increased by more than 12% between 1996 and 2001. Over the same period, the number of self-employed dwindled by more than 9.2%.

In terms of the number of employees alone, the services sector nowadays accounts for more than seven out of every 10 jobs, compared with two for industry and virtually none for agriculture.

In 2000 the construction sector experienced the biggest growth of employees and created the same number of jobs as industry did over two years. The number of employees in these two branches is growing while the number of employees in services is tending to stabilize.

However, in 2001 the services sector represented 71.2% of total employment in Aquitaine. In 2001 employees in education, health and social services represented 23.7% of total employees in the services sector, and employees in distributive trades for 19.5%.

In 2001 the employees working in the production of intermediary goods and capital goods sector represented respectively 44.0% and 31.7% of total employees in industry (excluding the agri-food industry and energy sector).

At the end of the year 2001, the unemployment rate was 9.2%, a decrease of 0.2% compare to the previous year, however still over the national average of 8.8%.

From 1990 to 1994 the unemployment rate increased, between 1995 and 1997 it remained stable. Since 1998 the unemployment rate has constantly decreased, however this reduction mainly concerned people aged less than 25 who in 2000 accounted for 19.1% of all job seekers compared to 31.4% in 1998.

Aquitaine is the French region where women are the most affected by unemployment. At the end 2001 they represented 54.7% of those looking for a job. The percentage of people looking for a job for more than one year (32.9%) is above the national average.

In 1999 average wages in Aquitaine were far below the national average in the private and semi-public sectors. However, if the Paris region is excluded, these differences disappear.

The disposable household income of 13 520 Euro per inhabitant in 1997 was close to the French average.

FR62–Midi-Pyrénées: Geography and history

With its eight départements (Ariège, Aveyron, Haute-Garonne, Gers, Lot, Hautes-Pyrénées, Tarn, Tarn-et-Garonne), Midi-Pyrénées is the largest region of France. It covers 8.3% of the national territory. Its area of 45 300 km2 has a very varied relief consisting of plains, hills and mountains of differing height:

- in the south, the Pyrénées, the highest point of which in France is the Vignemale at 3 298 metres;
- in the north and east, the Massif Central and the Quercy plateaux;
- between these areas, on either side of the Garonne valley, hills which harbour the valleys hewn out by the rivers flowing down from the mountains, constituting the only real plains in the region.

Although equally distant from the Mediterranean and the Atlantic, Midi-Pyrénées is particularly influenced by the latter. Its climate is characterized by hot, dry summers with heatwave temperatures among the highest in France and by mild winters, except on the uplands. There is usually plenty of rainfall in spring and autumn

Employment

Over a decade employment in the region grew by 0.6% per year between 1990 and 1999. At the beginning of 2001 Midi-Pyrénées represented 4.3% of employment in metropolitan France, with 1 023 000 jobs.

From 1996 to 2001 employment increased at the same rate as the average for metropolitan France: 1.7% per year. The region's rural character explains the high proportion of self-employed persons: 13% as against 9% for the country as a whole. The share of self-employed however is falling (15.7% in 1996) and the number of self-employed decreased by 2.0% between 1996 and 2001. Conversely, the annual average growth rate of employees in the region rose by 2.5%.

In 2001 the activity rate of people between 15 and 65 years old was below the average for metropolitan France: 53.9%. The activity rate for 15 to 24 year olds was nearly the same as the average for metropolitan France, whereas for those aged 25 and over the activity it was higher. The same is true for the activity rates of women.

Modernization of employment in industry

Taking the period 1996 - 2001 employment in industry grew by an average of 1.1% per year in the Midi-Pyrénées, whereas at national level it decreased by 0.1% per year. Compared to the average for the provinces (19.3%) jobs in industry in the region are proportionally fewer: 15.8% at the beginning of 2001.

The construction sector represented 6.5% of employment in the Midi-Pyrénées in 2001. This is roughly the same as the average for the provinces in general (6.3%).

The tertiary sector continues to hold up the regional economy as a whole. The region's services sector is of comparable importance as in the rest of the country, excluding the Paris region. Beginning 2001, most jobs in the Midi-Pyrénées were in the services sector (71.2%), at little bit higher than the average for the provinces (69%) in 2001. Employment in services continued to grow over the nineties: +16.5% between 1900 and 1999. Between 1996 and 2001 employment in the services sector increased at 2.4% per year; roughly the same rate as the average for the provinces. Wholesale and retail trade employed 18.1% of employees working in the services sector, business services 16.8% and personal services 10.8% in 2001.

The agricultural sector is still important in terms of employment in Midi-Pyrénées. At the beginning of 2001 employment in agriculture accounted for 6.5% of total employment in the region, compared to 3.5% on the national scale. Between 1996 and 2001 employment in agriculture decreased by 2.7% per year; nearly 1 percentage point more than for the provinces as a whole.

FR63–Limousin: Geography and history

The Limousin comprises three départements of France: Corrèze, Creuse and Haute-Vienne. With an area of 17 000 km2 it is one of France's smallest regions, covering only 3% of the country and ranking it in 16th place on the national scale.

Located in the centre west of France, 200 km from the Atlantic coast, it lies at the border of two great geographical features: the Massif Central and the Basin of Aquitaine.

The relief of the region rises gradually from west to east, with its highest point at Mont Bessou, 978 m. The western slopes face the Atlantic; those on the east merge into the foothills of the Massif Central.

Climatically the region is virtually oceanic, tending towards a mountain climate, with mean temperatures between 8° and 12°C and fairly heavy rainfall. Accidents in the relief nevertheless result in the existence of microclimates.

The land is frequently granitic or slaty, cut through by deep valleys which alternately broaden and narrow.

Water in the region originates from a multitude of springs and surface water, rising mainly on the plateau de Miltevaches. The water itself is of excellent quality.

Forest cover is fairly dense (34% of total land area), consisting mainly of deciduous natural forest (oak and chestnut), with some conifer plantations.

Employment

In 1999 272 000 people were employed in the Limousin region, of which 220 000 were employees, accounting for 1% of national employment in 1999.

At the beginning of 2001 282 000 people were employed in the region. Between 1996 and 2001 the annual average growth rate of employment in Limousin was 1.3%, below the national average (1.7%).

hereas, the annual average growth rate of employees in the region was +1.9%, the number of self-employed was -2.0%. The share of self-employed has fallen from 15.8% in 1996 to 13.4% in 2001. The high percentage of self-employed compared to the average for the provinces (9.9% in 2001) is explained by the importance of agricultural employment.

The activity rate of the population aged 15 years and over in 2001 was below the average for metropolitan France with 50.2% in Limousin. The activity rates for 15 to 24 years old (33.2%) and 25 to 49 year olds are higher than the metropolitan rate, whereas as the activity rate for 50-64 year olds is lower.

For women the activity rate is higher than for metropolitan France as a whole for all age bands. This is explained by the low fertility rate, the extent of agricultural activity with its large numbers of family workers, and the region's low average wages which mean that females' earnings are less dispensable than elsewhere. In 1999 the agricultural sector accounted for 8.2% of employment, but its share is falling. At the beginning of 2001 it accounted for 7.4%. Nevertheless, employment in the sector is still nearly twice the percentage of the national average. Between 1996 and 1999 employment in agriculture declined by an average of 2.3% per year.

Employment in industry in 2001 represented 18.2% of total employment. In 2001 60% of employees working in the industrial sector worked in the production of intermediate goods, and 20% in the production of consumer goods. The production of electrical equipment, paper and cardboard, and the agri-food industry are the main employers in industry.

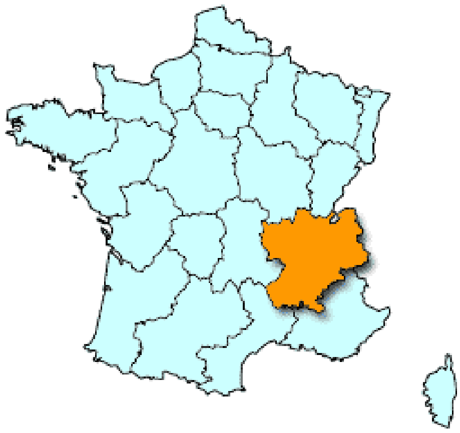
The tertiary sector accounts for two thirds of employment (68%). Employment in the services sector is less important than the national average, particularly in real estate (accounting for a mere 0.9% of total employees in services) and in business services (14.6% of total employees in services).

Low unemployment

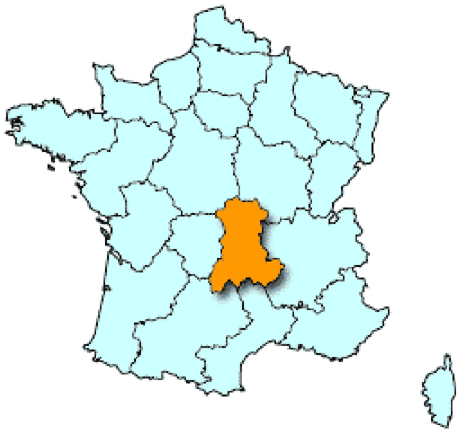
One of the consequences of the limited number of young persons arriving at working age, and of the large numbers of retirements, is that Limousin has a lower unemployment rate than the average. In June 2002 Limousin had the second lowest unemployment rate in France: 6.7%. The unemployment rate is roughly 2 points lower than the national average.

Unemployment affects young people and women more than in other regions, whereas long- term employment is less pronounced. At the end of 2001 job seekers aged between 15 and 24 years accounted for 21.6% of all job seekers in the region. This is higher than the national average. Nearly 28.8% of job seekers were registered for more than one year, which is below the national average (31.7%). The gap between supply and demand for jobs for women has been widened by the relatively high numbers of women's jobs in the traditional sectors, the end of the services-sector boom and the growing general desire for employment. At the end of 2001 female job seekers accounted for 54.1% of all job seekers, which is above the national average.

FR7 — Centre-Est [Rhône Alpes–Auvergne]



FR71 (Rhône Alpes)



FR72 (Auvergne)

FR71–Rhône Alpes: Geography and history

Rhône-Alpes is France’s second largest region (44 000 km2) and the second most highly populated. Rhône-Alpes is up made of eight départements: Ain, Ardèche, Drôme, Isère, Loire, Rhone, Savoie and Haute-Savoie. The eight départements of the region comprise nearly 10% of the national population.

The region is made up of three very different geographical zones:

- to the west, the highlands of the Massif Central;
- down the middle, the Saône-Rhône corridor;
- to the east, the high Alps including Mont Blanc, the highest peak in Europe (4 807 m).

Rhône-Alpes is notable for its highly varied relief. The mountain areas (about 600 m) account for almost half the total territory of the region.

The climate changes progressively from continental in the northern part of the region to Mediterranean in the south.

38% of the total area of the region is used for agriculture and woods and forests cover a third.

Rhône-Alpes is in a prime geographical position, with Switzerland and northern Italy as neighbours and the Mediterranean within easy reach. The Rhône valley is in fact the main corridor of communication between the north and east of France and the Midi, and between the countries of northern Europe and the Mediterranean countries

Employment

The regional activity rate is above the national average; this is true for all age groups. The most significant difference is for the age group 50 to 64, whose activity rate (60.3%) is 3 points higher than the national average. The activity rates for women are also higher than the national average, except for those aged between 15 and 24 years.

The services sector providing more and more jobs

Since 20 years, Rhône-Alpes has enjoyed a much more favourable employment growth than at national level, with employment increasing by 12% compared to the national average of 7%.

From 1996 to 2001 employment in Rhône-Alpes increased at roughly the same rate as the average for metropolitan France: 1.8% per year. The proportion of self-employed persons (9%) is the same as on the national scale and has followed the same trend. The number of self-employed decreased by 1.2% between 1996 and 2001 and the annual average growth rate of employees in the region rose by 2.3%.

Cause or consequence of the development of services to businesses, industry accounting for 22% of jobs (compared to 19% at national level) remains a characteristic trait of the region. Metalwork and smelting is the leading industrial sector of the region, employing 77 300 employees. With 71 300 jobs, the mechanical equipment sector remains one of Rhône-Alpes’s prize sectors. From 1996 to 2001 employment in industry increased very slowly (+0.4%).

Employment in the services sector of Rhône-Alpes has grown considerably over the past four decades. In 2001 it accounted for 69% of all jobs in the region. From 1996 to 2001 employment in services increased by an average of 2.8% per year.

Employment in agriculture makes a smaller contribution to total employment than at national level accounting for only 2.7% of jobs in 2001 compared to the national average of 3.8%. From 1996 to 2001 employment in agriculture decreased by an average of 1.8% per year.

Over the period 1996 - 2001 the number of jobs in the construction sector of Rhône-Alpes increased by 1% per year and accounted for 6.1% of jobs in the region.

Transborder employment exists in the départements neighbouring Switzerland. In Haute-Savoie, for example, some of its working population travels to work in the cantons of Geneva and Vaud.

FR72–Auvergne: Geography and history

Auvergne covers some 26 000 km2 in the heart of the Massif Central, culminating at the Puy de Sancy (1 886 m).

More than half the municipalities in Auvergne are classified as mountain communities. The Massif Central is fairly compact, with few valleys allowing easy access. Access is thus not easy except from the north, where it appears as a vast amphitheatre. In the heart of the Massif is a vast alluvial plain, drained by the River Allier and its tributaries, surrounded by the old crystalline rock and granite, while to the south-east and west the volcanic massifs provide the region with a unique landscape and a considerable tourist attraction. These contours help protect the central hollows from the influence of the Atlantic, but the price for this is heavy but irregular rainfall on the western and eastern ranges of hills. This contrast between the plains and the mountains of Auvergne is typical.

Auvergne is served by a dense system of watercourses. Their annual flow, some 11 000 million cubic metres, lies behind Auvergne's reputation as 'the water-tower of France'.

Auvergne is quintessential a forest region. On higher ground the ecological conditions are ideal for conifers; lower down, deciduous forest predominates.

Population concentrated in urban areas

The population is centred on the plains and the Allier Valley, the only areas where a town of any size could expand. During the last years the urbanisation of Auvergne went on. In 1999, 65% of the population was situated in urban areas; these areas also concentrated two-thirds of the regional employment (502 000 persons).

Clermont-Ferrand is the regional capital, at the foot of the mountains. But the city has also developed a substantial services sector; in 1999, Clermont-Ferrand itself has 258 541 inhabitants, but the whole urban expanse of Clermont-Ferrand houses more than a quarter of the region's total population.

Along the Allier Valley, three fair-sized towns have grown up: Montlucon, the industrial; Vichy, the spa; and Moulins, the administrative. In the mountainous southern part of the region, only Aurillac and Le Puy have achieved any size, essentially as a result of their administrative roles. These are two of France's handful of towns which, despite being situated at an altitude of more than 600 m, maintain a population of more than 20 000.

Employment

In 2001 the activity rate in Auvergne (51.2%) is under the activity rate of metropolitan France (54.7%). However the activity rate for the less than 50's reflects the French average, while the activity rate of people between 50 and 64 years old was lower than the national rate. In 2001, the activity rate of women was higher than the average for metropolitan France.

Since 1994, the number of employees is constantly increasing, however, the importance of this increase differs according the sectors: the service sector is in constant development, the wholesale and retail trade sector has also faced a positive development but to a lesser extent. On the other hand the construction industry, after having suffered form the economic crisis, is now back to its 1989 level.

In 2001, Auvergne was the region where in industry (excluding the agri-food industry and energy) the proportion of employees in the production of intermediate goods was the highest: 67.3% of the total number of employees in industry.

During the last years the number of employees in agriculture remained stable, at around 1% of the total number of employees.

In ten years, the number of self-employed persons has faced an sharp decrease, however, they still represent 15.8% of the total employment in Auvergne. Self-employed persons represent 42% of the employment in agriculture, this share being far over the national average.

Unemployment lower than the national average

Since several years Auvergne had an unemployment rate under the national average, at the end of 2001 it was of 8%. The regional unemployment is less reactive to economic fluctuations; this is due to the characteristics of the job market and the economic fabric of Auvergne.

At the end 2001 women accounted for 53.6% of all job seekers. At the same date the proportion of people who had looking for a job for more than one year was higher than the national average: 33.7% while the national average was 31.7%. The share of job seekers aged between 15 and 24 years old in the total number of job seekers was over the national average. They accounted for 22.7% of job seekers while the national average is of 19.8%.

In 1999 the annual average wages of the private and semi-public sectors were 2 000 Euro under the national average. However, the difference is less important for women than for men.

In 1997, the disposable household income in Auvergne was 1.6% below the French average, although over the average if Île-de-France is not taken into account. It increased by 3.1% per year between 1994 and 1997.

In 1999, the share of the wages and salaries in the declared tax revenue (59.9%) was under the national average (65.2%) while the share of the pensions accounted for 26.4%, being over the national average of 22.5%.

ITc1 — Piemonte

Geography and history

Piemonte means 'at the foot of the mountains' ('a pie' dei monti') and is situated in north-west Italy surrounded on three sides - north, west and south - by the great arc of the Alps and the northern Apennines, the highest point being Monviso (3 841 m). Hilly in the centre, it is bounded on the east by natural frontiers - Lake Maggiore and the course of the Ticino.

The physical features of the region - 43.3% mountains, 30.3% hills and 26.4% plains - have influenced many aspects of the social, political and economic life and the temperament of the population.

The climate is continental, with wide variations between the maximum summer and minimum winter temperatures, and there are a large number of mountain and winter sports resorts.

The river system of Piemonte essentially arises in the Alps, with the rivers arranged in the shape of a fan and flowing into the Po.

Dynamic industry, traditional agriculture

Piemonte boasts a well-established economic structure. The industrialisation which started at the turn of the century was based on the availability of hydroelectric power and on the existence of a comprehensive network of good-quality communications. The growth of small businesses followed on the rapid expansion of major undertakings such as Fiat. In fact, the development of the automobile industry made its effects felt in many sectors from rubber products to plastics, textiles, glass, etc.

Another factor in this trend was the availability of unskilled labour from the rural areas of the region and from the depressed areas of southern Italy.

This aspect of the economy of Piemonte is, however, a Sword of Damocles. Short-term economic downturns and inadequate technological upgrading to improve market competitiveness can have a ripple effect on the entire economic structure of the region. And agriculture, which makes only a very small contribution to the region's wealth, is in a very weak state - high production costs, inadequate marketing and transport networks, holdings amongst the smallest in Europe and ageing farmers.

Employment

The activity rate (% of the working population in relation to the corresponding total population) in Piemonte was 50.4% in 2001, just above the national average of 48.3%. It is however made up of a male activity rate, slightly below the national average, and which has slightly fallen since 1990, and a female activity rate, above the national average, and which has shown a positive trend in the last decade.

The employment rate (% of the working population in relation to the corresponding population in working age) is well above the national average (61.2% compared to 54.5%), and has increased by 6% since 1990. This growth has been due exclusively to the rise in the number of working women, as the female employment rate has passed from 43% in 1990 to 50.8% in 2001.

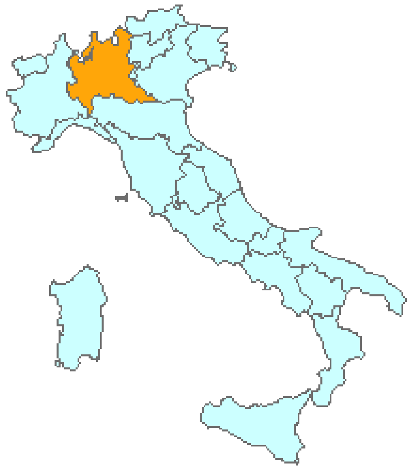
From industry to services

After the war 30% of the employed were in agriculture, whereas the figure 30 years later was only 8%. The figure has continued to fall, and in 2001 the share of those employed in agriculture was 3.7% of the total. Whereas between 1960 and 1970 industry confirmed its role as the motor of the economy of Piemonte, in the 1980s it was the services sector which absorbed much of the labour laid off as a result of industrial rationalisation. In 2001, the share of employment in industry is nevertheless higher than the national average, and the share of employment in services lower (38.2% and 58.1% respectively). Employment in the services sector has grown by 5% in the second half of the 1990's.

The level of unemployment in Piemonte, equal to 5.2% in 2001, is well below the national average (9.5% for the same year), but is the highest amongst the regions of the north of Italy, after Liguria. This level is the same as it was at the beginning of the 1990's, although there has been a slight rise in the male unemployment rate and a slight fall in the female unemployment rate. Almost half of the unemployed persons in 2001 were concerned by a long term unemployment (more than 12 consecutive months).

ITc4 — Lombardia

Geography and history



The region of Lombardia covers just under 18 391 km2, corresponding to 7.9% of the national territory. In terms of area, Lombardia is the fourth region in Italy, after Sicily, Piemonte and Sardegna. 40.5% of the regional area is mountainous, both to the north, where the Alps form a natural border with Switzerland, and to the southwest, where the mountainous area of Pavia reaches the Apennines of Piacenza.

The hilly area (representing 12.5% of the regional territory) has also two distinct features: the Alpine foothills, which cross the entire region longitudinally, from the lake ‘Maggiore’ to the lake of ‘Garda’ and, to the south, the hilly ‘oltrepo’, rich in high quality vineyards. The fertile plane of the Pianura Padana extends between these two belts, covering 47% of the regional territory.

The fertility of this area is guaranteed firstly by the river Po, which crosses longitudinally the whole area of Lombardia, marking the boundaries of the region with Emilia-Romagna for a long stretch. The major left tributaries of the river Po, such as Ticino, Adda, Oglio, Mincio, are not less important: the first borders Piemonte, the second (and longest: 313 km) flows between the provinces of Milano and Bergamo, the third between those of Bergamo and Brescia, and finally the last borders the region of Veneto. Their rivers, in turn, feed the major lakes of the region, the biggest of which, Garda, is almost 400 km2 in surface.

The vast extension of the mountainous and hilly areas leads to the presence of a rich forest area, equal to over 5 thousand km2, which corresponds to 21.7% of the entire regional area, even though the region has a high density, both of population and of industries (382 inhabitants per km2 and 31 enterprises per km2, around the double of the national average).

Concerning the use made of the land, around 46% of the regional surface is given up to cultivations (amongst which cereals and fodder predominate), whereas just less than a quarter (23.2%) is destined to non agricultural uses (building and infrastructure, etc). One fifth of the total area (21.3%) finally, is made up of protected areas (parks and natural reserves), a share more than double of the national average (10.5%) and below only those of Abruzzo and Campania.

Employment

Lombardia has registered a progressive improvement in recent years in its level of employment.

The activity rate reached 64.9% in 2001 (compared to a national figure of 60.8%) with a rise of 0.9 points with respect to the previous year. This rise has concerned both men and women: the male activity rate in fact passed from 75.3% to 75.9%, whereas the female rate rose from 52.4% to 53.7%. These figures translate in a total increase of 60 000 ‘active’ persons. Demographic forecasts for 2010, however, foresee a reduction in the active population of almost 200 000 persons, due to the fall of the population in active age, even when taking the labour force foreseen from immigration into account.

In 2001, the number of persons employed grew by 84 000 (2.2%) with respect to the previous year, with a consequent fall in unemployment, leading to an unemployment rate of 3.7%. Both male and female unemployment rates have been falling in the last years, reaching respectively 2.5% and 5.5%. In particular, there is a constant growth of persons employed with new kinds of non-standard contracts, such as part-time, fixed term and interim contracts.

Employment by sector

The 2001 figures on employment confirm the importance of the services sector of the economy, which employs 58.2% of the total workforce (compared to a national figure of 63%), equal to 2 305 000 persons. The agricultural sector, which had remained stable for a few years in terms of persons employed (80 000), registered a fall in employment in 2001. The industrial sector, on the other hand, has grown in the last years, after the fall registered in the 1990s, reaching a share of 39.9% of total employment in 2001, well above the national average (31.8%). Employment in construction has been following a positive trend in the last few years.

Wages

According to the data available on wages in Lombardia (which is taken from administrative sources and should thus be considered with caution), the average wages in 2000 were 8.2% higher than the national average. The highest level can be found in the province of Milan (7.7% higher than the regional average), whereas the lowest level in the province of Sondrio (about 17% lower than the regional average).

ITd5 — Emilia-Romagna

Geography and history

The region of Emilia-Romagna consists of nine provinces and covers an area of 22 124 km2. Nearly half of the region (48%) consists of plains while 27% is hilly and 25% mountainous. The Emilia-Romagna section of the Apennines is marked by areas of flisch, badland erosion (calanques) and caves. The mountains stretch for more than 300 km from the north to the south-east, with only three peaks above 2 000 m - Monte Cimone (2 165 m), Monte Cusna (2 121 m) and Alpe di Succiso (2 017 m).

The plain was formed by the gradual retreat of the sea from the Po basin and by the detritus deposited by the rivers. The geology varies, with lagoons and saline areas in the north and many thermal springs throughout the rest of the region as a result of groundwater rising towards the surface at different periods of history.

All the rivers rise locally in the Apennines with the exception of the Po, which has its source in the Alps in Piedmont and follows the northern border of Emilia-Romagna for 263 km.

Well integrated at sectoral and territorial levels but an uneven age pyramid

Emilia-Romagna is located in one of the most developed parts of Italy and one of the earliest areas to become industrialised: the Adriatic belt which follows the old Roman road, the Via Emilia, from Piacenza to the Adriatic coast. The process of industrialisation took root in the 1950s, using capital from farming, and developed throughout the region without being concentrated in any specific area, covering all sectors, overcoming the barriers which traditionally excluded the weaker parts of the economy. There is a fairly homogeneous business structure, comprising mainly small and medium-sized firms.

Another point in Emilia-Romagna’s favour is the intense specialisation in the sector of mechanical engineering, textiles, foodstuffs and ceramics, which makes the region one of Italy’s foremost export areas. Tourism, after the slump in 1988 as a result of the pollution scare in the Adriatic, generally revived in 1990 with a restructuring programme involving investment in upgraded facilities and staff. There is a risk, however, that this pattern of brisk economic growth may be disrupted by the gradual ageing and the steady thinning of the working population. The massive influx of immigrants (17 000 in 1999) will go some way towards meeting the shortage of labour in the region but it is also creating other problems of social integration.

Employment

The activity rate (% of the working population in relation to the corresponding total population) in Emilia-Romagna is amongst the highest in Italy. In 2001, it was equal to 52.3%, compared to a national average of 48.3%. Whereas the male activity rate (62.2% in 2001) has remained more or less stable since 1990, the female activity rate has increased from a level of 39.9% in 1990 to 43.2% in 2001. It is amongst the highest in Italy, after Valle D’Aosta.

The employment rate (% of the working population in relation to the corresponding population in working age) in Emilia-Romagna, equal to 65% in 2001, is the highest in Italy. It has increased by 3% since 1990. This increase reflects, however, a fall of 3% in the male employment rate, and a rise of 12% in the female employment rate.

The increased number of women in employment has been accompanied by a massive drop in the number of jobs in farming, a slight fall of the employment in industry, and a rise in the services sector.

In 2001, the share of workforce in agriculture (5.6%) was in line with the national average (5.2%), the share of those in the industrial sector (35.9%) was slightly above the national average (31.8%), and finally the share of those working in the services sector (58.5%) was slightly below the national average (63%). Amongst those working in the services sector, there is a slightly higher share than the average of those involved in trade, hotels, transport, etc., and a slightly lower share of those in the public administration.

ITe4 — Lazio

Geography and history

Divided administratively into five provinces (Viterbo, Rieti, Rome, Latina and Frosinone) and with an area of 17 227 km2, Lazio is split geologically into three areas which run parallel to the coast: an interior area of limestone mountains, an intermediate area marked by seismic features and a coastal area of alluvial plains. Mountains comprise 26% of the territory, with the highest peak rising to 2 455 m, while hills and plains account for 54% and 20% respectively of the territory. The climate is maritime along the coast, temperate in the hill areas and continental in the mountains.

The Vatican City State is located within Rome itself. Since the unification of Italy the area around the city has been greatly influenced by the capital, whereas the rest of the region, comprising territories which formerly belonged to other States, has retained some of the social and cultural characteristics of these other areas.

Stable employment and potential to be exploited

One of the strengths of the region is the stability in the working population. The city of Rome (which, according to the last Census in 2001, has nearly 50% of the total population of the region) accommodates various government ministries and head offices of State-run bodies, national banks and a wide variety of other organisations. This means that a large proportion of those in employment benefit from ‘job security’, and even if in 2002, 10% of employees had a fixed term contract.

This advantage also hides a weakness, however, since it has prevented the development of an entrepreneurial class with modern business skills. The fact is that the existence of so many people with ‘safe jobs’ has in turn ensured the growth of retail, craft and services activities, which also ‘play safe’. While this situation has eroded the social differences which are more apparent in other regions of the country, the widespread prosperity of the region has attracted workers from outside the EU who are bringing with them the inevitable problems of immigrant labour.

Thanks to the Jubilee in the year 2000, these have been given proper publicity, in order to generate more tourism and visitors steered towards the smaller towns in the region.

Population and economic activity concentrated around Rome

The domination of Rome and the effects of certain political and economic decisions in the past have split Lazio into two distinct parts. Upper Lazio, comprising the provinces of Viterbo and Rieti (with 37% of the region’s area and 8.5% of its population), has an economic structure based on family and small firms, while lower Lazio, which consists of the provinces of Latina and Frosinone (32% of the region’s area and 19% of the population), is more developed industrially due to the presence of big industries.

Between the two lies the province of Rome, with a much higher population density and where industry and high-tech services coexist. The smaller provinces are still at a disadvantage because, apart from the road network (basically all roads still lead only to Rome), there are differences in the provision of other infrastructures as well.

Employment

The activity rate (% of the working population in relation to the corresponding total population) in Lazio is in line with the national average. In 2001 it was equal to 48.6%.

The employment rate (% of the working population in relation to the corresponding population in working age) is also very close to the national average (53.7% in 2001). Since 1990, the overall rate has remained at the same level, whereas the male rate has fallen by 4.7%, and the female rate has increased by 6.6%.

In 2001, the share of employment in agriculture was the fourth lowest among the Italian regions (2.7% of the total) after Lombardia, Friuli-Venezia Giulia and Liguria. The situation is of course very varied around the region, with the share of total employment rising to 12.7% in the province of Viterbo.
Employment in the industrial sector is also very low, with a share of 17.8% of total population employed in 2001, the lowest in Italy after Calabria. The national figure equalled 29.4% in the same year.

The share of employment in the services sector, on the contrary, equal to 79.5% of total employment in 2001, is the highest in Italy. This is due to the high number of persons employed in the public administration, as stated above.

UKf — East Midlands [Derbyshire and Nottinghamshire – Leicestershire, Rutland & Northamptonshire – Lincolnshire]

UKf1 (Derbyshire and Nottinghamshire)

UKf2 (Leicestershire, Rutland & Northamptonshire)

UKf3 (Lincolnshire)

UKf1–Derbyshire and Nottinghamshire: Geography and history

Derbyshire and Nottinghamshire are located in the north of the English Midlands, with a total area of 4 788 km². Both counties are landlocked. The north of Derbyshire contains the southern end of the Pennine hills in an area known as the Peak District, which is noted for its rugged scenery. The Peak District National Park borders partially on the north of Nottinghamshire. Most of the centres of population and industry are in the lower-lying southern and eastern parts of the counties, in the valleys of the rivers Trent and Derwent. By far the largest is the Nottingham urban area with a population of over half a million, making it the largest conurbation in the East Midlands. Other main centres are Derby to the west and Chesterfield and Mansfield to the north.

The area is traversed by the M1 motorway, which is the principal north-south road route through England. The A1(M) also runs north-south through the area in the east of Nottinghamshire. Nottingham, Derby and Chesterfield are all located close to the M1, as is East Midlands international airport to the south. The A52 trunk road runs east to west and links Derby with Nottingham and the east coast. The A50 trunk road passes through the south of Derbyshire linking the M1 to the M6 at Stoke on Trent. Main-line rail services are available linking the area with London to the south and Yorkshire, the North East and Scotland to the north.

Decline of traditional industries

Historically, the two counties lay at the heart of the East Midlands coalfield, which was until around a decade ago the most productive coalfield in the country. Rationalisation of the coal-mining industry over the past two decades has reduced employment significantly and there are now only a handful of pits remaining.

Another traditional industry that has declined in the past few years is textiles and clothing, which has generally shed labour as companies have switched production to the Far East.

Derby is an important city in the engineering industry with Rolls Royce and Bombardier (the train manufacturer) in the city and Toyota a few of miles to the south-west. Rolls Royce has suffered from the downturn in the aeronautical industry since the aeroplane-based terrorist attacks in the USA of September 2001. Toyota, however, have recently moved to a third shift at their plant. Nottinghamshire by contrast has a wider employment base that includes pharmaceuticals, food processing and electronics, in addition to engineering, but is now dominated by the service sector.

Nottingham, the regional centre

Differences in industrial structure and settlement patterns throughout Derbyshire and Nottinghamshire are basically derived from the geography underlying the region. The total population in 2002 was nearly 2 million inhabitants, with a 4.4% increase since 1982, and an average population density of 415 inhabitants per km².

The north is generally more sparsely inhabited, with a number of smaller communities that traditionally served the coal-mining industry. Also the north and west of Derbyshire are mainly covered by the uplands of the Peak District. In the district of Bolsover in northern Derbyshire nearly a quarter of all employment is in the energy and water supply industry. Similarly, in Newark in Nottinghamshire this proportion is one in five.

The city of Nottingham has an economy depending much more on services, reflecting its role as the regional centre. Nearly a half of all employment is in 'other services'.

Recent movements in population broadly follow national patterns; there has been a fall in population in most urban areas and corresponding increases in more rural areas. The largest growth in population from 1982 to 2002, in LAU1 areas, was almost 15% in Rushcliffe in Nottinghamshire. The decline in urban area population has however been much less pronounced than is the case nationally. The biggest fall in population from 1982 to 2002 was in Nottingham city, a decrease of 3%.

UKf2–Leicestershire, Rutland & Northamptonshire: Geography and history

These three counties, with a total area of 4,902 km², are situated at the southern end of the Midlands and therefore benefit from their central location in England. The largest city is Leicester, with a population of over a quarter of a million, although the urban area based on Leicester is significantly larger, with a population of 400,000. Other urban centres are Loughborough, Northampton, Corby and WelIingborough. Some parts, particularly in the north of Leicestershire, are forested; most notably Charnwood forest in the north-west. Much of the land however is used for agriculture; principally arable farming and stock rearing in Northamptonshire, while there is more dairy farming in Leicestershire.

Due to their central location, the counties have good communications with much of the UK. The main north to south road route is the Ml motorway which runs from London to Yorkshire. Both Leicester and Northampton are situated close to this motorway. Birmingham to the west is connected by another motorway, the M6, which affords access, via the M5, to the south west and Wales. East Midlands international airport is located in the extreme north of Leicestershire. It serves the entire East Midlands region, providing scheduled services to Europe.

Central location and good communications

The counties' central location and good communications have allowed them to establish a wide economic base, particularly in manufacturing and distribution. The unemployment rate, at 4.1% in 2002, is below the national average of 5.2%.

The traditionally important industries in Leicestershire, footwear and clothing, have been joined by manufacturing, particularly plastic manufactures, and electronic engineering. Footwear and clothing manufacture is also important in Northamptonshire, as is food processing. However, recent years have seen particular growth in packaging and distribution due to the advantageous location of the county and the availability of land for commercial use. Daventry International Rail Freight Terminal (DIRFT) has created over 370,000 m² of outline planning consent for distribution and warehousing land since the early 1990s.

Nearly 40 % of the work-force of Daventry in Northampton works in the construction, distribution, transport and communication sector. In many districts elsewhere in the county, manufacturing is the largest sector — employing over half the total in Corby.

Northamptonshire has two so-called new towns: Corby new town, established in 1950, and Northampton new town, established in 1968. The closure of the steelworks at Corby in the mid-1980s led to severe unemployment, and measures to combat this included the establishment of an Enterprise Zone to stimulate the local economy. An Enterprise Zone has also been established in Wellingborough. Although some areas remain above the average for both the region and the UK (notably Corby, which in October 2003 had a claimant count 0.5 per cent above the regional average,) all other Northamptonshire authorities perform better than the UK.

In Rutland, the largest single sector, in terms of numbers employed, is public administration, education and health, followed by distribution, hotels and restaurant employees, which reflects the importance of tourism in the local economy.

Sparsely populated rural areas, densely populated cities

The total population of the counties is around 1.6 million inhabitants (in 2002) and has increased by 12.5% since 1985. The population density is of 321 inhabitants per km².

Much of this sub-region is rural, though population density is increasingly heavy with Leicestershire now above the regional average and Northamptonshire very close. The city of Leicester is the most densely populated district, with over 3 800 persons per km². At the other extreme, Rutland, Melton in Leicestershire, and Daventry in Northamptonshire each have around 100 persons per km².

In Britain generally, inner city and more urban districts have experienced declining populations over the last few years while those for more rural districts have increased. Hence for Leicestershire, the district of Oadby and Wigston, a suburb of Leicester, together with Leicester city have seen their populations fall since 1982 whilst that of Rutland increased by over 5%.

In Northamptonshire, the pattern is more unusual because the district containing the largest town, Northampton, also contains a rapidly expanding new town. The population of Northampton district has thus increased by 20% since 1982. In contrast, the depressed economy of the other new town, Corby, saw its population increase by only 2.8% over this period, much less than that for the UK.

UKf3–Lincolnshire: Geography and history

Lincolnshire is a historic county and the birthplace of influential figures in many different fields. Such notable people include Sir Isaac Newton, who set down the laws of gravity, the poet Lord Tennyson, the founder of Methodism John Wesley, King Henry IV of England and Britain's first female Prime Minister, Margaret Thatcher.

Lincolnshire is the largest county in the Midlands, and is the fourth largest county in England, covering an area of 5 921 km². It is predominantly low-lying although two ranges of rolling hills cross the county from north to south. On the western border with Nottinghamshire is the Lincolnshire Edge, whilst in the centre of the county lie the Lincolnshire Wolds. To the south east lie The Fens, a low-lying marshy area surrounding the inlet known as 'The Wash'.

The county has long been one of England 's foremost agricultural areas with The Fens having been subject to drainage for land reclamation since the dark ages. 87% of the county's area is now given over to agriculture. Of this area, 77% is used for crops such as wheat, barley, oilseed rape, sugar beet, open grown vegetables, potatoes, bulbs and flowers.

The county's population, 658,000 in 2002, is widely dispersed. The largest urban centre, Lincoln, has a population of 86,000, with the other two sub-regional centres being Grantham (38,000) and Boston (36,000). There are 19 other urban areas and market towns, with populations ranging from 2,000 to 22,000.

The importance of agriculture has largely determined the industries that have developed in these towns: food processing, agricultural machinery and distribution being examples.

Two trunk roads cross the county north to south, the A15 links Lincoln with Hull to the north, while the A16 joins Spalding and Boston with Grimsby. The A1(M) trunk road passes through the south-west of the county. Transport links generally in the county are poor.

High productivity agricultural land but poor communications

Lincolnshire's principal natural assets are its very productive agricultural land and its coastal scenery. The importance of agriculture and horticulture has had both advantages and disadvantages for the county. Arable farming on large mechanised farms predominates. While this means that the county's agriculture and horticulture is highly efficient, the high degree of mechanisation means that the industry is unlikely to provide new jobs and employment in agriculture and horticulture is more likely to fall in the medium term. Industries serving agriculture, or integrated with it such as agricultural engineering and food processing, provide a somewhat wider economic base. However, the prevalence of agriculture and horticulture is a factor in keeping average earnings in Lincolnshire amongst the lowest in England. It is thought that a large proportion of seasonal work in agriculture is often formed from illegal or 'grey' economy migrant workers. The county's unemployment rate of 4.0% in 2002 was lower than the national average.

The relatively sparse population together with a rather peripheral location have meant that historically the county has had poor communications with the rest of the country. Development of transport infrastructure on The Fens is further hampered by the inherent problems of building on the low-lying marshy ground. Though improved communications have encouraged the growth of tourism in the county, poor transport remains a barrier to economic growth. The coastal resorts of Skegness and Mablethorpe in particular attract visitors from the East Midlands, principally from the conurbations, though again problems in employment result from the seasonal nature of many jobs – Lincolnshire and particularly the coastal Local Authorities experience the widest swings of in-year employment levels in the East Midlands.

Agriculture in rural areas, services in the cities

Much of the county is agricultural. More than one-tenth of the work-force in the districts of East Lindsey and North Kesteven are engaged in agriculture, while South Holland has one of the highest proportions in the UK: more than one in seven of the workforce. The city of Lincoln is the county's administrative centre and so has a high proportion of employment, nearly half, in the 'other services' sector. Manufacturing is most important in West Lindsey and South Kesteven.

The average population density in the county is 111 inhabitants per km². It is by far the highest in the city of Lincoln : at over 2,400 persons per km². This is 15 times as high as any of the other NUTS3 areas. East and West Lindsey have the sparsest populations — the density of settlement in these districts is less than 75 persons per km².

As with many of Britain's rural areas, the population of Lincolnshire is increasing rapidly as people choose to move from urban to rural locations. For the county as a whole, the population rose by more than 19% over the period 1982 to 2002.

UKh — Eastern [East Anglia – Bedfordshire, Hertfordshire – Essex]

UKh1 (East Anglia)

UKh2 (Bedfordshire, Hertfordshire)

UKh3 (Essex)

UKh1–East Anglia: Geography and history

East Anglia constitutes the northern part of the East of England region. It is bounded by the two other sub-regions of East of England to the south - Bedfordshire & Hertfordshire and Essex - and by East Midlands to the north west. The north-eastern and the eastern parts of the region are bordered by the North Sea. In terms of its administrative structure, East Anglia is made up of the Cambridgeshire, Norfolk and Suffolk County Councils and the unitary authority of Peterborough. It covers an area of 12,561 km².

The Breckland, an area of sandy heathland and forest in the centre of the region, and the Broads, large-scale medieval peat workings subsequently flooded, have become tourist attractions.

Population

In 2001, there were 2.2 million inhabitants in East Anglia. Between 1981 and 2001, the population increased by 21.5 per cent in Cambridgeshire, 13.5 per cent in Norfolk, 17.9 per cent in Peterborough and 11.3 per cent in Suffolk – significantly higher than the UK average of 4.8 per cent. However, the region remains sparsely populated with 173 people per square kilometre, compared to the UK average of 244 people per square kilometre.

The four main urban centres (Cambridge, Ipswich, Norwich and Peterborough) contain around a quarter of East Anglia's population and Cambridge, Ipswich and Norwich each have population densities of over 2,000 persons per square kilometre. However, in Ipswich and Norwich the population has actually been falling — by 2.4 per cent and 3.5 per cent respectively over the period 1981 to 2001. This is in marked contrast to the remainder of the region: in the East Cambridgeshire district the population growth over this period was nearly 36 per cent.

East Anglia has an older age structure than the United Kingdom as a whole. In 2001, the proportion of people aged under 25 in the region was lower than the UK average (29.5 per cent compared to 31.2 per cent respectively) while the share of people aged 65 and over was higher (17.8 per cent compared to 15.9 per cent for the UK).

In 2001-2002, the birth rate in East Anglia, of 10.2 per thousand inhabitants, was lower than the death rate, of 10.5 per thousand inhabitants. This suggests that recent population growth has been due to migration. Furthermore, the infant mortality rate was lower in the sub-region compared to the UK.

Economy

East Anglia has a broad economic base. There are significant clusters of biotechnology and Information and Communications Technology (ICT) based companies in and around Cambridge. This biotech cluster is the largest in the world outside of the United States. The Cambridgeshire Fens, one of the most fertile areas in the East of England, has a local economy that is predominantly agriculture based. Agriculture and related industries also make a major contribution to the Norfolk economy. Industries that are strongly represented in Suffolk include food and drink, telecommunications and transport. Over the past fifteen years, agricultural and manufacturing employment has declined. There has been a growth in the service sector, which reflects the national trend.

1.1 million persons of working age in East Anglia were employed in 2001. The proportion of the working age population in employment was six percentage points higher than the national average while the inactivity rate was three percentage points lower. The percentage of people unemployed and claiming benefit in 2003 was also below the national average in all but four of the 23 districts: the cities of Ipswich and Norwich and the coastal areas of Great Yarmouth and Waveney all experienced high unemployment levels.

Part of East Anglia is included in the London-Stansted-Cambridge corridor. This is one of four growth areas in the United Kingdom. These areas have experienced significant economic success resulting in pressures on housing and services which cannot readily be dealt with within existing towns and cities. New and expanded communities are therefore needed to support the sustainable growth of these areas. Within the London-Stansted-Cambridge corridor, growth has been underpinned by clusters of some of the United Kingdom 's most successful businesses in biotechnology, life sciences and ICT. Funding has been provided to help with the consequent need for increased housing provision, with Cambridge experiencing considerable shortages of affordable housing. Growth in housing provision will also, over time, require significant improvements to transport infrastructure.

Infrastructure

There are two regional airports - at Norwich, which provides scheduled services to continental Europe, and Cambridge. The ports of Felixstowe and Ipswich are two of the five ports forming the Haven Gateway Partnerships. This represents the single most important cluster of ports in the United Kingdom. The Partnership provides a framework within which its partner organisations from the private and public sectors can work together to promote economic opportunities and secure future prosperity. Felixstowe is the largest container port in the United Kingdom and the fifth largest in Europe : the new Trinity terminal expansion, which will allow the largest container vessels to dock, is expected to be fully operational by July 2004.

There has been significant investment in wind-generation in East Anglia, particularly offshore. Thirty wind turbines, generating a total of 60 megawatts, were installed on Scroby Sands in 2004, 2.3 miles off the eastern shore of East Anglia. Wind farms have also been approved to generate over 3,600 megawatts in the Greater Wash area, to the north-west of East Anglia.

UKh2–Bedfordshire, Hertfordshire: Geography and history

Bedfordshire is situated in the southwest of the East of England Region and is separated from Greater London by the county of Hertfordshire. The area’s administrative structure consists of the Bedfordshire and Hertfordshire County Councils and the unitary authority of Luton. It covers an area of 2,878 km².

Hertfordshire has a wide variety of towns from the old Roman town of St Albans (Verulamium) to four new towns at Hemel Hempstead, Hatfield, Stevenage and Welwyn Garden City. Welwyn Garden City was also one of the pioneer planned garden cities (with Letchworth) in the early 20th century.

Population

Bedfordshire and Hertfordshire had a population of over 1.6 million inhabitants in 2001. Between 1981 and 2001, the population increased by 10.7 per cent in Bedfordshire, 7.0 per cent in Hertfordshire and 12.7 per cent in Luton - considerably higher than population growth across the United Kingdom (4.8 per cent). The Bedfordshire and Hertfordshire region has a population density of 558 inhabitants per square kilometre (2001 figures).

Of the two counties, Hertfordshire is fairly heavily populated with 631 inhabitants per square kilometre while Bedfordshire is more sparsely populated with 323 inhabitants per square kilometre. The most densely populated district in the Bedfordshire and Hertfordshire area is the unitary authority of Luton. With 4,295 inhabitants per square kilometre, Luton is the third most densely populated district in England outside Greater London.

The age structure of Bedfordshire and Hertfordshire is slightly younger than that of the United Kingdom as a whole. In 2002, the proportion of people aged under 25 in the area was marginally higher than the national average (31.5 per cent compared to 31.2 per cent in the United Kingdom) while the share of people aged 65 and over was lower (14.6 per cent compared to 16.0 per cent nationally). This situation was particularly evident in Luton where 36.4 per cent of inhabitants were aged under 25 and just 12.1 per cent were aged 65 and over.

Population growth as the result of natural causes rose in Bedfordshire and Hertfordshire in 2001-2002. The birth rate was higher than the national average at 12.4 per thousand inhabitants while the death rate was lower than the national average at 9.0 per thousand inhabitants. The infant mortality rate is also lower in Bedfordshire and Hertfordshire than across the UK.

Economy

The electronics, light and precision engineering industries are major employers in Bedfordshire. Advanced automotive engineering and research has developed from a traditional motor vehicle manufacturing heritage. Sectors that are important to the Hertfordshire economy are the fast growing, high technology and high value added industries, including biotechnology and pharmaceuticals, electronics, film, TV and Media and Information Technology.

Both counties have significant areas of land devoted to farming. In Bedfordshire about half of the county’s land area is devoted to agriculture and in Hertfordshire farming and market gardening is concentrated in the north of the county. Approximately 30 percent of the wards in Bedfordshire and Hertfordshire are classified as rural.

The counties of Bedfordshire and Hertfordshire have the advantages and disadvantages that accompany close proximity to the political and administrative centre of the country in Greater London. A number of people in the area, especially those in Hertfordshire, commute to London to work.

0.8 million persons of working age in Bedfordshire and Hertfordshire were employed in 2001. The proportion of the working age population in employment was over 5 percentage points higher than the national average while the inactivity rate was almost 4 percentage points lower. The percentage of people unemployed and claiming benefit in 2003 was also below the national average in all of the 22 districts apart from Luton.

Part of Bedfordshire and Hertfordshire is included in the Milton Keynes-South Midlands growth area. This is one of four growth areas in the United Kingdom. These areas have experienced significant economic success resulting in pressures on housing and services which cannot readily be dealt with within existing towns and cities. New and expanded communities are therefore needed to support the sustainable growth of these areas. Within the Milton Keynes-South Midlands growth area, Bedford and Luton have been identified as key centres for growth due to their status as major transport nodes and to address their significant regeneration needs.

Infrastructure

Luton airport, on the southern border of the county of Bedfordshire, and close to Hertfordshire, is the seventh largest airport in the UK. It is an important international transit point, especially for charter flights. In 2001, 6.5 million passengers used Luton airport.

UKh3–Essex: Geography and history

Essex, historically the 'land of the East Saxons ', is situated in the south-east of the East of England Region. In terms of its administrative structure, Essex consists of Essex County Council and the two unitary authorities of Southend-on-Sea and Thurrock. It covers an area of 3,670 km². The south-west of Essex borders London and is made up of industrialised urban and suburban areas although Essex is neither prominently urban nor rural in character. Chelmsford is the administrative centre of Essex with Clacton-on-Sea and Southend-on-Sea being principal seaside resorts.

Its terrain is generally flat; the chalk highlands in the north-west slope gradually south and east towards the low alluvial coast with its many inlets and coastal islands. Much of what used to be marshland has now been reclaimed. Essex borders the River Thames to the south, which the Lea and Roding rivers flow into, and the Crouch, Blackwater and Stour flow into the North Sea.

Its coastline, though still consisting of marshland in parts, also provides important port facilities.

Population

The population of the sub-region increased by 9 per cent to 1,616,000 between 1981 and 2001; this was nearly twice the rate of increase for the UK. The south-west of the county, with a number of commuter towns, is very densely populated.

The age structure of the population is fairly well balanced but some of the coastal areas, particularly Tendring, have a much higher percentage of people who are older.

In 2001, the birth rate of 11.0 per thousand inhabitants was higher than the death rate of 10.1 per thousand inhabitants in 2001. The infant mortality rate is lower in the sub-region compared to the UK.

Economy

Essex is an established base for businesses engaged in electrical engineering, mechanical engineering, motor vehicles, chemicals, pharmaceuticals, plastics, financial and business services and research and development. Although the County's manufacturing base has declined in recent years service sector employment has increased, particularly in banking, insurance and business services.

In 2003, the number of people unemployed and claiming benefit in the county of Essex was considerably below the rate for the United Kingdom in all districts. However the rate for Southend-on-Sea was above that of the United Kingdom.

Part of the sub-region to the south is included in the Thames Gateway growth area – one of four growth areas in the United Kingdom. These areas have experienced significant economic success resulting in pressures on housing and services which cannot readily be dealt with within existing towns and cities. New and expanded communities are therefore needed to support the sustainable growth of these areas. Within the Thames Gateway, considerable funding has been provided to help with improvements in housing provision and infrastructure, the remediation of brown-field land and the regeneration of existing communities. Initiatives covering education, health and environmental programmes have also been provided for.

Infrastructure

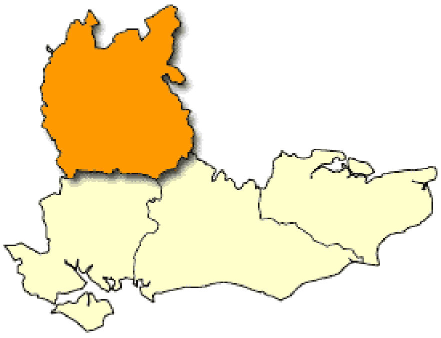
The county has two airports. The airport at Stansted, to the north of London and close to the M11, is London 's third airport and is the fastest growing in the country with plans approved for a second runway by 2012. The airport at Southend-on-Sea is small with little international traffic.

Essex has a road network of approximately 7,500 kilometres in length. A number of major strategic roads radiate out from London and across Essex. All are linked by the M25, which encircles London and runs along the south-western border of the county. The M25 crosses the Thames from Thurrock in Essex to Dartford in Kent. The county has excellent radial rail links with London, with over half the stations in Essex within one hour of The City of London.

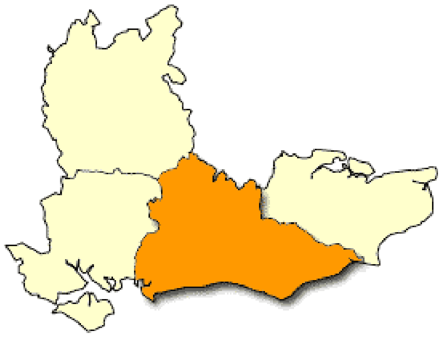
The area is also an important gateway to Europe through the seaports of Harwich and Tilbury. The port of Tilbury, which handles containers, bulk grain and forest products, is developing into a freight distribution hub and Harwich is benefiting from the increase in sea-borne container traffic. The number of passengers using ships to and from the port of Harwich was around 1.3 million in 2002.

The ports of Harwich International and Harwich Navyard are two of the five ports which form the Haven Gateway Partnerships. This represents the single most important cluster of ports in the United Kingdom. The Partnership provides a framework within which its partner organisations from the private and public sectors can work together to promote economic opportunities and secure future prosperity.

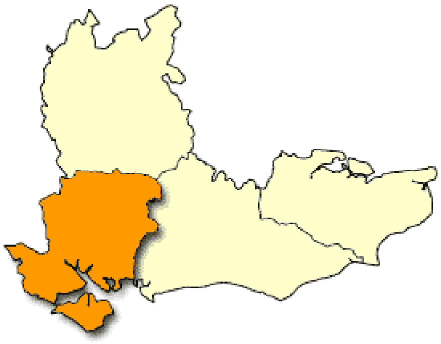
UKj — South Est [Berkshire, Buckinghamshire, Oxfordshire – Surrey, East-West Sussex – Hampshire, Isle of Wight – Kent]



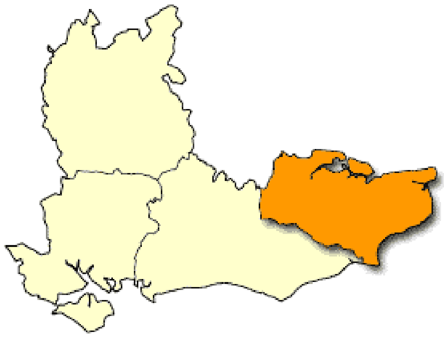
UKj1 (Berkshire, Buckinghamshire, Oxfordshire)



UKj2 (Surrey, East-West Sussex)



UKj3 (Hampshire, Isle of Wight)



UKj4 (Kent)

UKj1–Berkshire, Buckinghamshire, Oxfordshire: Geography and history

This area forms the north-western quadrant of the South East region with a total area of 5,741 square kilometres.

English local government reorganisation in 1997 saw the establishment of Milton Keynes as a Unitary Authority separate from Buckinghamshire. Similarly in 1998, 6 Unitary Authorities – Bracknell Forest, West Berkshire, Reading, Slough, Windsor and Maidenhead and Wokingham – were established to replace the county of Berkshire.

The 6 Unitary Authorities which replaced Berkshire have a combined area of 1,259 square kilometres and are relatively populous compared to Buckinghamshire and Oxfordshire. They occupy a long narrow area which follows the Thames Valley from its border with Greater London westwards. Oxfordshire, which borders them to the north, has the smallest population of the three areas. Buckinghamshire, to the east of Oxfordshire, is only some 30 kilometres wide and about 60 kilometres from north to south, with Milton Keynes located to its north.

Reading and Milton Keynes are the most densely populated parts of the sub-region. Oxfordshire, which is still largely rural, lies almost entirely within the Thames Basin. The most densely populated area is in and around the county town of Oxford itself. The most densely populated areas of Buckinghamshire are in and around High Wycombe and Slough.

The most notable building in Berkshire is the very large Royal Castle at Windsor, which is near to the famous racecourse at Ascot.

Chequers, the Prime Minister’s official country residence since 1921, is in Buckinghamshire, close to London.

Thames Valley, an important economic place

The Thames Valley area has one of the lowest unemployment rates in Western Europe and the entire area has been highly successful in attracting key industrial sectors such as computing, research and development, business and financial services, telecommunications, pharmaceuticals and the automotive industry. Nevertheless, there remain some pockets of social exclusion at Slough, Reading, High Wycombe, Milton Keynes and Oxford. The area has proved a highly attractive location for inward investors. However, strong economic growth has created pressures for more skilled employees and pressure on transport and housing availability. Forecasts have suggested that the Thames Valley economy will continue to grow at a faster rate than other areas. Ensuring that growth is managed in a sustainable way is one of the challenges for the area.

Buckinghamshire shares a small part of its border with Greater London. Oxfordshire is only 50 kilometres from the centre of London with good road and rail links. The whole area, which has fertile soils and mixed economies, has the advantages and disadvantages of being in close proximity to the administrative and economic centre of the country.

A significant number of residents in Reading, Slough, Windsor and Maidenhead & Wokingham are employed in London. Incomes are therefore among the highest in the country but so are land and house prices.

Oxford is famous for its ancient university but the town has also attracted a wide range of institutions of further and higher education both in the public and private sectors. Cowley, a suburb of Oxford, is a major industrial centre (motor vehicles and pressed steel mainly for the Rover Group). The economy of modern Oxfordshire is nevertheless basically agricultural. The North Oxfordshire Heights are important for livestock farming, especially sheep, mostly on large farms.

There is no heavy industry in Buckinghamshire but High Wycombe still has a reputation for furniture manufacturing and there are important factories at Aylesbury and Bletchley.

Differences reduced by good communications

The towns nearer to the metropolis have experienced more growth in terms of both industry and population. Further from the capital the region is more sparsely populated and is more rural in character. This is particularly true of Oxfordshire both to the west, in the Vale of the White Horse, and to the north, in the area of Chipping Norton.

The imbalances are nevertheless reduced by good communications; particularly the M1 motorway, which passes close to Milton Keynes. Similarly, the M4 runs through the Thames Valley linking London to Wales and the west of England. The M40 motorway to the Midlands runs through the county of Oxfordshire and has therefore tended to reduce the remoteness of parts of that county. The M25 and railway lines also link different parts of the region to the capital.

The New Towns of Milton Keynes and have gone some way to reducing the imbalances in economic development in the various parts of the region.

UKj2–Surrey, East-West Sussex: Geography and history

Surrey lies to the south of London and has surrendered some of its territory to the metropolis over the years. Surrey, whose county town is Guildford, is mainly low-lying, but across the middle of the county from east to west run the chalk North Downs (uplands) narrowing in the west to the Hogs Back.

West Sussex is one of the most wooded counties in Britain. The larger towns in the county include Crawley to the north, near the Surrey border, and Worthing and Bognor Regis on the south coast which attract many tourists.

The chalk ridge of the South Downs runs south-eastwards across the counties of West and East Sussex forming imposing cliffs between the resorts of Brighton and Eastbourne, notably at Beachy Head. Arable lands are found on the coastal plain while the area around Worthing, which has attracted relocated offices from London in recent years, is still a centre for market gardening.

English local government reorganisation in 1997 saw the establishment of Brighton and Hove as a Unitary Authority separate from East Sussex.

Most of Surrey and part of West Sussex is protected by ‘green belt’ regulations and the South Downs in East and West Sussex are an Environmentally Sensitive Area.

There are many horse-racing courses in the area including Epsom, where the world famous Derby is run each year.

The pull of London versus the pull of the coast

Surrey is an expensive and popular area from which residents commute across the county boundary into London. West and East Sussex, further south, have good train services from the larger towns to London which enable many residents also to commute to London for work.

The M25 London orbital motorway runs on an east-west axis through Surrey. The M23 links the M25 to Gatwick airport, near Crawley, which is London ‘s second airport and has served to increase economic activity in the area still further. Rail links with London are good, with main line links to the coastal towns and the South West.

Although all three counties are relatively prosperous by UK standards there are considerable differences from one area to another. In Surrey, earnings are high and unemployment is low even by the standards of the South East. A similarly favourable picture applies to West Sussex. In East Sussex however, which is largely rural and has very few high-technology industries, earnings are lower and unemployment is near the UK average.

Imbalances among the three counties are related in part to their proximity to London. Surrey has a denser population than the other counties and is popular with London commuters. The coastal areas of East and West Sussex and the more rural areas inland offer relatively lower-paid jobs in the tourist industry and a smaller number in farming and horticulture.

As far as industry is concerned, Surrey and the Crawley area are popular locations for inward investors with many company headquarters locating there. Financial services, information technology, call centre and service sectors are also strong in the area, and tourism remains important to the economy of the Sussex Coast.

Labour costs are relatively high, especially in Surrey and West Sussex. Unemployment has however been low in those two counties by UK standards, at 2.5% and 2.3% respectively compared to the UK average of 5.0% in 2001. The popularity of Surrey and parts of West Sussex, together with some of the coastal resorts, has made property very expensive in those areas. East Sussex has been generally less prosperous than the other two counties, but it has many tourist attractions including some historic sites.

UKj3–Hampshire, Isle of Wight: Geography and history

Hampshire stretches north from a central position on the English south coast. The Isle of Wight is a small diamond shaped island of only 36 kilometres from east to west and 22 kilometres from north to south, separated from the mainland by a strait known as The Solent.

English local government reorganisation in 1997 saw the establishment of Portsmouth and Southampton as Unitary Authorities separate from Hampshire. From 1995 the Isle of Wight was similarly established as a Unitary Authority.

Hampshire is bounded by Dorset and Wiltshire to the west, the 6 Unitary Authorities making up the former county of Berkshire to the north, and Surrey and West Sussex to the east. Outside the South Hampshire urban area, which includes Eastleigh, Fareham and Gosport, much of Hampshire consists of open countryside, of which 15% is Green Belt land and over 20% is designated as Areas of Outstanding Natural Beauty (AONB). The New Forest, a former royal hunting ground, is internationally recognised for its beautiful landscape and rich natural habitat.

The county of Hampshire has always had a strong agricultural base, its main agricultural concerns now being dairying and cereal production, and there is still a large area of woodland — for instance, in the New Forest.

There is a broad belt of rolling hills with a chalk bedrock running across Hampshire from east to west. On the Isle of Wight, the geology, and therefore the scenery, is more varied. The island is largely rural with popular holiday resorts on its south-east coast at Sandown, Shanklin and Ventnor that enjoy some of the highest sunshine levels in the United Kingdom.

The tugboat and the tug of London

Although Hampshire is on the south coast, its north-east tip is only some 50 kilometres from the centre of London and so residents in that area can readily commute to London. The major settlements and most of the industrial developments on the south coast are around Portsmouth and Southampton, which are also key commercial deep-sea and ferry ports. Economic growth has also been encouraged around Andover, Basingstoke, and to a lesser extent Farnborough where new office and industrial development has been concentrated.

On the other hand, employment growth is restricted in the centre of the county around the region of the cathedral city of Winchester.

In Hampshire average earnings are similar to the average of the South East, which puts it well above the average for the United Kingdom as a whole, and unemployment rates are low. In contrast, the Isle of Wight, which is only about one-tenth of the size of Hampshire, earnings are lower and unemployment is higher than in any other county in the South East. The relative remoteness of the island has enabled it to preserve its rural character and to attract tourists.

Although only relatively small with a population of around 130,000, the Isle of Wight nevertheless has frequent ferry, hovercraft, hydrofoil and air services to the mainland.

Mainland versus the Island

The most obvious imbalance within the region is between the county of Hampshire, Southampton and Portsmouth on the mainland and the Isle of Wight. Hampshire is a prosperous county with important growth areas particularly around Basingstoke and Farnborough. There are also important growth areas around Southampton and Portsmouth. In contrast, the Isle of Wight is one of the least prosperous areas of the South East with relatively few employment opportunities and, despite quite frequent and varied means of crossing The Solent to the mainland, it nevertheless suffers from its relative inaccessibility.

Southampton is a very important passenger port and perhaps the most successful of the UK 's seven 'free ports'. Further down Southampton Water, at Portsmouth and Gosport, is one of UK 's principal Royal Navy centres and there is a large important oil refinery at Fawley on the western shore. It also has diversified its economy with a special emphasis on electrical and electronic engineering.

On the Isle of Wight, agriculture, shipbuilding and aircraft construction offer some employment but tourism, notably at Freshwater, Yarmouth, Ryde, Sandown-Shanklin and Ventnor are more important to the economy.

The sub-region in general remains an attractive location for businesses and its overall level of unemployment is generally low, though there are pockets of deprivation in the south. Southampton is a key national port concentrating on freight container traffic. Throughout the region the service sector, both public and private, provides the bulk of employment, though manufacturing continues to provide jobs on a large scale, particularly in the south, and many are still dependent on agriculture, both directly and indirectly, for their livelihood.

UKj4–Kent: Geography and history

Kent, sometimes called 'the Garden of England ', is on the south-eastern tip of England, only 30 kilometres from the coast of northern France. It has a long coastline, with the Thames Estuary to the north and the Strait of Dover to the south and east. To the west, it has a common border with the Surrey, East and

West Sussex region. The North Downs which run broadly through the centre of the county from west to east are gently rolling chalk hills that end at the White Cliffs of Dover.

English local government reorganisation in 1998 saw the establishment of Medway as a Unitary Authority separate from Kent.

Kent gets its title ‘the Garden of England ‘ mainly because of fruit growing, especially apples and cherries, and hop growing, largely in the Medway valley and north Kent. Further upriver the area is more industrial and paper making is an important activity.

About half the agricultural land is under grass, on which both cattle and sheep are raised. This is a particular feature of the east of the region around and beyond Canterbury. Nearly 20% of the county is Green Belt and 33% is made up of Areas of Outstanding Natural Beauty.

The M2 motorway carries traffic to and from the cross-Channel port at Dover (the busiest passenger port in the European Community) and the M20 serves the same purpose for Folkestone. Kent has always been a communications centre: The Channel Tunnel at Folkestone, the Eurostar station at Ashford, deepwater ports at Sheerness and Grain, and the Ebbsfleet development all ensure this strength.

The link to continental Europe

Among the important strengths of the county of Kent is its proximity both to London and France - via the Channel ports and the tunnel link. The importance of the links with mainland Europe is expected to increase still further as trade and communications continue to develop.

The Thames Gateway area in North Kent and Medway is a major development area. The Bluewater development is the most visible symbol of the investment taking place in this area of Kent. To the east of the county, the regeneration and modernisation of traditional seaside towns, such as Ramsgate, is now well under way. Despite the decline in some of the traditional manufacturing industries, newer (often high-tech) industries are expanding in the county.

At the eastern end of the county and along the more remote coastline, which does not have direct links with the continental mainland, incomes are lower and unemployment is higher.

The county is attractive to tourists not only because of the beautiful old cathedral town of Canterbury but also because of the prettiness of the countryside, including for example its picturesque Oast Houses (for drying hops) and old fashioned lap-board façades. Tourists are also attracted to Norman castles such as those at Dover and Rochester, and to Elizabethan mansions such as Knole House near Sevenoaks. Some of the small coastal towns such as historic Deal, Sandwich and Broadstairs are more remote but nevertheless benefit from tourism in the summer season.

Among the county’s weaknesses is the high cost of land and housing, particularly in the west from where it is convenient to travel to work in London.

Agriculture still important, but The Channel beckons

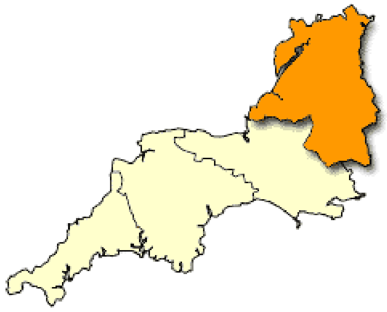
The imbalances in the county of Kent stem mainly from its proximity to London, the River Thames and to France on the one hand, and the relative remoteness of the north-east of the county around Margate and Ramsgate and the rural south-western area in the Vale of Kent.

Employment opportunities vary considerably across the county. In Tunbridge Wells, for example, where many residents commute to London, the proportion of the unemployed who have been without a job for more than a year was only 8% in 2003, whereas in Thanet at the extreme eastern end of the county it was 15%. Similarly, employment opportunities are much greater near the Channel ports and in the industrial areas in the north-west of the county than they are in the rural areas and elsewhere along the coast.

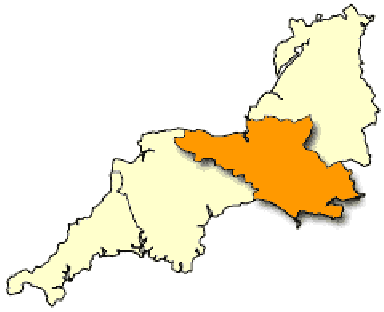
In terms of employment, the primary sector had a share of 2.7% in the county in 2001but this varied considerably across the sub-region; the UK average was 1.6%. The share of the secondary sector was 20.5% in 2001 while the tertiary sector represented 76.8%, both of which were comparable to the UK average.

The population density of the county, 425 inhabitants per km², was relatively high compared to the national average, 244 per km², in 2002. Population densities were much higher however in the industrialised areas near the Thames and Medway rivers and near London, although the ‘green belt’ policy has tended to keep the population density down. In the rural and coastal areas, excluding the main Channel ports, the population density was much lower.

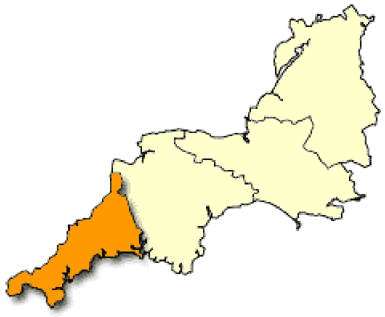
UKj — South Est [Gloucestershire, Wiltshire and North Somerset – Dorset, Somerset – Cornwall and Isles of Scilly – Devon]



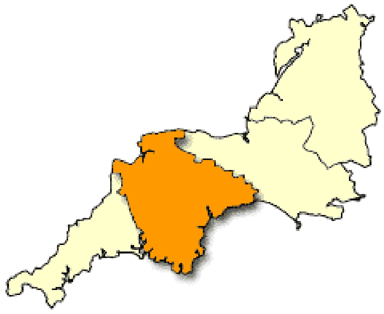
UKk1 (Gloucestershire, Wiltshire and North Somerset)



UKk2 (Dorset, Somerset)



UKk3 (Cornwall and Isles of Scilly)



UKk4 (Devon)

UKk1–Gloucestershire, Wiltshire and North Somerset: Geography and history

The NUTS2 area of Gloucestershire, Wiltshire and North Somerset include the counties of Gloucestershire and Wiltshire and the Unitary Authorities of the City of Bristol, South Gloucestershire, Bath & North East Somerset, North Somerset and Swindon. In the main, these areas are situated around the Severn Estuary, which leads to the Atlantic Ocean. The region is bounded to the north-west by Wales, to the north-east by the West Midlands and to the east by the South East. The sub-region is predominantly rural covering 7,465 square kilometres,. Wiltshire covers 3,255 square kilometres including Salisbury Plain; a large sparsely inhabited chalk upland area.

There are two ranges of hills; the rolling Cotswolds cover much of Gloucestershire and extend into North Somerset and Bath & North East Somerset. The Mendips lie in both North Somerset and Bath & North East Somerset as well as the county of Somerset. Bristol is the regional centre for the South West, and its population was 382 thousand in 2002. The other largest urban areas are the cities of Bath and Gloucester and the towns of Swindon and Cheltenham.

Two major motorways serve the area: the M4 runs from London to South Wales via Bristol, while the M5, running from the Midlands to the South West, connects with the M4 at Bristol. There are also three smaller motorways: the M32 leading from Bristol city centre to join the M4, the M49 leaving the M5 at Avonmouth and joining the M4 at the Severn Bridge crossing to Wales, and the M48 - the old Severn Bridge. The area's largest docks and port facilities are at Avonport and Portbury on the Severn Estuary at the mouth of the River Avon.

Good communications, service industries important

Although Bristol has long been an industrial and commercial centre, agriculture has been an important element in the economy of much of the area. Since the 1960s however, improved communications with the South East have encouraged the growth of industries in the 'M4 corridor' — the area served by the M4 motorway running from London to Bristol via Swindon. Service industries in particular have been encouraged to relocate from London ; thus, half of employees in Cheltenham and Gloucester now work in 'other service' industries.

Long-standing manufacturing centres include the British Rail engineering works at Swindon, which closed in 1986, and the docks at Avonmouth and Portbury; characterised by car import and chemical works. Wilton, in Wiltshire, has given its name to the luxurious carpets manufactured in the town. The region has developed a reputation for high-technology industries, most notably the British Aerospace and Rolls Royce factories at Filton to the north of Bristol. Telecommunications and electronics are also important with major producers in the area such as Orange, British Telecom, Telewest Communications and Hewlett Packard.

Recent relocations of Lloyds TSB, NatWest Life and Sun Life Assurance have also meant that Bristol is now one of the UK 's largest financial centres outside London.

The result of this expansion is that unemployment is generally well below the UKl average and the region has one of the lowest unemployment rates in the country. Pockets of severe unemployment exist however both in the more remote rural localities and in urban areas, most notably inner city areas of Bristol.

Movement from urban to suburban

In common with the rest of Britain, the pattern of settlement in the South West in recent years has been for people to move from urban to suburban and rural locations. Allied to this the South West region experienced a population increase of 12.7% between 1982 and 2002.

From 1982 to 2002, the population of the City of Bristol UA fell by 4.8%, while that for Plymouth UA fell by 6.2%. In contrast, South Gloucestershire experienced an increase in population of one-fifth over the same period. The sharpest increases in population over this period occurred in Tewkesbury in Gloucestershire, where the population increased by 22%.

UKk2–Dorset, Somerset: Geography and history

Dorset and Somerset lie to the eastern end of the south-west peninsula of England. Dorset to the south has the smaller area but is more populous. The sub-region has a total area of 6,401 square kilometres.

The chief centres of population are located on Dorset 's south coast. Bournemouth, Poole and Christchurch form a continuous conurbation close to the border with the South East region, while the port of Weymouth and Portland lies further to the west. The largest towns in Somerset lie inland from the northern coast and include Taunton, Yeovil and Bridgwater.

Road and rail communications within the counties are somewhat limited due to the sparseness of settlement in the region. However Dorset 's main centres of population are linked to the South East via the A31 trunk road which leads to the M3 motorway, and Bournemouth is well served by express trains to the South East. Somerset is linked directly to the Midlands and to south Wales by the M5 motorway which passes close to Taunton and Bridgwater. The M5 also connects with the M4 at Bristol, which allows easy access to London and the South-East.

Important area for dairy farming and cider production

Somerset and Dorset contain several ranges of hills such as the Mendips and Quantocks in Somerset and the chalk Downs stretching east to west across Dorset. However much of the land remains highly suitable for agriculture; Somerset one of the foremost dairying areas in the UK, especially on the Levels and Moors. Historically, Dorset was renowned as a source of building stone, from the quarries at Purbeck. The county continues to be an important source of minerals, particularly limestone.

The manufacturing sector represents around 14% of employment in Dorset and Somerset. An example of enterprise is the Weymouth and Portland naval shipyards and other port-related activities.

All of the SouthnWest region of England has long been a popular destination for tourists and the relative accessibility of Somerset and Dorset to the population centres in both the South-East and in the Midlands has aided the development of this and associated industries. Bournemouth is now a major centre for conferences and entertainment.

The south coast has become popular in particular as a destination for people retiring. Some districts have had amongst the highest proportions of retired persons in the country. In Christchurch, roughly a third of the population was over retirement age in 2002. About 21% of the population was aged 65 and more in Dorset and Somerset in 2002, which is the highest rate of any sub-region of the United Kingdom.

A popular area: rapid increases in population

Population density in Dorset and Somerset was 197 inhabitants per km² in 2002 but varied from over 3,500 in Bournemouth to 50 in West Somerset.

The population of the subregion increased more rapidly than the South West as a whole between 1982 and 2002. Dorset increased by 16.7% and Somerset increased by 16.5%, compared to an increase in the South West as a whole of 12.7%. North Dorset saw the largest increase for the whole South West at 27.2%. The popularity of Dorset has been such that the population of Bournemouth increased throughout the 1980s, whilst that of many English towns of similar size fell.

However, the natural increase was negative in Somerset and Dorset in 2001, as the birth rate of 9.3% was under the mortality rate of 11.9%.

UKk3–Cornwall and Isles of Scilly: Geography and history

Cornwall and Isles of Scilly is a rural and maritime county with a population of 508,000 in 2002. It has an area of 3,563 square kilometres. It has had a relatively low population density for a county in the South West region, with 143 inhabitants per square kilometre in 2002. The county comprises the westernmost part of the south west peninsula of England and the Isles of Scilly. It has around 700 kilometres of coastline, the longest of any English county. The sea forms the northern, southern and western boundaries. To the east, Cornwall 's border with Devon is formed by the River Tamar for all but 18 kilometres of its length. The Isles of Scilly lie 45 kilometres off Lands End, the westernmost tip of Cornwall.

Its geographical position has ensured that it has remained until recently one of the more remote and isolated parts of Britain. The nearest major centre outside the county, Plymouth, is 125 kilometres from

Penzance, while Bristol, the regional centre, is 290 kilometres from Penzance with London 450 kilometres away.

The distance between the north and south coasts varies from 72 kilometres at the eastern boundary to as little as 8 kilometres at the western end of the county between Hayle and Marazion. In length the county measures a maximum of 132 kilometres between Lands End and the north-eastern boundary at Morwenstow.

Strong growth of the tertiary sector

New manufacturing industry has been attracted in the region and this has helped to diversify the economy, although the manufacturing sector has remained much smaller than elsewhere in England and Wales at 11.4% in 2001. Cornwall 's long-standing china clay industry is also its most important extractive industry. As a result, the range of job opportunities is generally more limited than in many other parts of the country. The service sector however has shown particularly strong growth in recent years and accounted for 77% of employment in 2001. Gross Value Added (GVA) per inhabitant for Cornwall and Isles of Scilly was at around £8,212 in 2001 (only 57% of the United Kingdom figure). Average gross weekly full-time earnings in 2002 were £348, only 75% of the UK figure.

Cornwall and Isles of Scilly consistently comes at, or near to, the bottom of the league table of English counties in terms of economic performance. The 2002 average gross weekly earnings for men were 29% below the UK average and female earnings 15.5% below the UK average. The gap between local and national rates for men has tended to widen in recent years but there has been some improvement for women. Not only have earnings been low, but there has also been a smaller percentage of the working age population earning money. This is due to the fact that, compared to the other counties of the region, the unemployment rate has been relatively high and economic activity low, despite a significant increase in female activity rates during the 1980s and 1990s. The effect of this has reduced the prosperity of the county still further.

Over the past few years unemployment fell both nationally and in Cornwall and Isles of Scilly. However, in Cornwall and Isles of Scilly it did not decrease anywhere near as much as in either the South West or Great Britain and has remained high in winter.

Importance of tourism in the economy

The growth of tourism as one of the county's major industries has been significant. However, it is predominantly a seasonal employer and it provides relatively low rates of pay.

Cornwall and Isles of Scilly is one of the major holiday areas in Great Britain. 4.8 million visitors were attracted in 2001 to the spectacular coastal scenery and fine beaches. Growth was rapid up to 1978, particularly in self-catering holidays - including holiday flats as well as caravans and tents. At the peak of the season there can be over 270,000 visitors to the county, which adds more than 50% to the all year population.

The seasonal influx of visitors has a far-reaching effect upon the county's character and life during the summer. It enables many services to be provided which would not otherwise be viable. The pressure of numbers however creates problems such as traffic congestion, pressure on services and environmental damage. In 1999, 88.6% of the visitors travelled by car, 5.7% by train, 4.0% by coach and 1.7% by air and other modes. However, employment directly in the holiday industry and through additional trade to retail establishments and other businesses ensures considerable economic benefits. However, with the pressure from international competition there remains an enormous challenge to raise quality and to invest in the industry and related services.

The opening of the Eden Project near St Austell has had a positive impact on the tourist industry. In 2002, two years after opening, Eden attracted 1.8 million visitors, highlighting its status as the country's third leading tourist attraction. Longleat and the National Maritime Museum in Falmouth are further major attractions to the subregion.

The growth of festivals, the increasing popularity of visits to historic gardens and the success of many major attractions offer Cornwall and Isles of Scilly the opportunity to extend its season and offer more highly paid permanent jobs.

UKk4–Devon: Geography and history

Devon has an area of 6,707 square kilometres and includes the county of Devon and the Unitary Authorities of Plymouth and Torbay. It is bordered by sea to the north and south, and by the sub-regions of Cornwall and Isles of Scilly to the west and Dorset and Somerset to the east.

Devon is best known for its superb coastline, its rugged and beautiful National Parks of Dartmoor and Exmoor, and its patchwork of fields and hedgerows. Exeter is the County Town and has a fine cathedral and a history that can be visibly traced back to Roman times. The rest of the county is predominantly rural with many historic resorts, market towns and villages.

The M5 motorway links Exeter to the town of Taunton Deane in Somerset, while the A38 trunk road is the link between Exeter and Cornwall. The north of the region is linked to the south by the A361 national primary route and the A377 primary route. The A30 national primary route links the western and eastern parts of the region.

Devon has had a higher employment rate, 78.5% in 2001-02, when compared to the UK average; 74.4% in 2001-02

Key employers within Devon have been labour intensive manufacturing, wholesale/retail/repair industries and the health and social care sectors. Mining and quarrying has remained an important industry in Devon as well.

In 2001, over 15,000 people worked in agriculture in Devon. This represented a share of 3.2% in employment (against 1.5% for the national average) but it has registered an important decline compared to a few years ago. The shares of the production industry and services sectors are comparable to those observed for the country as a whole, with respectively 21% and 74.9%.

Declining unemployment rates

Gross value added (GVA) per head rose from £9,254 per inhabitant in 1995 to £11,412 per inhabitant in 2001 (compared with a UK figure of £14,852), representing an increase of 23% over the period.

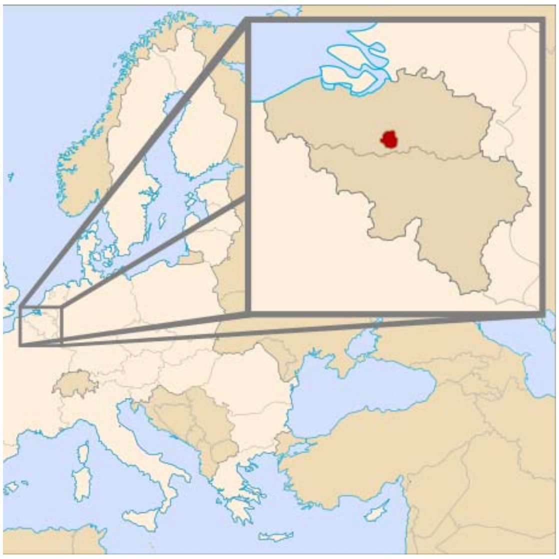
However, there is a widening gap between the productivity of the Devon economy and that of the United Kingdom as a whole. Based on an index where GVA per head in the UK is 100, Devon has decreased steadily from 86% in 1995 to 79% in 2001.

Average gross weekly earnings in Devon was 19% lower than the average in the rest of the UK in 2002 and 11.6% lower than the regional average. Indeed, Devon had the second lowest average earnings in the South West.

Following a UK trend, unemployment in Devon had been declining. In 2001/02, the unemployment rate was 4.0% in Devon, comparable to the UK average of 5.0%.

BE1 — Région de Bruxelles

Geography and history



Brussels, which became a fully-fledged region in 1989, consists of 19 municipalities covering a total area of 161 km².

Founded in the tenth century as a military outpost by the Duke of Lorraine, the Brussels conurbation grew up along the valley of the Senne, a small stream that has today been completely built over.

At Brussels the valley sides are asymmetrical: the western slope, composed of clay, is not so steep (1.5-2% gradient) as the eastern slope (6-8%).

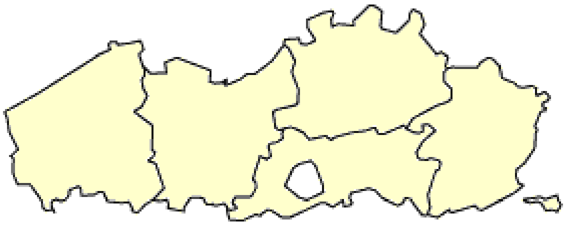
The conurbation has spread especially to the east and south.

Brussels is situated at the point where the low-lying plains of northern Europe meet the central plateaux. At the junction of these two topographical zones, Brussels is also the point of contact of two cultures and language areas: French and Dutch.

BE2 — Vlaams Gewest

Geography and history

Flanders is one of the three Belgian regions with its own government, parliament and administration. The other two are the regions of Brussels-Capital and Wallonia. Comprising the Dutch-speaking part of the country, the Flanders region has the largest population of the three (58%).



As a result of various state structure reforms over the last 30 years, Belgium has been transformed into a federal state, giving the regions more and more responsibilities. Apart from the environment, the Flanders government is also competent in other matters, such as the economy, employment, education and culture, agriculture, foreign trade, land planning, urban development, housing, public works, etc. Flanders covers 44% of Belgian territory. It consists of 22 administrative districts and 308 municipalities. The official language is Dutch.

BE3 — Region Wallonne

Geography and history

Wallonia lies in the south of Belgium and covers a total area of 16 844 km², over half of the total national territory.

The land rises gradually from west to east, reaching its highest point in the Signal de Botrange (694 m). The region has a climate which is influenced by the Gulf Stream and thus characterised by mild temperatures, heavy cloud cover and often abundant precipitation.

Wallonia has long exploited its natural resources. In the past this meant coal, but today shale, marble, sandstone, porphyry, bluestone, cement lime and dolomite are mined. Water, which has always served as a means of communication within the region, is still an important resource.

NL31 — Utrecht

Geography and history

The Amsterdam-Rhine canal passes through the region.

The province of Utrecht is the smallest and the third most densely populated province. In the seventh century the capital city Utrecht became the centre of ecclesiastical and temporal power. It became an important mercantile city, and in modern times has developed into a centre of the services sector. It forms the fourth largest area of the Randstad, which sprawls across the borders of the three western provinces.

The geography of the province is varied. In the west is the ‘green heart’, the polders, pastures and lakes. Heuvelrug, to the east of Utrecht, has much woodland, alternating with open moorland, sand flats and fens. In the south, the river Rhine and the river Lek flow through the region.

NL32 — Noord-Holland

Geography and history

It is a densely populated province, extensive areas of which have been reclaimed from the water over the centuries. Schiphol airport is situated on the old Haarlemmermeer. The area’s geomorphology had a profound effect on its urbanization, with towns built on land lying above the water-table. By far the most important city in the province is the national capital, Amsterdam, whose heyday was the ‘golden age’ of the seventeenth century. Other towns such as Hoorn, Enkhuizen and Alkmaar also have historic centres dating back to this era of prosperity.

The urbanized region of the province forms part of the Randstad, a horseshoe-shaped conurbation also comprising the western part of the neighbouring province of Utrecht and the conurbations of South Holland, including Rotterdam and The Hague.

NL41 — Noord-Brabant

Geography and history

The province of Noord-Brabant is situated in the southern part of the country; it is the second largest province (in km^2) in the Netherlands and is, accordingly, of a very varied nature. On the one hand there are five large cities which constitute the ‘row of cities’, i.e. Breda, Tilburg, Eindhoven, Helmond and ‘s-Hertogenbosch, the latter being the capital of the province.

On the other hand the predominant geographical features are rural areas, consisting of farmland, woodland and rivers. In the sandy areas in the south-east are fens, moorland and woodland, just as Vincent van Gogh painted them in his early period. The province borders on four other Dutch provinces and the Flemish-speaking part of Belgium, with which Noord-Brabant has always had very strong links.

FI18 — Etelä-Suomi

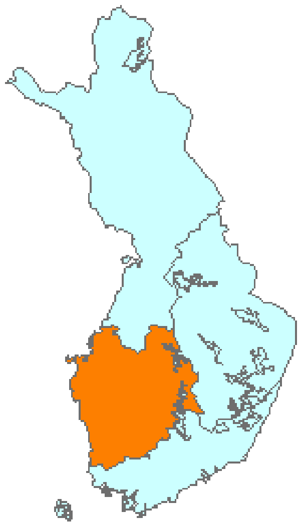
Geography and history

Etelä-Suomi (Southern Finland) covers 40 797 km2, which represents 13% of the total country's area. It has common borders with Länsi-Suomi and Itä-Suomi. It consists of seven regions. The population density in the region is the highest in the country and, with 62.7 inhabitants per km2, is more than three times higher than the country's average. The region is bilingual: it offers experiences in both of Finland's official languages (Finnish and Swedish), with its multicultural community of immigrants.

The capital of the country, Helsinki is situated in the region. It has 559 716 inhabitants at first of January 2003 and more than 3 000 inhabitants per square kilometre. Other cities with more than 100 000 inhabitants in the region are Espoo and Vantaa in the capital area and Turku in the south-western part of the region.

FI19 — Länsi-Suomi

Geography and history

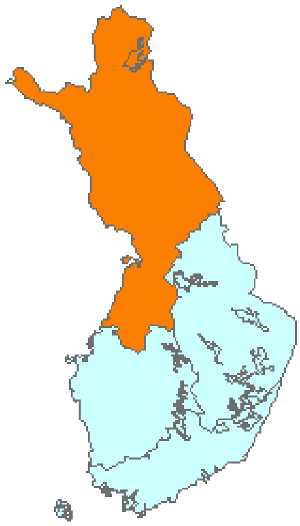


Länsi-Suomi is situated at the southwest of the country. It is bounded by Pohjois-Suomi to the north, Itä-Suomi to the east and Etelä-Suomi to the south. It is composed of several regions: Pohjanmaa (Ostrobothnia), Etelä-Pohjanmaa (South Ostrobothnia), Satakunta, Pirkanmaa and Keski-Suomi (Central Finland). The region has a total area of 58 276 km2, covering 19% of the country. Both Finnish and Swedish languages are spoken in the region. Tampere is the third biggest city of the country, with about 200 000 inhabitants at the first of January 2003.

The region is a multifaceted combination of sea, coastline, flat country, forests, wilderness and lakes. The waters are characteristic of the landscape. The coast and archipelago comprising more than 10,000 islands offer ample opportunities for recreation.

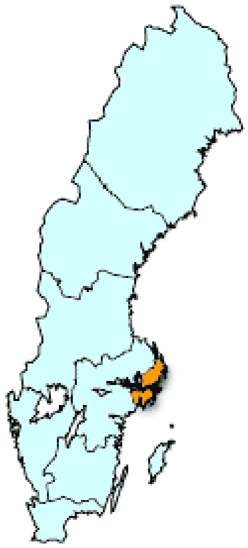
FI1a — Pohjois-Suomi

Geography and history



Pohjois-Suomi (Northern Finland) covers 133 579 km2 or 44% of Finland's total area. It comprises three regions: Lapi (Lapland), Pohjois-Pohjanmaa (North Ostrobothnia) and Keski-Pohjanmaa (Central Ostrobothnia). The major region has a common border with two other Finnish major regions: Länsi-Suomi and Itä-Suomi. It is also bounded by three other countries, Norway to the north, Sweden to the west and Russia to the east. It is the region with the lowest density of the country: 4.7 inhabitants per km2 against 17.1 at national level. The location of the region by the northernmost stretch of the Baltic Sea between the European Union and north-western Russia and co-operation both with the industrial centres of Europe and the economic districts of north-western Russia gives it a natural and crucial position as a gateway between West and East.

SE11 — Stockholm



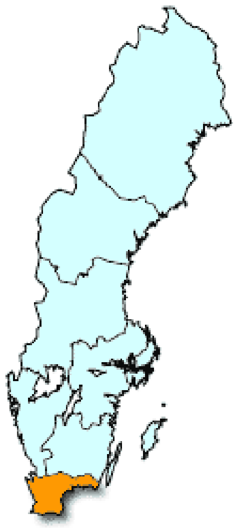
Geography and history

The region consists of only one county: the county of Stockholm, which also includes the capital of Sweden. The area is 1.6% of the national territory. Nearly 46% is forested and only 14% is arable land. The countryside is mostly flat with a great number of lakes.

The coast is jagged, with an archipelago of thousands of islands offshore. More than one fifth of the population of Sweden lived in this region in 2002. It is the most densely populated region in the country - 285 inhabitants per km2 - and has a total population of 1.85 million. Most of the people live in urban areas in the southern and central parts of the region. There are 26 municipalities, of which 8 have a population density ranging from 1000 to 4000 per km2.

The region offers a pleasant natural environment for recreation, for example in the archipelago, and it has excellent infrastructure with well-developed communication systems.

SE22 — Sydsverige



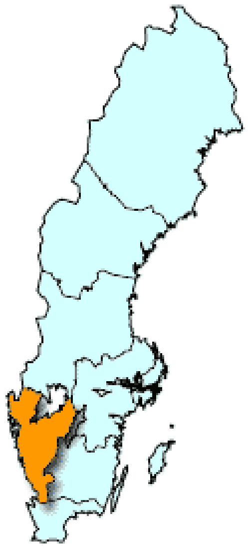
Geography and history

Sydsverige (Southern Sweden) is the southernmost region in Sweden and has common borders with Western Sweden and Småland and Islands. Denmark is discernible across the narrow Öresund strait.

Southern Sweden consists of the counties of Blekinge and Skåne, and comprises 38 municipalities. It has the highest population density (92.7 inhabitants per km2 on the 1st of January 2002) of any region except Stockholm. Malmö is the largest town with a population of 265 500 on the 1st of January 2003.

About one seventh of the country's total population live in Southern Sweden but the region comprises only 3.4% of the national territory.

SE23 —Västsverige

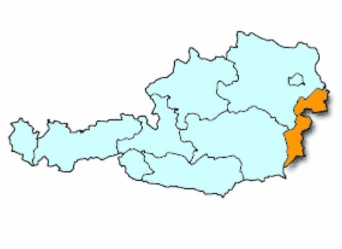


Geography and history

Western Sweden consists of the counties of Halland and Västra Götaland. It covers the provinces of Halland, Bohuslän, Dalsland and Västergötland. The region encloses areas of different character, from the archipelago in the northwest to the spurs of the highland of south Sweden in the southern and southeastern mainland. Vast areas are lowlands. Lake Vänern in the north is the largest lake in Sweden (5 585 km2).

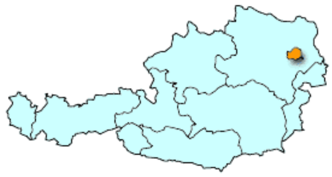
The average population density was 61 inhabitants per square kilometers in 2002, which was considerably higher than the Swedish average (22). The coastal area is especially densely populated. Of the 55 municipalities in the region, only 13 are characterised by a high degree of urbanisation (more than 80%). The municipalities with the lowest degree (less than 40%) are in the north and northwest.

AT1 — Ostösterreich [Burgenland – Niederösterreich – Vienna]



AT11 (Burgenland)

AT12 (Niederösterreich)



AT13 (Vienna)

AT11–Burgenland: Geography and history

This predominantly German-speaking, west Hungarian region became part of Austria in 1921 and has since been a Bundesland in its own right. It has an area of 3 966 km² which includes two chartered cities, the capital Eisenstadt and Rust (on the Neusiedler See) and seven political districts. In total, there are 171 municipalities (2005). It has international borders with Slovak Republic, Hungary and Slovenia and is also bounded by the Bundesländer Niederösterreich and Steiermark.

Burgenland for the most part borders the Hungarian Plain and is divided into three zones by Alpine foothills. In the north it is mainly flat whilst central and southern areas are largely hilly. Thanks to the warm, dry Pannonian climate, Burgenland has 3,9% of its area under vines, with agriculture and horticulture taking up 53.4% and forest 30.2% of the land.

AT12–Niederösterreich: Geography and history

The heartland of Austria is Niederösterreich (Lower Austria), which has a total area of 19 178 km², four chartered cities including Sankt Pölten (the capital) and 21 political districts. In 2005 there were 573 municipalities. Niederösterreich has the largest area and the second largest population (after Vienna) of the nine federal provinces in Austria. Niederösterreich is bordered to the north by the Czech Republic and to the east by Slovakia, where the river system of Thaya and March marks the frontier line.

In the south, the foothills of the Eastern Alps form a natural boundary with Steiermark. In the south-east, Niederösterreich borders the Burgenland and this is where the province also has a share in the Pannonian Plateau, which then stretches into Hungary which is a scant 4 km away. Vienna, which is Austria’s capital and at the same time a separate federal province, is located in the centre of Niederösterreich - similar to the situation of Berlin and Brandenburg in Germany.

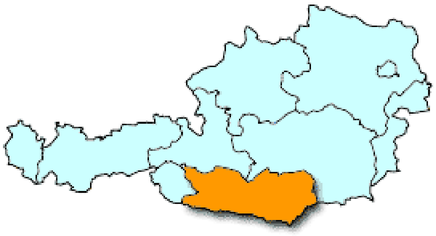
AT13–Vienna: Geography and history

Wien (Vienna), the capital city of Austria, with an area of 415 km², became a *Bundesland* in its own right, separate from the surrounding Niederösterreich, in 1922.

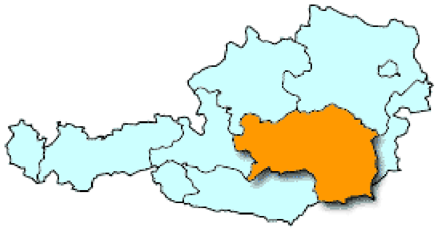
While most of the city lies in the Vienna basin, some north-western and western suburbs spread up into the Vienna Woods, part of the Pre-Alps. The warm Pannonian climate gives it an annual mean temperature of 10°C and low precipitation - just over 500 mm. Around 23% of the total land area is urbanized, 17% is given over to agriculture, 16.5% is wooded and 1.7% under vineyards.

For hundreds of years, Vienna has been one of the great cities of Europe. It is home to several important international organizations. Formerly an important industrial centre, it is increasingly concentrating on the services sector. The beauty of the city and its wealth of cultural resources make it a major centre for tourism. The Danube metropolis is at the centre of a major European traffic network, with most routes running west to east or north-east to south-west.

AT2 — Südösterreich [Kärnten – Steiermark]



AT21 (Kärnten)



AT22 (Steiermark)

AT21– Kärnten: Geography and history

Kärnten (Carinthia) has a history going back more than 1 000 years. It has an area of 9 536 km², two chartered cities - Klagenfurt, the capital and Villach -8 political districts and 132 municipalities (2005). It has international borders with Slovenia and Italy and is also bounded by the Bundesländer of Tirol, Salzburg and Steiermark.

In the north of Kärnten are the Central Alps, formed of Pre-Cambrian strata, which rise steeply in the west to culminate in Austria's highest mountain, the Großglockner, at 3 797 m. In the east they are much gentler. In the south are the southern Kalkhochalpen (Limestone Alps). The Klagenfurt basin, with hills and mountains as well as flatter areas and lakes, and the region's larger valleys have an lllyrian climate whereas the Alps have a humid-cool to humid-cold Alpine-climate. A fifth of the land is given over to agriculture and horticulture, 15,8 % to Alpine pastures and 52.9% to forests.

Kärnten attracts many tourists. In the south-east there is a Slovenian-speaking minority alongside the German-speaking population. North-east to south-west international road and rail links intersect with north-south traffic axes.

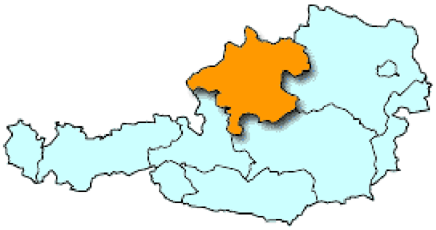
AT22– Steiermark: Geography and history

Steiermark (Styria), which has been part of Austria since the end of the 12th century, has an area of 16 392 km². Its capital is the chartered city of Graz and it has 16 political districts and 542 municipalities (2005). It has an international border with Slovenia and is bounded by five Bundesländer: Kärnten, Salzburg, Oberösterreich, Niederösterreich and Burgenland.

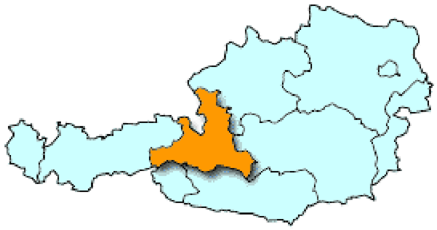
In the north, the massifs of the Limestone Alps are succeeded by the Pre-Cambrian Central Alps, which are gentler in the east and south-west and steep in the west. Between the two chains the valleys of the Mürz, Mur, Liesing-Palten and Enns run longitudinally. Both ranges have an Alpine climate. The south-east of Steiermark, with both hills and flatlands, is part of the gateway to the Hungarian Plain. Here, fruit trees and vineyards flourish in the milder Illyrian climate. Forests cover 57.1% of the land area, the highest percentage in Austria, and mountain pastures account for 6.6 %, with 26,8 % used for agriculture or horticulture.

The Mur and Mürz valleys house an important iron and steel industry and there is a further industrial bell around Graz. Otherwise, the main activity is forestry in the more mountainous parts and agriculture in the south-east. International transport routes running north-east to south-east intersect with those which run in a north-south direction.

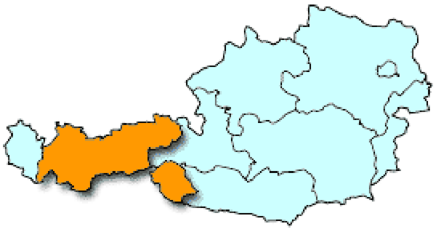
AT3 — Westösterreich [Oberösterreich – Salzburg – Tirol – Vorarlberg]



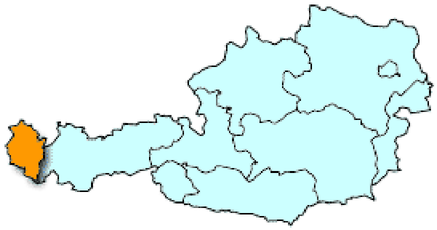
AT31 (Oberösterreich)



AT32 (Salzburg)



AT33 (Tirol)



AT34 (Vorarlberg)

AT31–Oberösterreich: Geography and history

Oberösterreich (Upper Austria) came into being in the High Middle Ages. It has an area of 11 982 km², three chartered cities including its capital, Linz, 15 political districts and 445 municipalities (2005 figures). It has international borders with Germany and the Czech Republic and internal borders with the Bundesländer of Niederösterreich, Steiermark and Salzburg.North of the Danube lies the Mühlviertel, an area of hills and low mountains, which is part of the Bohemian Massif.

To the south stretches the fertile, predominantly hilly but in some places flat, Alpine foreland, with its transitional climate (between the southern German and the Pannonian climate zones). In the east, the central region of Oberösterreich is the most highly industrialized part of Austria. The Alps then rise southwards and the climate, too, becomes more Alpine. Here, the Salzkammergut was one of the first areas to be opened up to tourism. Just over the half (50.5 %) of the land area of Oberösterreich is agricultural or horticultural land and 38.8% is forested.

Most traffic routes, whether by the Danube, road or rail, run east to west or north-west. An old road leads south from Bohemia via Linz.

AT32–Salzburg: Geography and history

The Bundesland of Salzburg, which finally passed to Austria in 1816, has an area of 7 154 km², the chartered city and capital, Salzburg, 5 political districts and a total of 119 municipalities (2005 figures). It has international borders with Germany and Italy and is also bounded by the Bundesländer of Oberösterreich, Steiermark, Kärnten and Tirol.

Although the flatter area in the north, the Flachgau, can be assigned to the Alpine foothills, most of Salzburg lies within the Alps proper. To the south of a sandstone zone are the northern Limestone Alps, which consist of the lower Alpine foothills and high limestone massifs. These are separated from the Pre-Cambrian Central Alps further south, where the Großvenediger rises to 3 674 m, by the gentler Schieferalpen (Shale Alps), which have been opened up for skiing, and the Salzach Valley which occupies the northern longitudinal valley gap. The climate is Alpine. Nearly 17.8 % of the land area is given over to agriculture and horticulture, 25.6% is mountain pastures and 39.7 % wooded.

This mecca for tourists, with a thriving economy based on its capital, is crossed from north to south by major European rail and road links, which intersect in the city of Salzburg with east-west routes. Main trunk routes follow the longitudinal valley corridor.

AT33–Tirol: Geography and history

Tirol has existed as a territorial unit since the 13th century. It has an area of 12 648 km², one chartered city - its capital, Innsbruck - 8 political districts and 279 municipalities (2005). It has international borders with Italy, Switzerland and Germany and is also bounded by the Bundesländer of Salzburg, Kärnten and Vorarlberg.

Although it has a substantial industrial sector, Tirol, with its Alpine scenery, is a noted tourist area. South of the northern Limestone Alps, there are the Pre-Cambrian Central Alps to the west of the Brenner Gap and a less rugged area of slate hills to the east. The generally broad sweep of the Inn valley, part of the northern longitudinal valley gap, cuts through Tirol. Most of Osttirol lies in the Central Alps, which culminate in the Großglockner, at 3 797 m Austria’s highest mountain.

South of the Drau (Drava) valley, it forms part of the southern Limestone Alps. The region has an Alpine climate. Only 10.7 % of the land area is used for agriculture or horticulture but 26.9 % is mountain pasture and 36.8% wooded. Tirol’s Alpine character means that only 12.2 % of its total area is available for permanent settlements.

AT34–Vorarlberg: Geography and history

Over an area of 2 601 km², Vorarlberg has four political districts with a total of 96 municipalities. Its capital is Bregenz. It has a border with Tirol and international borders with Germany, Switzerland and Liechtenstein.

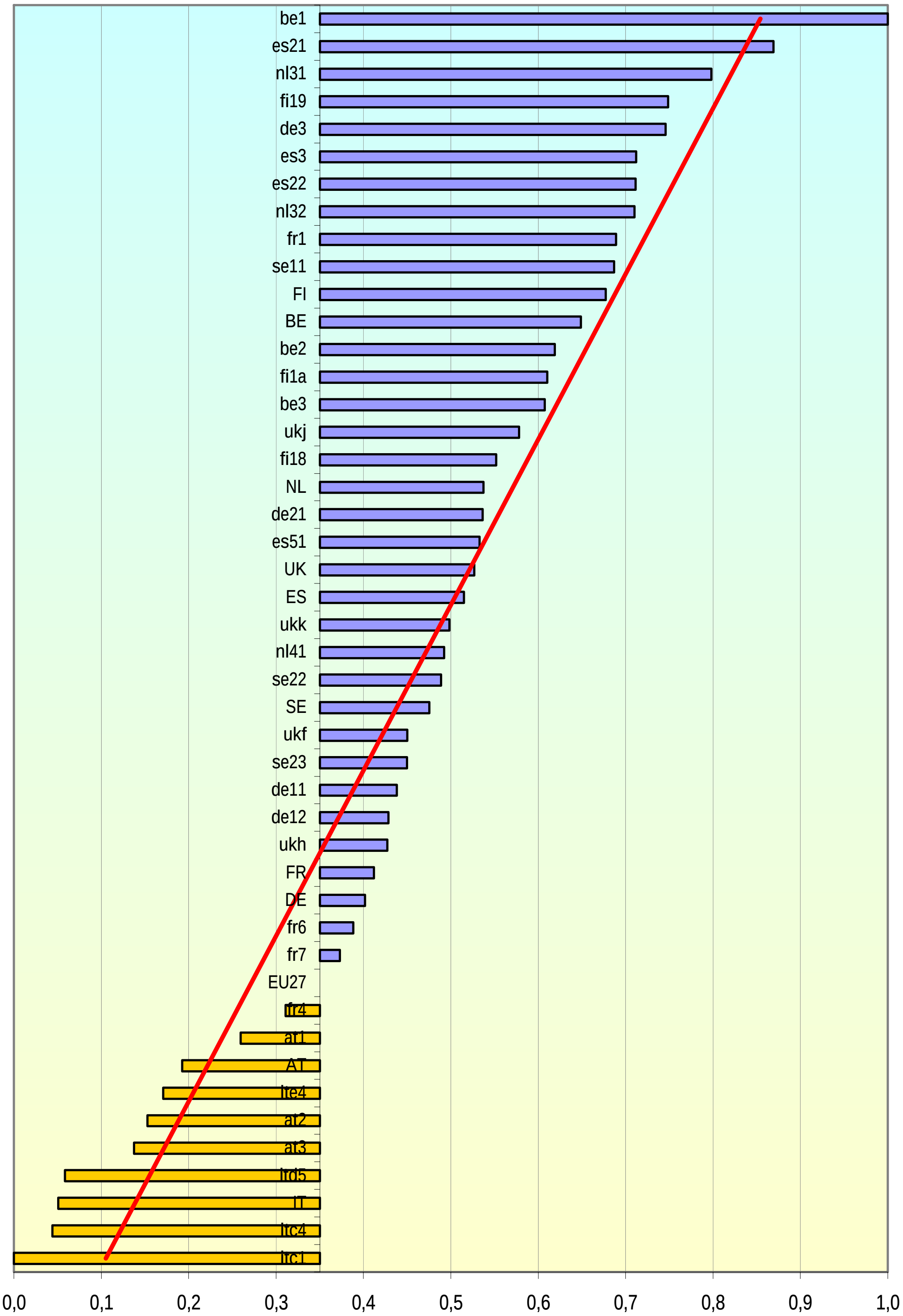
Vorarlberg is largely mountainous. The area around the Bodensee (Lake Constance) in the north-west has a very favourable climate, whilst the broad Rhine valley in the west and the lower III valley also benefit from having the climate of the Alpine foreland as opposed to the humid-cool Alpine climate which predominates in the rest of Vorarlberg. The northern, lower mountains form part of the Bregenzerwald (Bregenz woods), assigned to the Flysch range. To the south are the northern Limestone Alps and, in the south-east, the Pre-Cambrian Central Alps. Only 19.8 % of the land is used for agriculture or horticulture, 26.6 % is taken up by the Alps and 33.9 % is wooded.

Three quarters of the population live in the heavily-industrialized Rhine valley, in the surrounding area and near Lake Constance. Tourism is a major industry throughout Vorarlberg. The two tunnels through the Arlberg (road and rail) form the main links with the rest of the country and roads and railways lead to Germany and Switzerland.

Appendix 2

The rescaled values (min-Max scores): 17 indicators, 4 Pillars, and 35 regions

Figure A1 – *1.1.3 Tertiary education 2005*



Notes: be1 = Région de Bruxelles ; es21 = Pais Vasco ; nl31 = Utrecht ; es22 = Navarra ; fi19 = Länsi-Suomi ; de3 = Berlin ; se11 = Stockholm; es3 = Madrid; fr1 = Île de France; nl32 = Noord-Holland; be2 = Vlaams Gewest; fi1a = Pohjois-Suomi ; be3 = Région Wallonne ; Ukj = South East; fi18 = Etelä-Suomi; es51 = Cataluña; se22 = Sydsverige; Ukk = South West; de21 = Oberbayern; nl41 = Noord-Brabant; se23 = Västsverige; Ukf = East Midlands; de11 = Stuttgart; Ukh = Eastern; fr6 = Sud-Ouest; de12 = Karlsruhe; fr7 = Centre-Est ; EU27 ; fr4 = Est ; at1 = Ostösterreich; ite4 = Lazio; at2 = Südösterreich; at3 = Westösterreich; itd5 = Emilia-Romagna; itc4 = Lombardia; itc1 = Piemonte.

Figure A2 – *1.1.4 Life-long learning 2005*

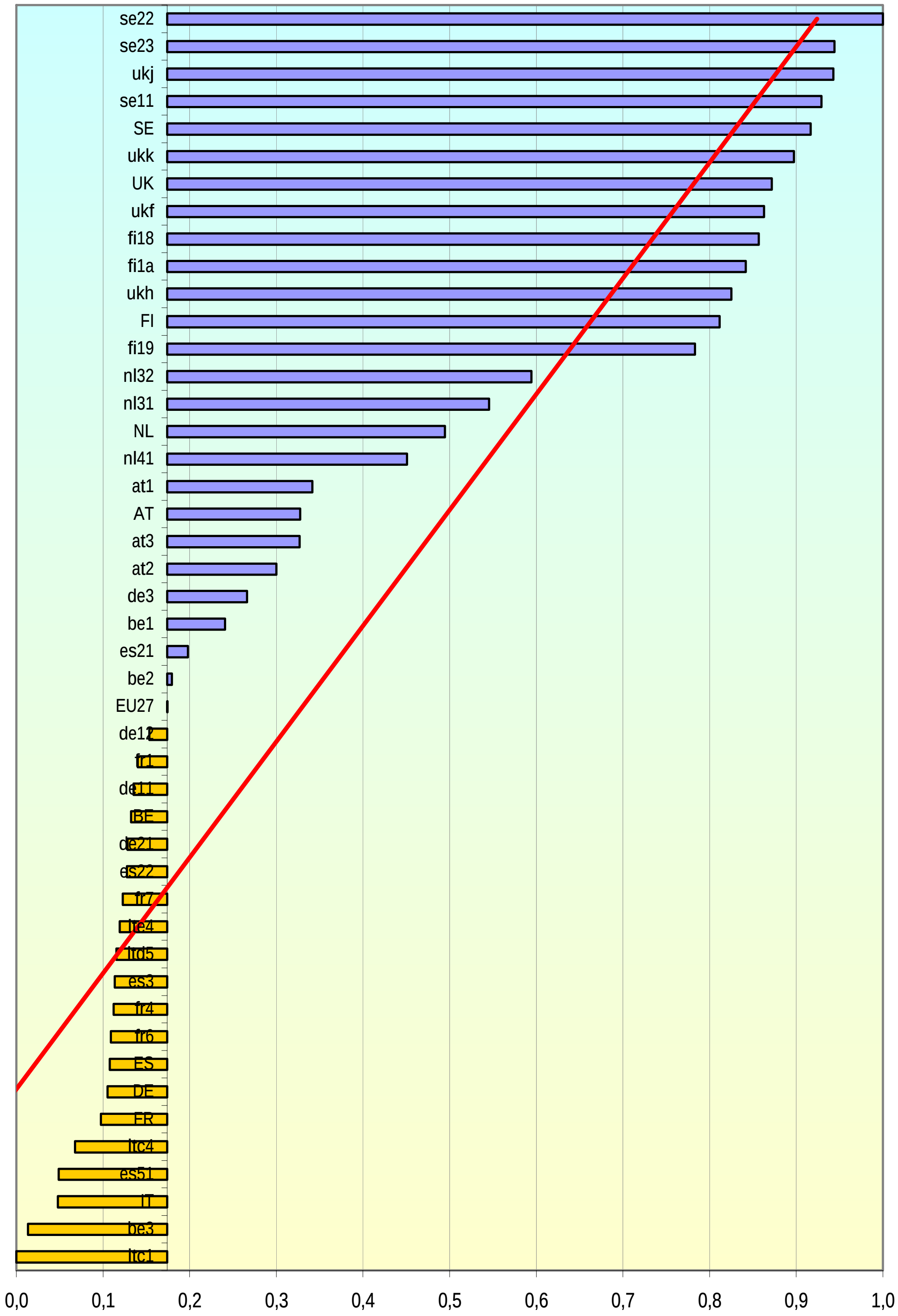


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Figure A3 – *1.2.1 Public R&D expenditures 2005*

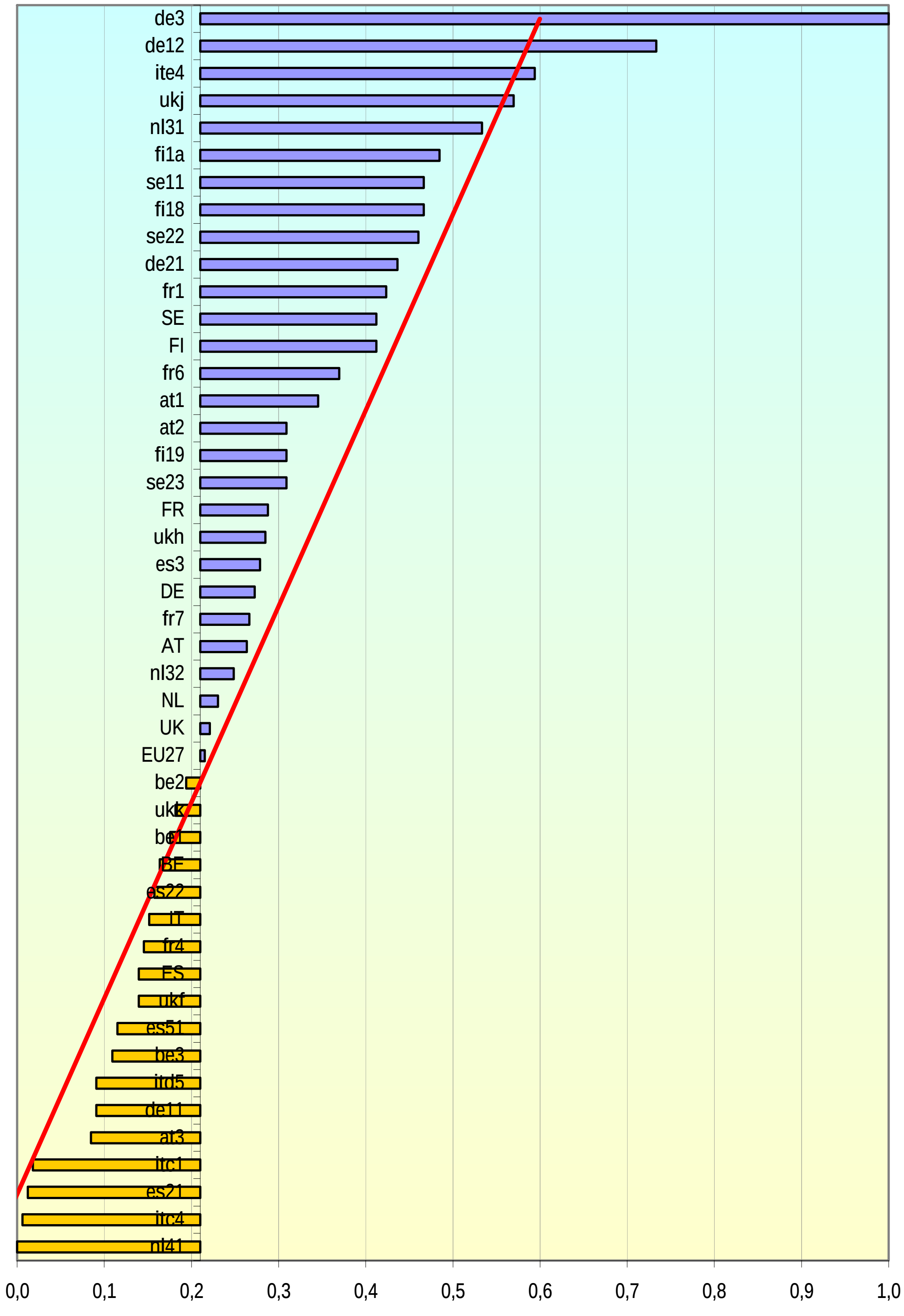

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Figure A4 – *1.2.4 Broadband access 2006*

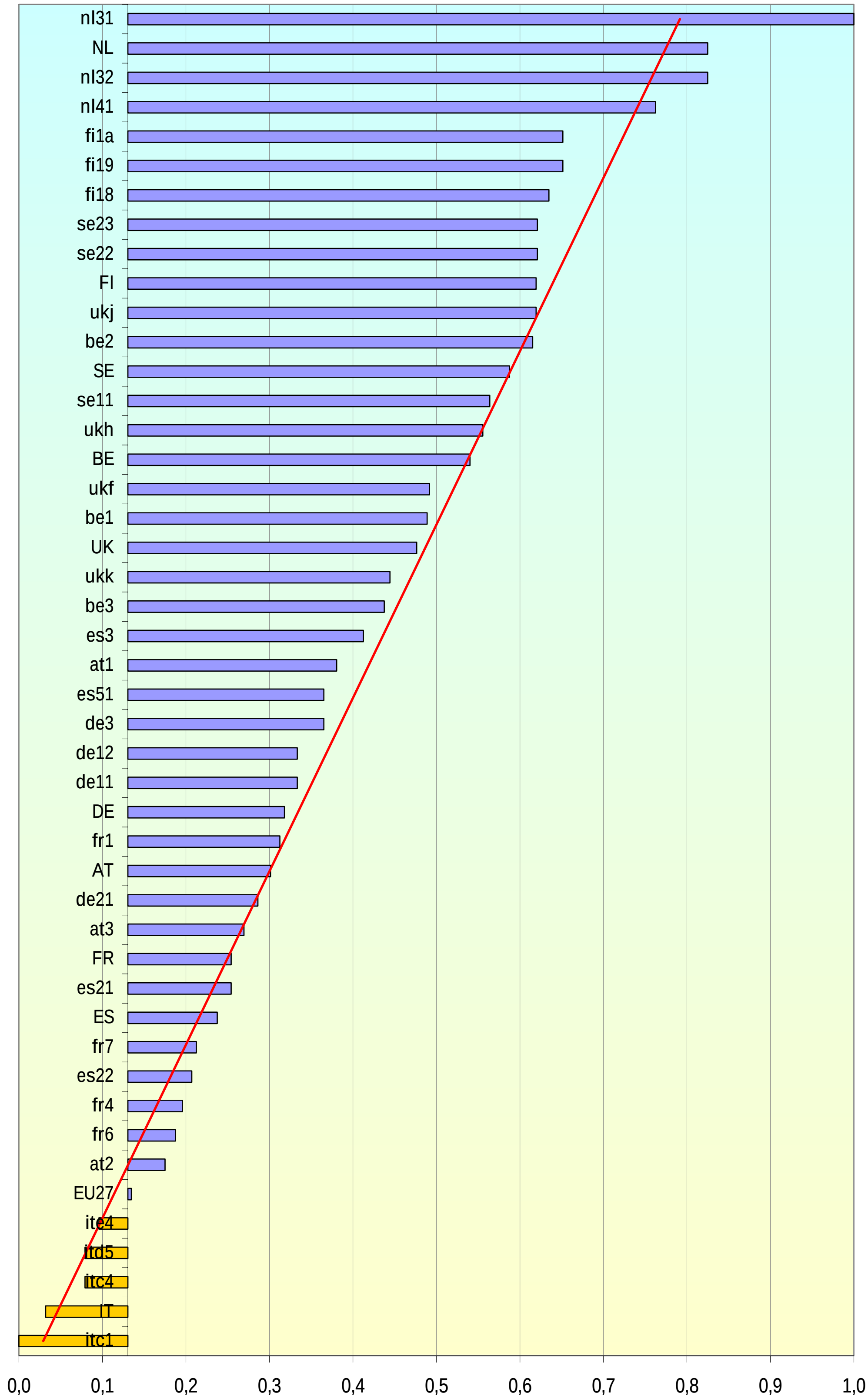

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Figure A5 – *2.1.1 Business R&D expenditures 2005*

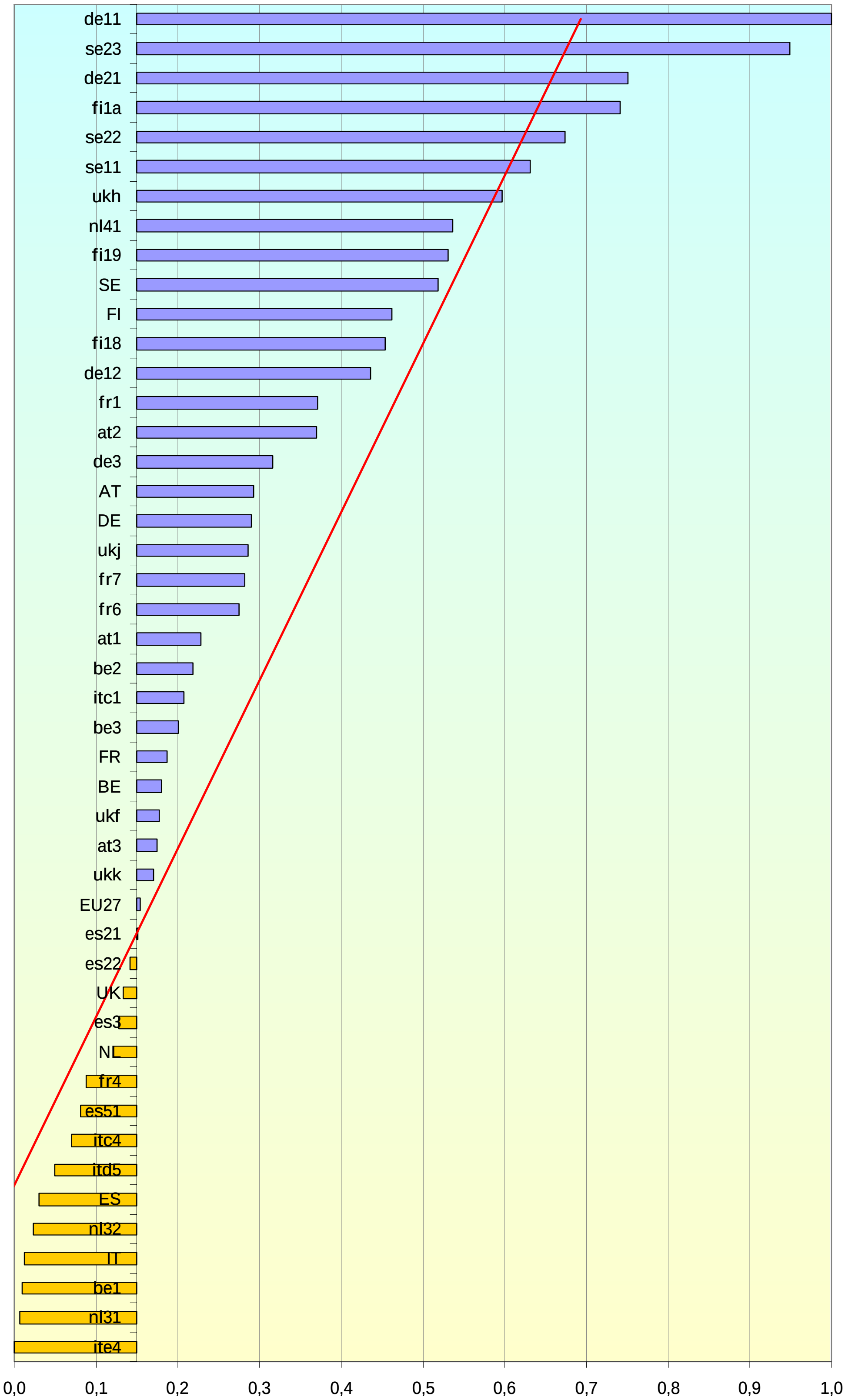

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Figure A6 – *2.1.3 Non R&D innovation expenditures 2005*

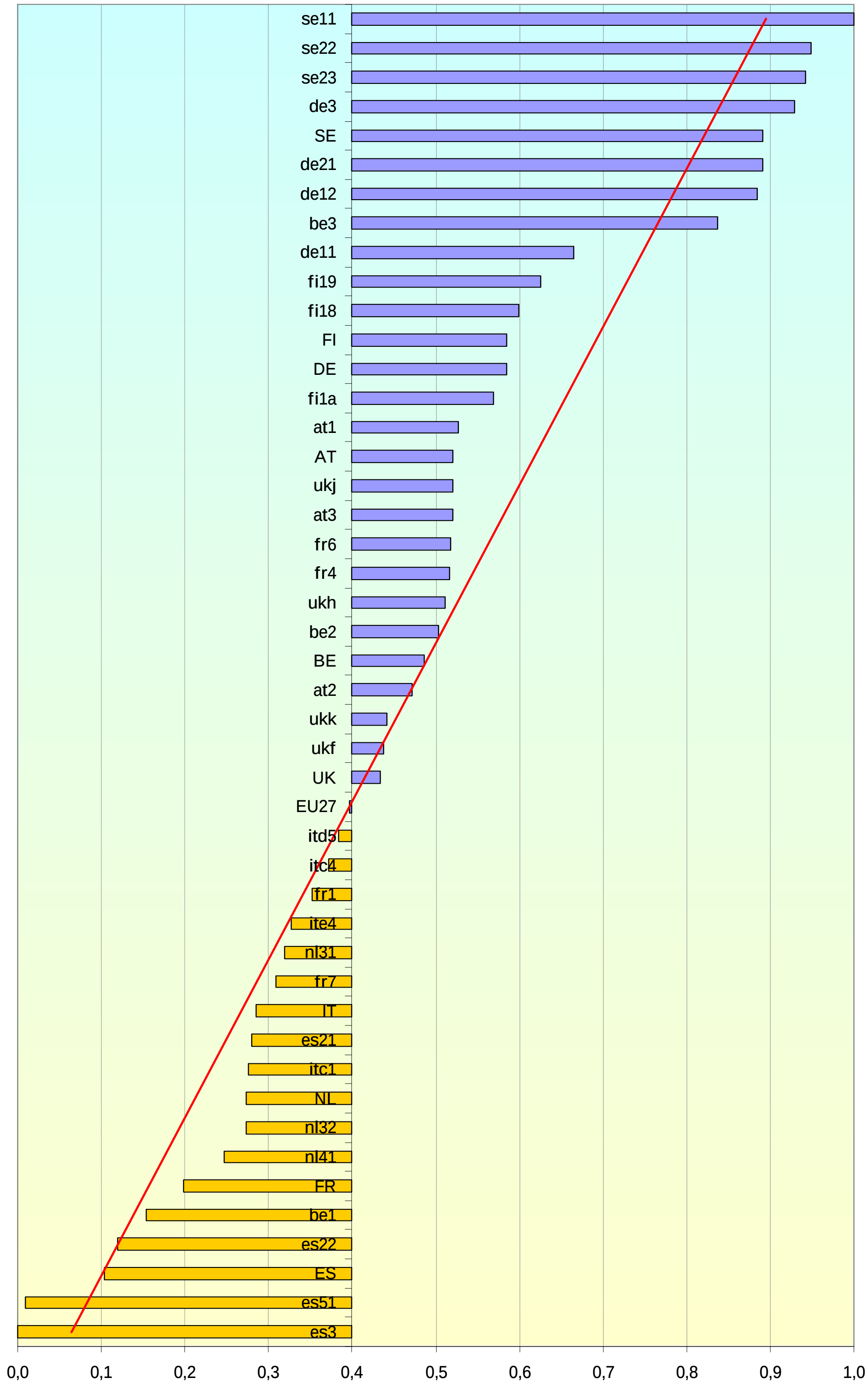

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Figure A7 – *2.2.1 SMEs innovating in-house 2005*

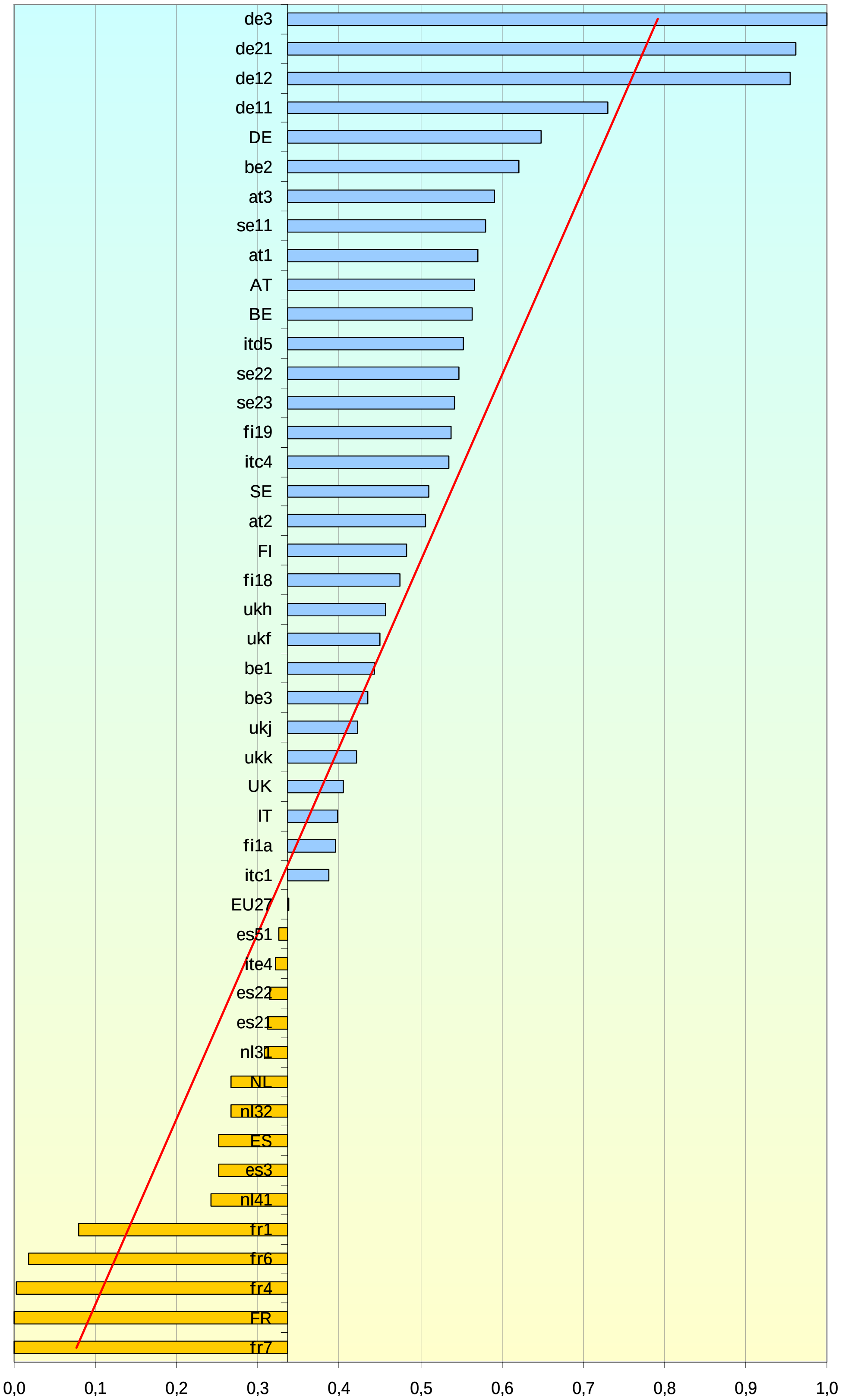

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Figure A8 – *2.2.2 Innovative SMEs collaborating with others 2005*

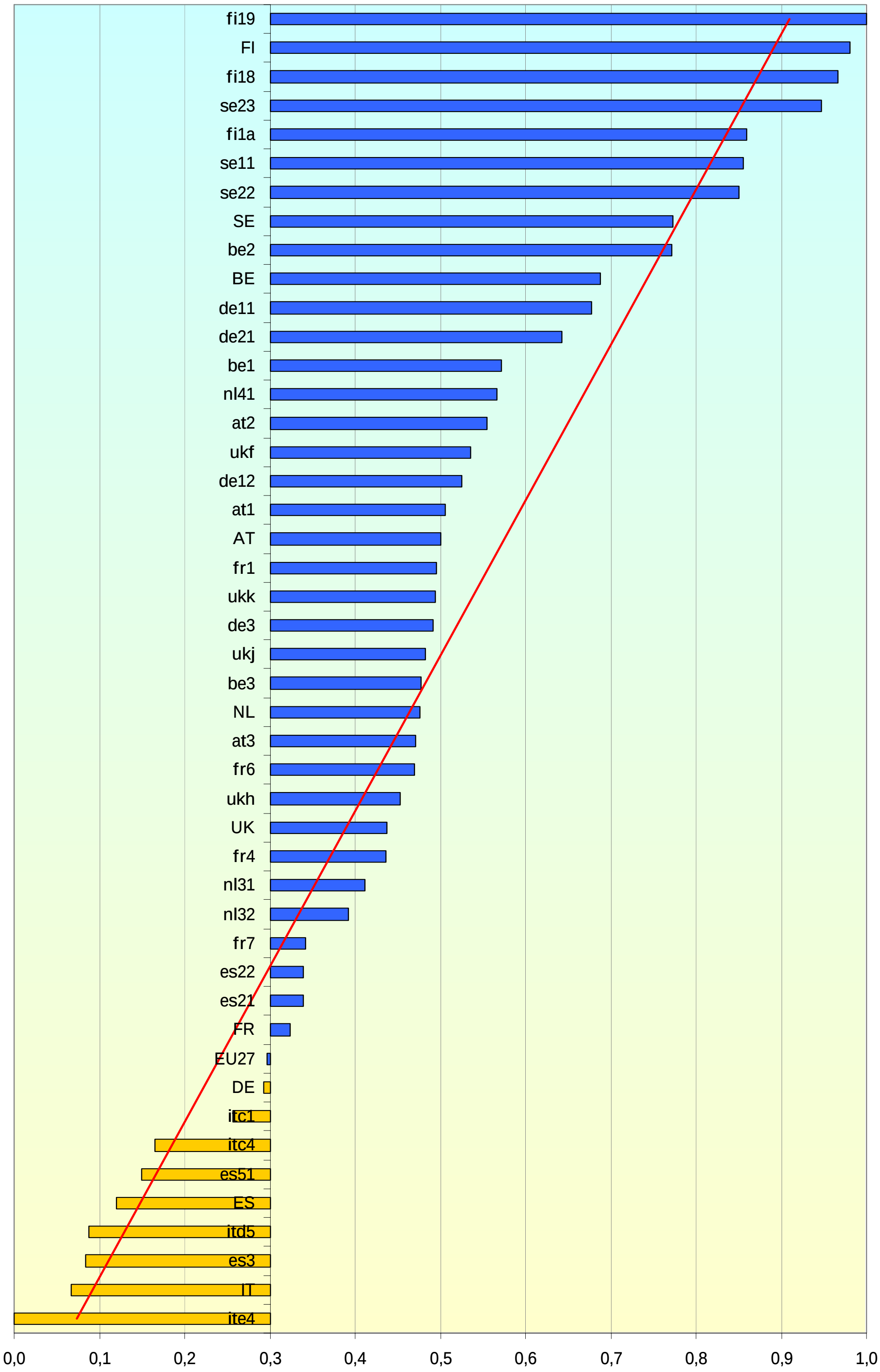

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Figure A9 – *2.3.1 EPO patents 2005*

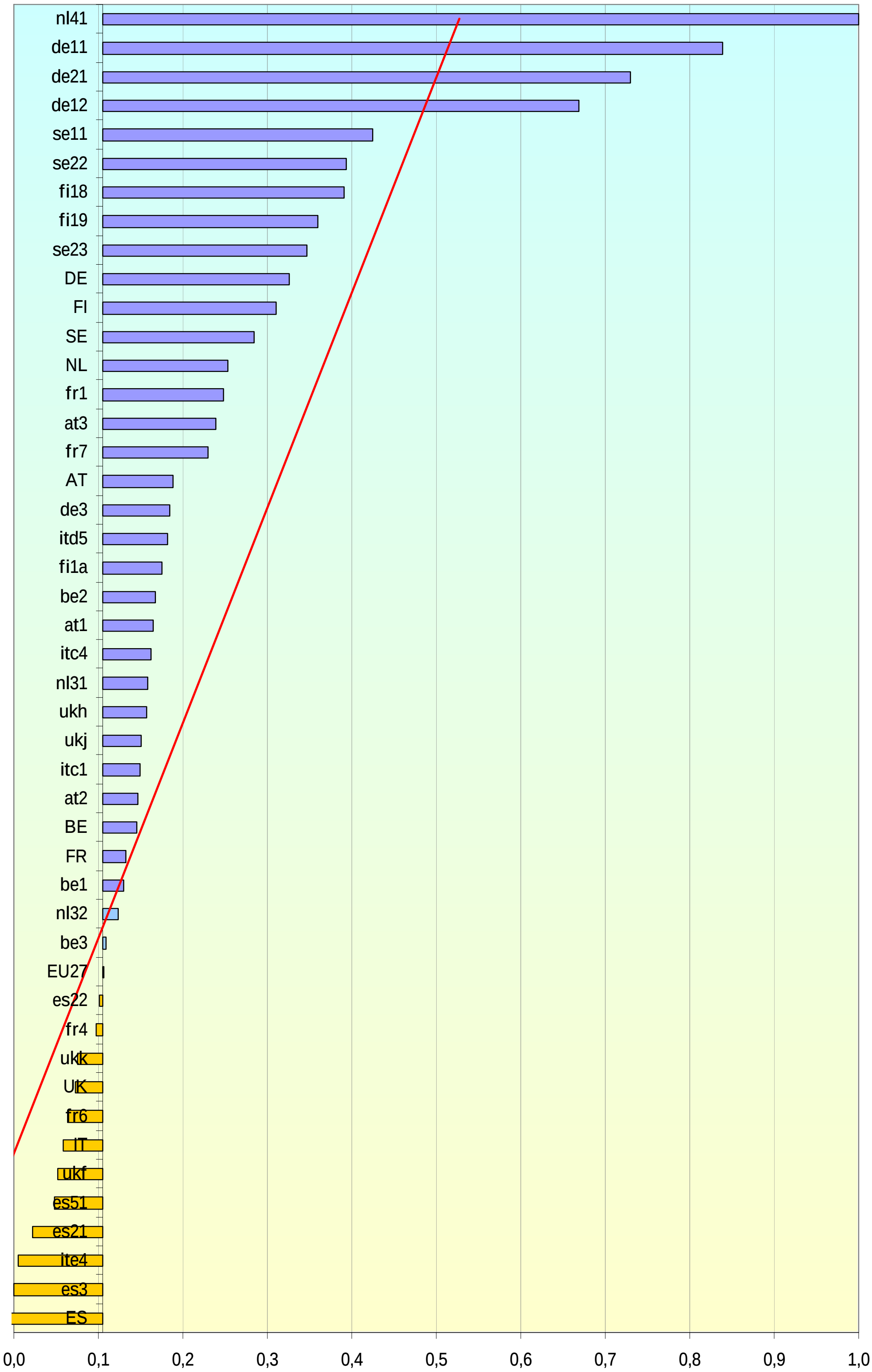

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Figure A10 – *3.1.1 Product and/or process innovators 2005*

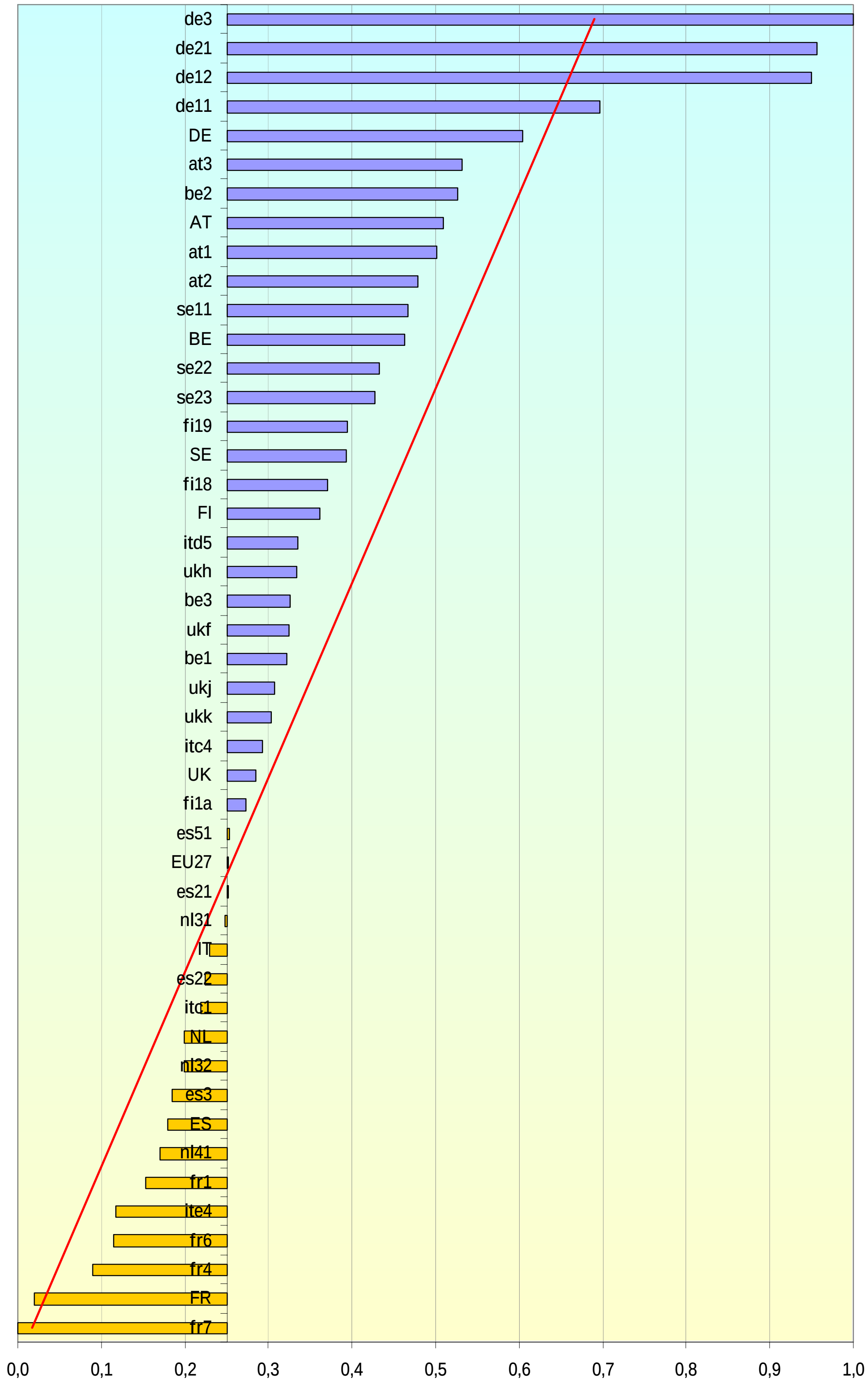

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Figure A11 – *3.1.2 Marketing and/or organizational innovators 2005*

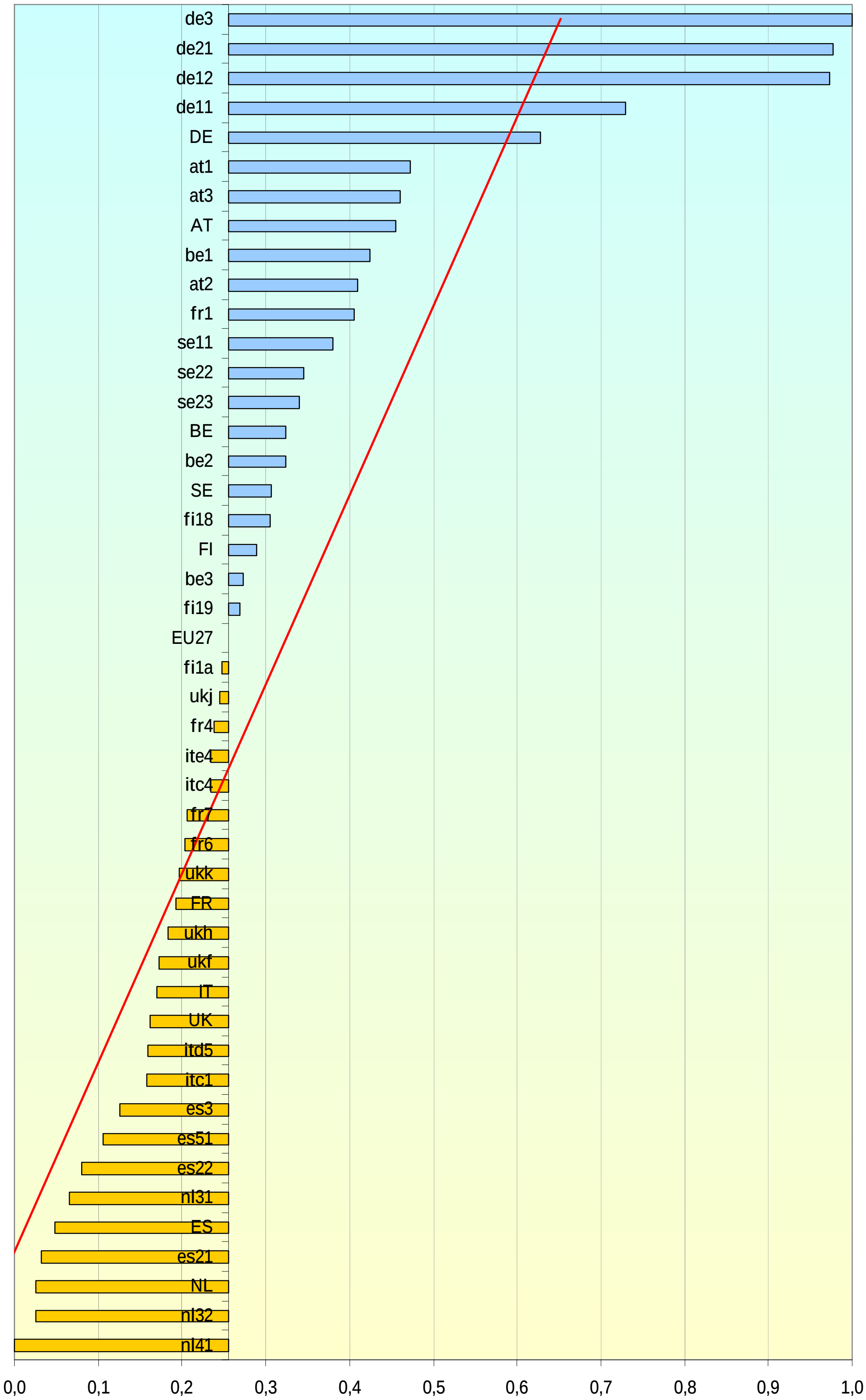

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Figure A12 – *3.1.3a Resource efficiency innovators – Labour 2005*

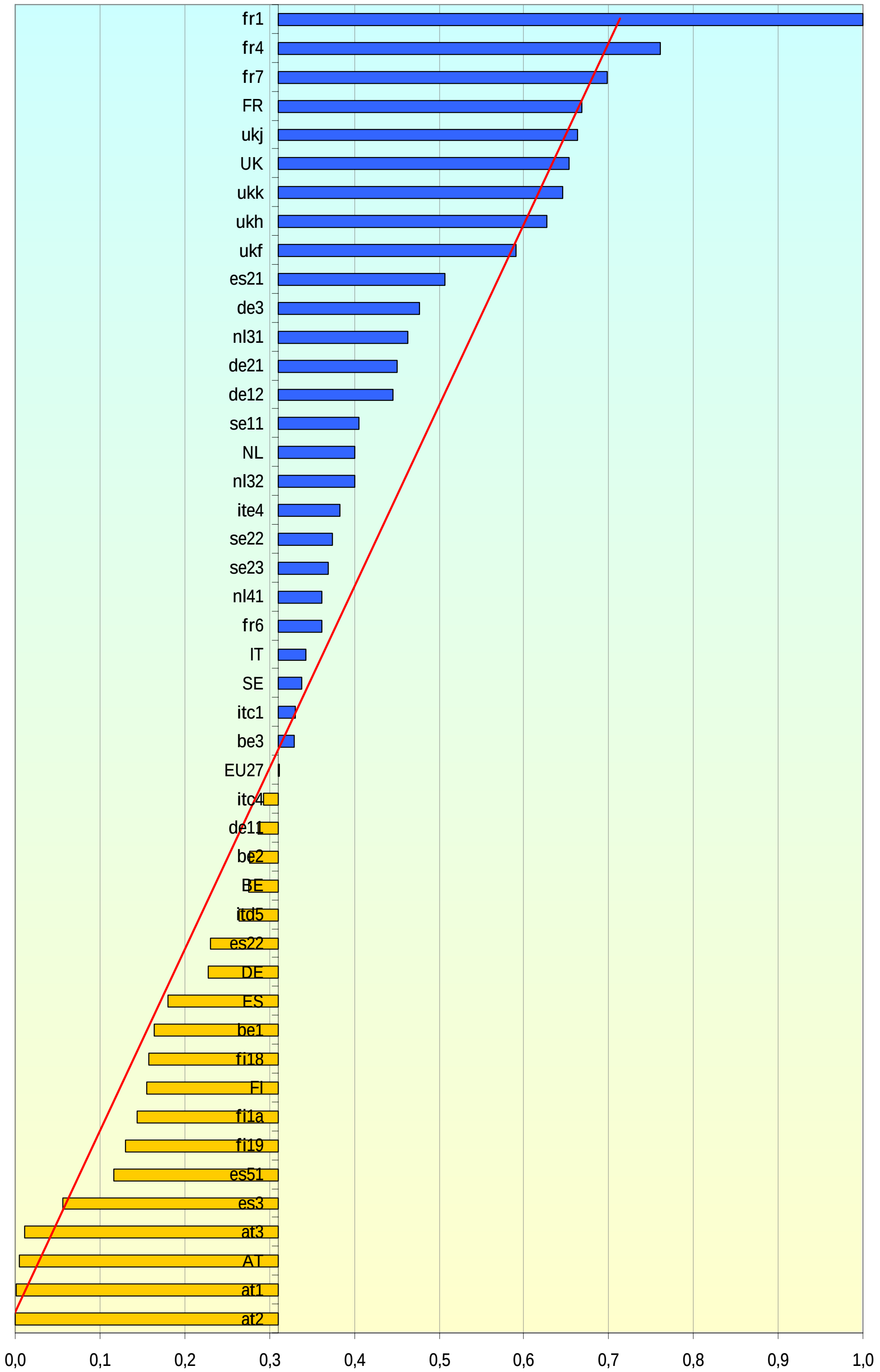

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Figure A13 – *3.1.3b Resource efficiency innovators – Energy 2005*

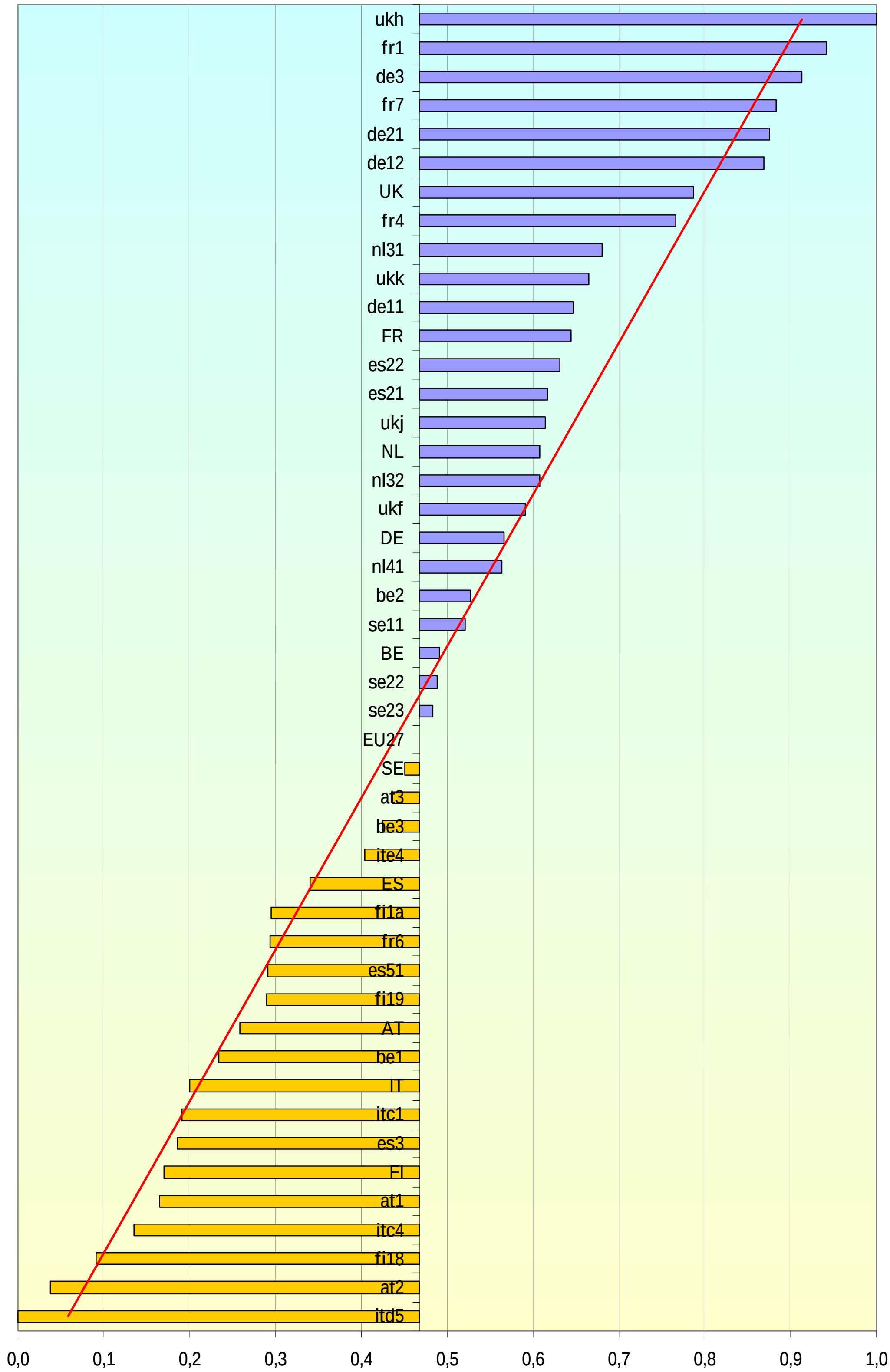

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Figure A14 – *3.2.1 Employment medium-high & high-tech manufacturing 2005*

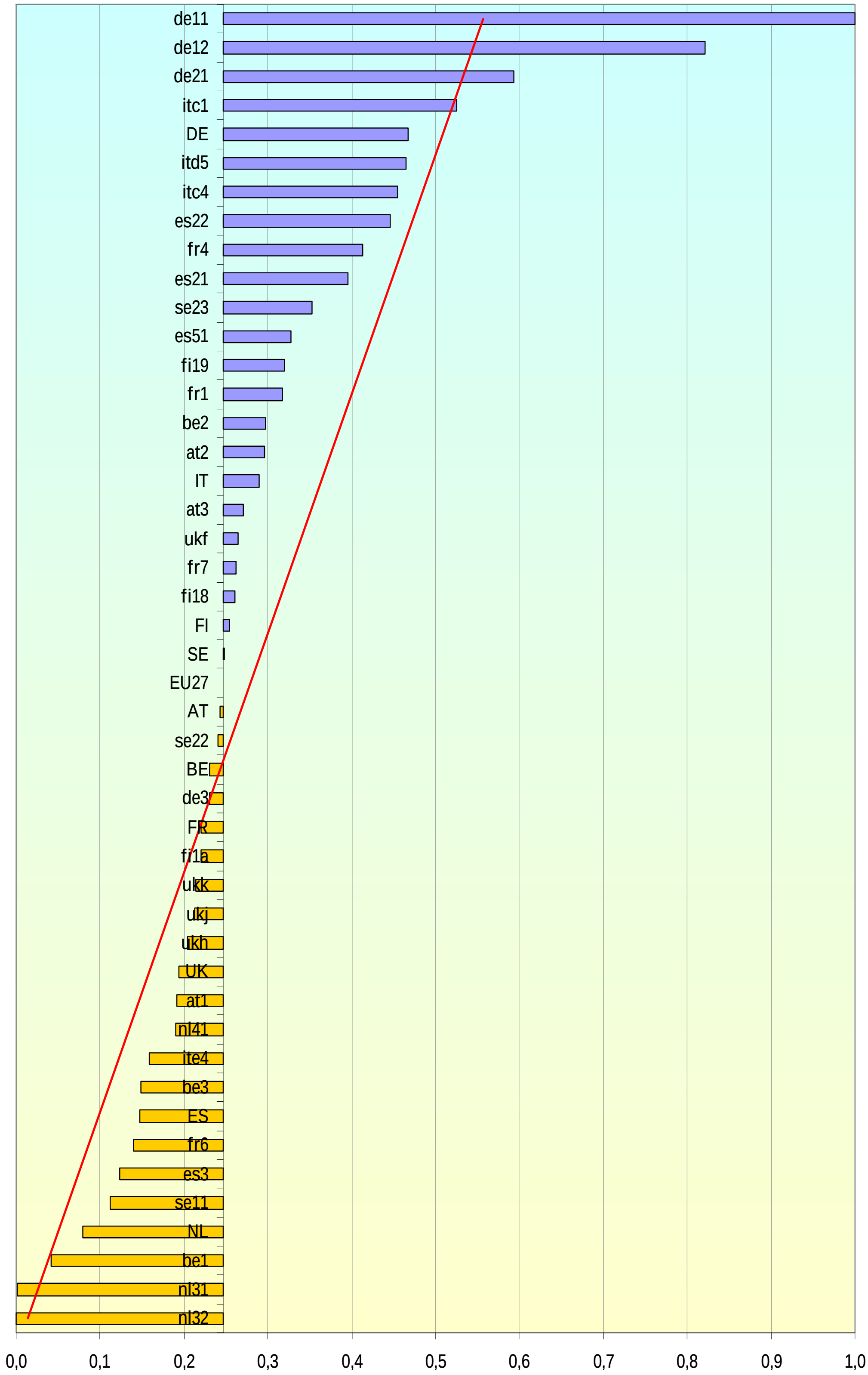

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Figure A15 – *3.2.2 Employment knowledge-intensive services 2005*

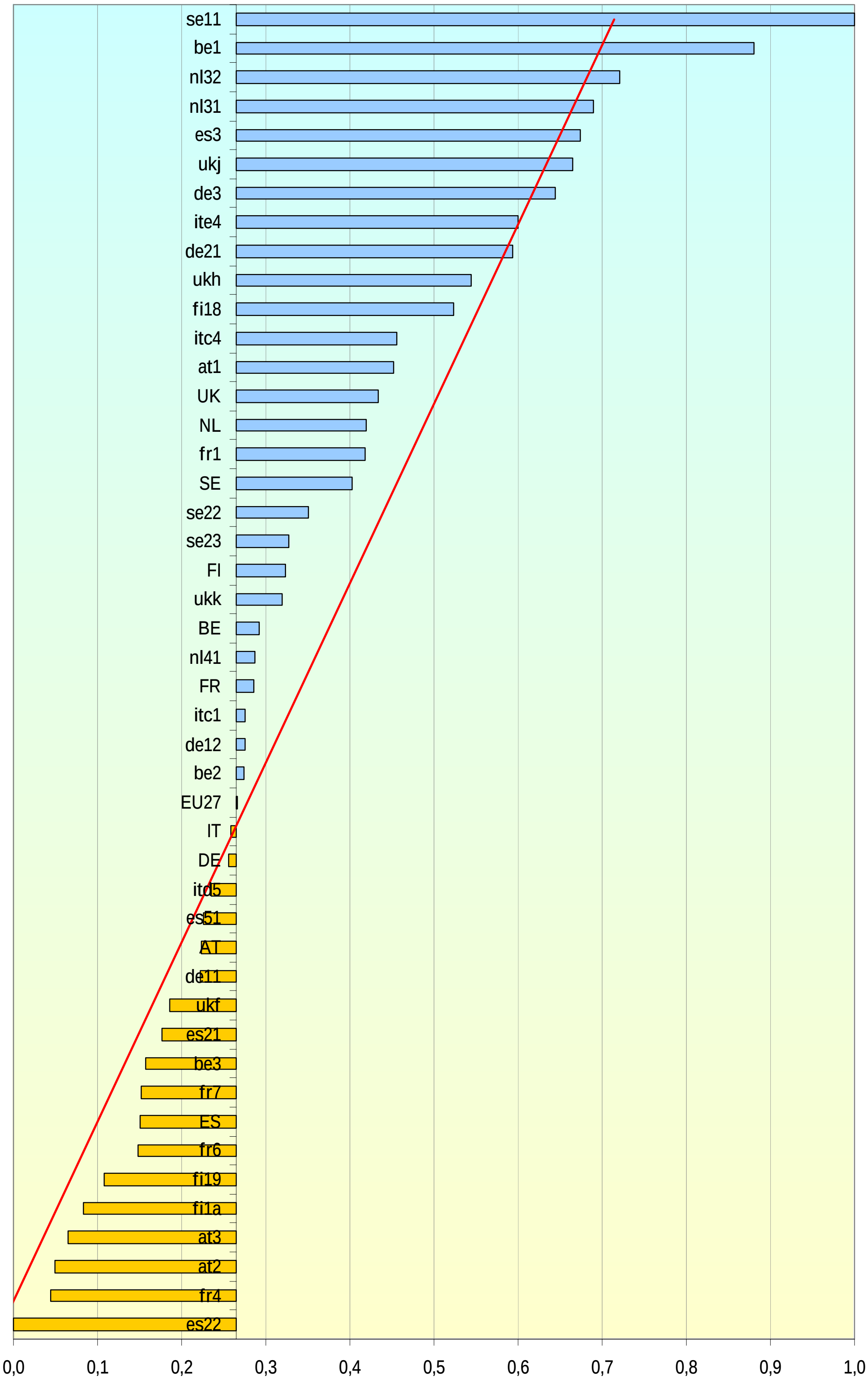

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Figure A16 – *3.2.5 New-to-market sales 2005*

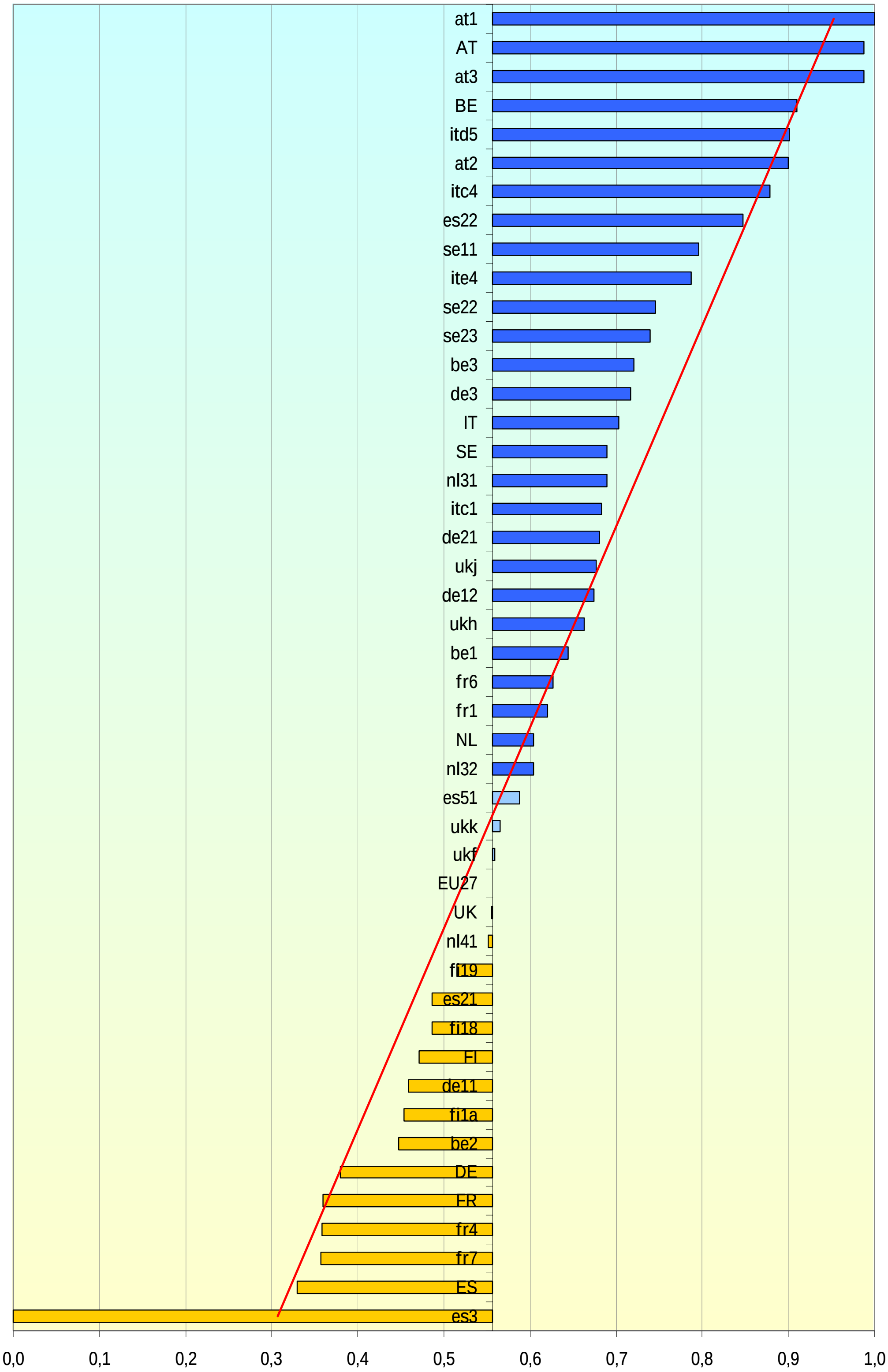

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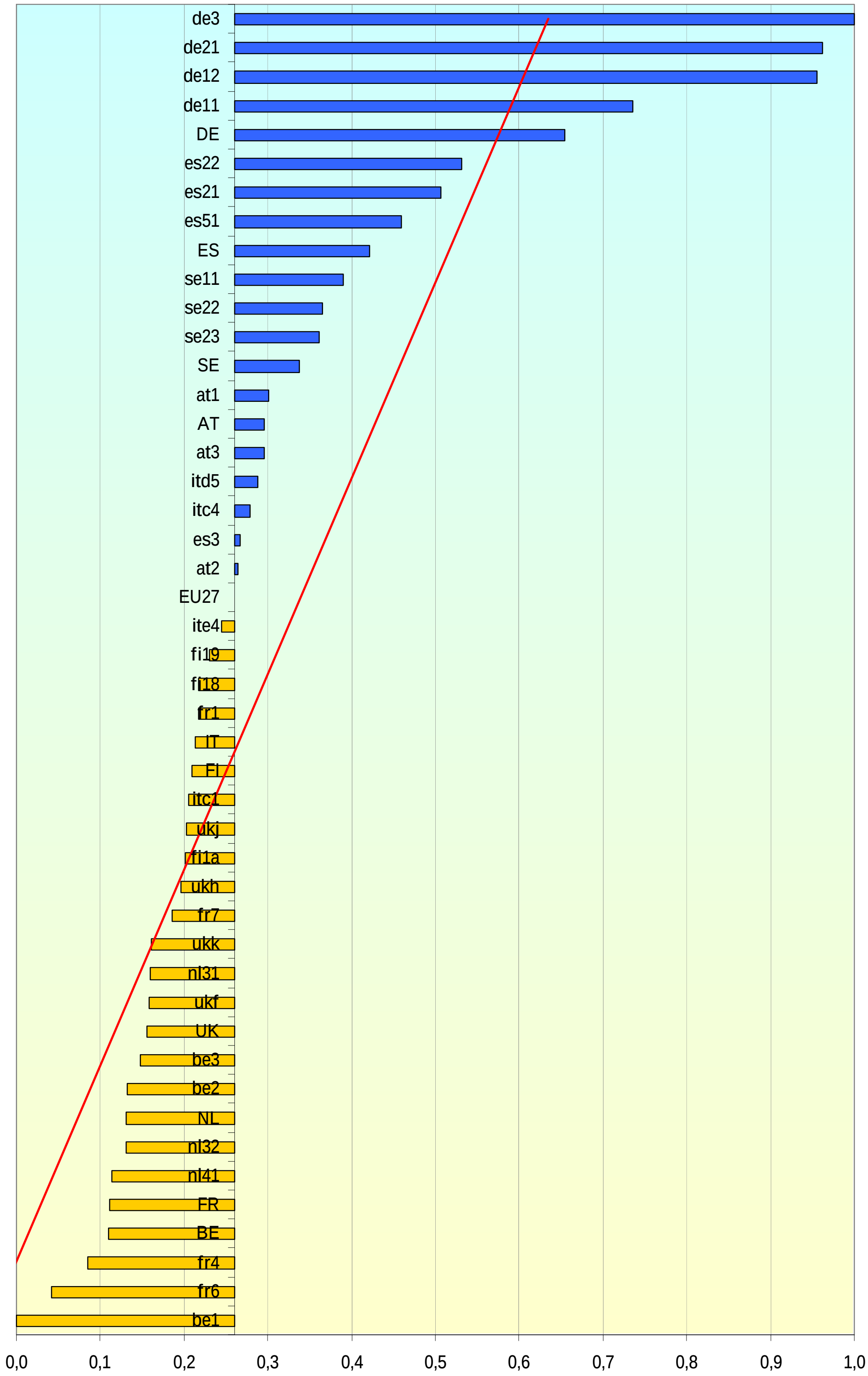
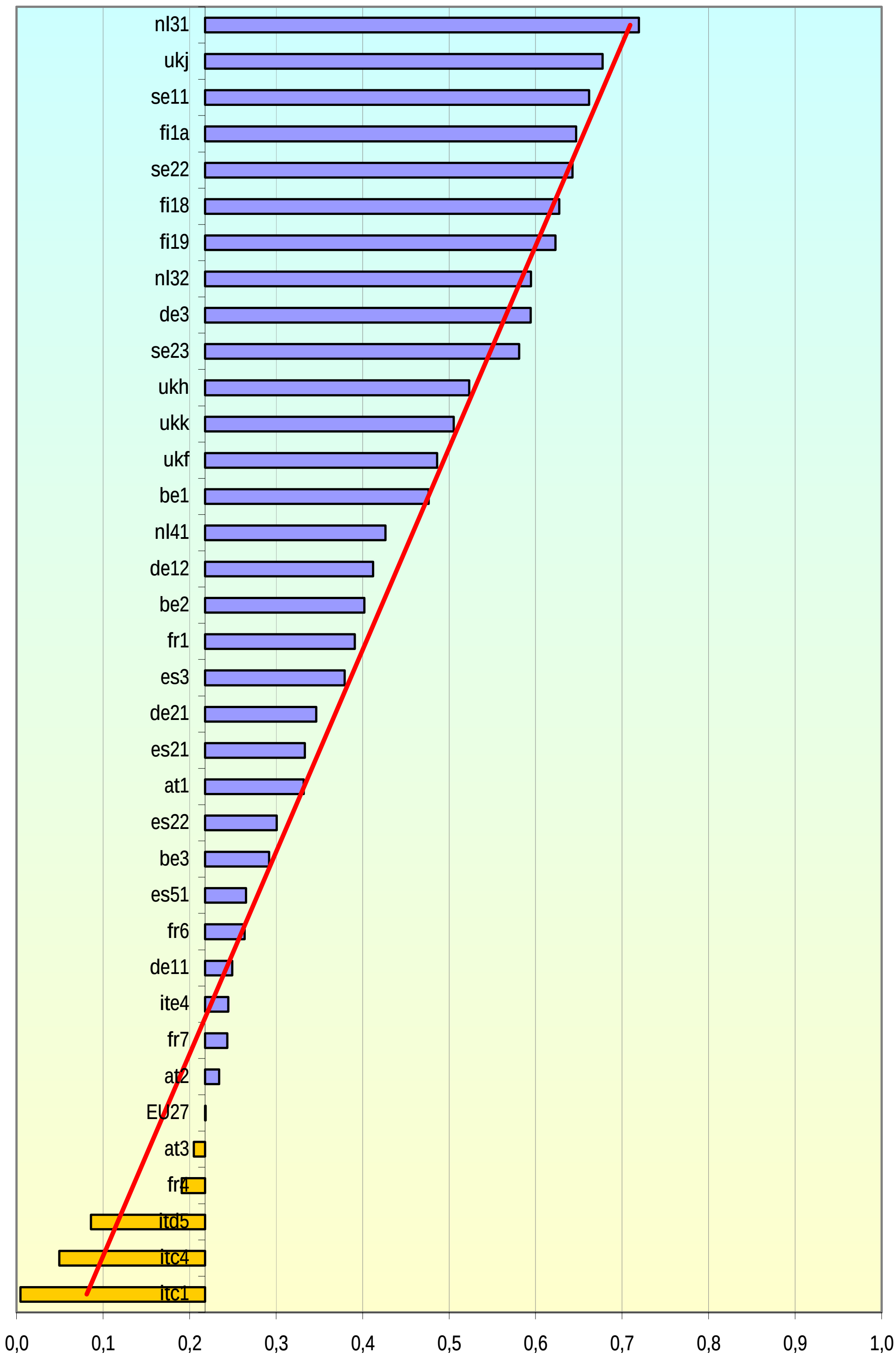
Figure A17 – *3.2.6 New-to-firm sales*



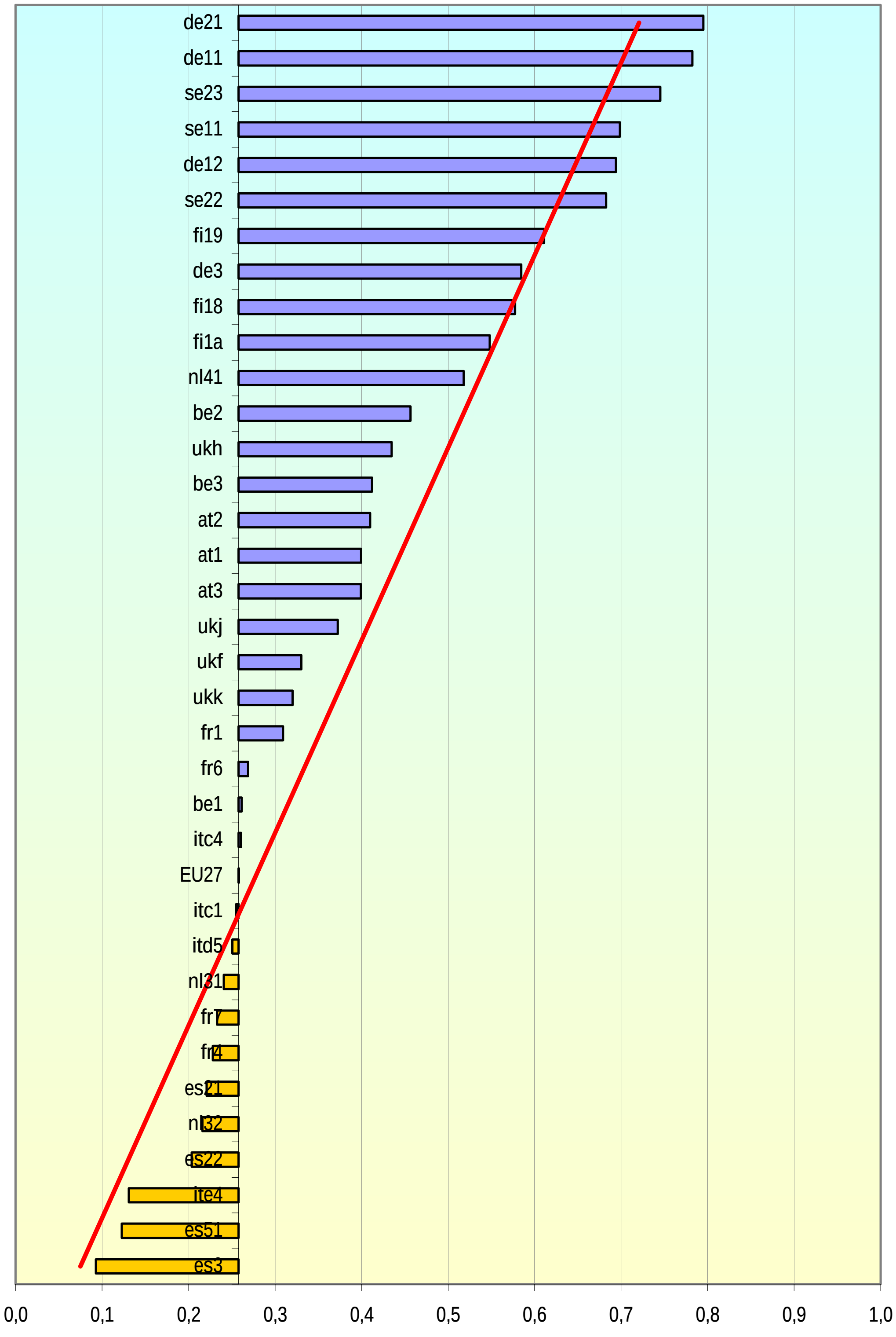
Notes: be1 = Région de Bruxelles ; es21 = Pais Vasco ; nl31 = Utrecht ; es22 = Navarra ; fi19 = Länsi-Suomi ; de3 = Berlin ; se11 = Stockholm; es3 = Madrid; fr1 = Île de France; nl32 = Noord-Holland; be2 = Vlaams Gewest; fi1a = Pohjois-Suomi ; be3 = Région Wallonne ; Ukj = South East; fi18 = Etelä-Suomi; es51 = Cataluña; se22 = Sydsverige; Ukk = South West; de21 = Oberbayern; nl41 = Noord-Brabant; se23 = Västsverige; Ukf = East Midlands; de11 = Stuttgart; Ukh = Eastern; fr6 = Sud-Ouest; de12 = Karlsruhe; fr7 = Centre-Est ; EU27 ; fr4 = Est ; at1 = Ostösterreich; ite4 = Lazio; at2 = Südösterreich; at3 = Westösterreich; itd5 = Emilia-Romagna; itc4 = Lombardia; itc1 = Piemonte.

Figure A18 – *Pillar I (4 indicators)*



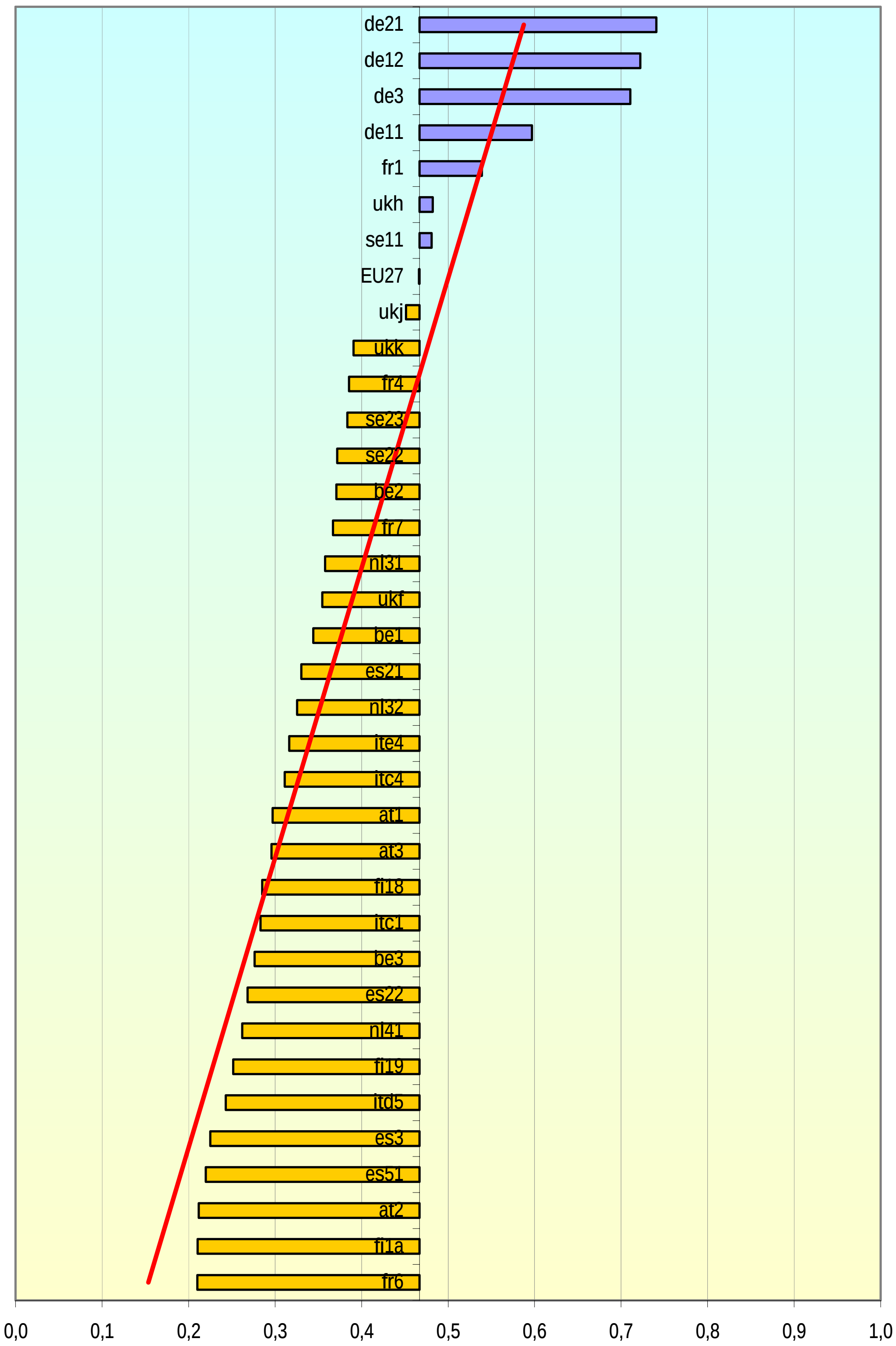
Notes: be1 = Région de Bruxelles ; es21 = Pais Vasco ; nl31 = Utrecht ; es22 = Navarra ; fi19 = Länsi-Suomi ; de3 = Berlin ; se11 = Stockholm; es3 = Madrid; fr1 = Île de France; nl32 = Noord-Holland; be2 = Vlaams Gewest; fi1a = Pohjois-Suomi ; be3 = Région Wallonne ; Ukj = South East; fi18 = Etelä-Suomi; es51 = Cataluña; se22 = Sydsverige; Ukk = South West; de21 = Oberbayern; nl41 = Noord-Brabant; se23 = Västsverige; Ukf = East Midlands; de11 = Stuttgart; Ukh = Eastern; fr6 = Sud-Ouest; de12 = Karlsruhe; fr7 = Centre-Est ; EU27 ; fr4 = Est ; at1 = Ostösterreich; ite4 = Lazio; at2 = Südösterreich; at3 = Westösterreich; itd5 = Emilia-Romagna; itc4 = Lombardia; itc1 = Piemonte.

Figure A19 – *Pillar II (5 indicators)*



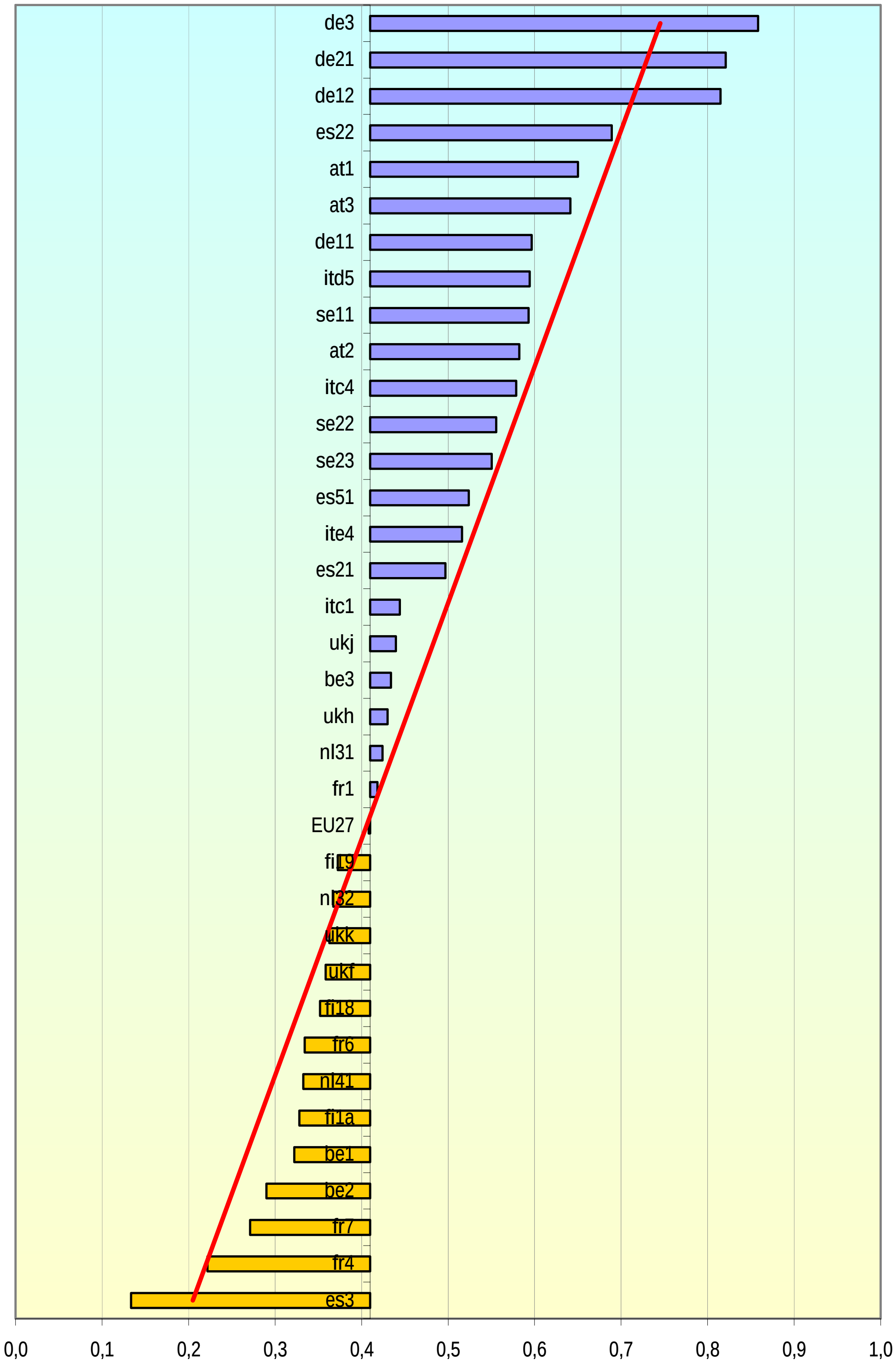
Notes: be1 = Région de Bruxelles ; es21 = Pais Vasco ; nl31 = Utrecht ; es22 = Navarra ; fi19 = Länsi-Suomi ; de3 = Berlin ; se11 = Stockholm; es3 = Madrid; fr1 = Île de France; nl32 = Noord-Holland; be2 = Vlaams Gewest; fi1a = Pohjois-Suomi ; be3 = Région Wallonne ; Ukj = South East; fi18 = Etelä-Suomi; es51 = Cataluña; se22 = Sydsverige; Ukk = South West; de21 = Oberbayern; nl41 = Noord-Brabant; se23 = Västsverige; Ukf = East Midlands; de11 = Stuttgart; Ukh = Eastern; fr6 = Sud-Ouest; de12 = Karlsruhe; fr7 = Centre-Est ; EU27 ; fr4 = Est ; at1 = Ostösterreich; ite4 = Lazio; at2 = Südösterreich; at3 = Westösterreich; itd5 = Emilia-Romagna; itc4 = Lombardia; itc1 = Piemonte.

Figure A20 – *Pillar III (6 indicators)*



Notes: be1 = Région de Bruxelles ; es21 = Pais Vasco ; nl31 = Utrecht ; es22 = Navarra ; fi19 = Länsi-Suomi ; de3 = Berlin ; se11 = Stockholm; es3 = Madrid; fr1 = Île de France; nl32 = Noord-Holland; be2 = Vlaams Gewest; fi1a = Pohjois-Suomi ; be3 = Région Wallonne ; Ukj = South East; fi18 = Etelä-Suomi; es51 = Cataluña; se22 = Sydsverige; Ukk = South West; de21 = Oberbayern; nl41 = Noord-Brabant; se23 = Västsverige; Ukf = East Midlands; de11 = Stuttgart; Ukh = Eastern; fr6 = Sud-Ouest; de12 = Karlsruhe; fr7 = Centre-Est ; EU27 ; fr4 = Est ; at1 = Ostösterreich; ite4 = Lazio; at2 = Südösterreich; at3 = Westösterreich; itd5 = Emilia-Romagna; itc4 = Lombardia; itc1 = Piemonte.

Figure A21 – *Pillar IV (2 indicators)*



Notes: be1 = Région de Bruxelles ; es21 = Pais Vasco ; nl31 = Utrecht ; es22 = Navarra ; fi19 = Länsi-Suomi ; de3 = Berlin ; se11 = Stockholm; es3 = Madrid; fr1 = Île de France; nl32 = Noord-Holland; be2 = Vlaams Gewest; fi1a = Pohjois-Suomi ; be3 = Région Wallonne ; Ukj = South East; fi18 = Etelä-Suomi; es51 = Cataluña; se22 = Sydsverige; Ukk = South West; de21 = Oberbayern; nl41 = Noord-Brabant; se23 = Västsverige; Ukf = East Midlands; de11 = Stuttgart; Ukh = Eastern; fr6 = Sud-Ouest; de12 = Karlsruhe; fr7 = Centre-Est ; EU27 ; fr4 = Est ; at1 = Ostösterreich; ite4 = Lazio; at2 = Südösterreich; at3 = Westösterreich; itd5 = Emilia-Romagna; itc4 = Lombardia; itc1 = Piemonte.

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Title: **Regional Innovation Index – Regional Champions within National Innovation Systems**

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Abstract
We look at the most innovative regions in Europe with the aim of detecting and describing the distinguished features oftheir innovation profiles, and to reach a workable synthesis of such a multi-faceted phenomenon called innovation. Composite indicators seem to be the natural candidates for this job as they ideally measure multi-dimensional concepts which cannot be captured by a single variable. In the first part of the report we carry out a robustness testing and thesensitivity analysis of the computed composite indicator. The report examines a large basket of possible meaningful alternatives and tests robustness as well as sensitivity both in a deterministic as well as in a probabilistic setting. In the second part of the report, written by one of the authors, we look at composites from the point of view of the policy-making process. Policy-makers in Europe are re-framing policy goals within the Europe 2020 strategy. The attention oninnovation is moving from the simple 'fostering innovation' objectives, towards the more complex and interdependent goals of 'gaining value from knowledge'. The declination of this new attention has been on entrepreneurship andhuman capital instead of simply raising R&D expenditures and patent application

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