European Commission

JRC SCIENTIFIC AND POLICY REPORTS

Update on the Composite Indicators of Structural Change towards a More Knowledge-Intensive Economy

Deliverable for WP3 of the research project "COMPOSITES_4_IU"

Daniel Vertesy and Vincent Van Roy

2013

Report EUR 26409 EN

Joint Research Centre

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

Contact information
Daniel Vertesy
Address: Joint Research Centre, Via Enrico Fermi 2749, TP 361, 21027 Ispra (VA), Italy
E-mail: daniel.vertesy@jrc.ec.europa.eu
Tel.: +39 0332 78 3556
Fax: +39 0332 78 5733

http://ipsc.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

This publication is a Reference Report by the Joint Research Centre of the European Commission.

JRC87000

EUR 26409 EN

ISBN 978-92-79-35009-2

ISSN 1831-9424

doi: 10.2788/51665

Luxembourg: Publications Office of the European Union, 2013

Printed in Italy

Update on the Composite Indicators of Structural Change towards a More Knowledge-Intensive Economy

Daniel Vertesy and Vincent Van Roy

October 2013

Executive summary

In the last decades, the European industrial and innovation policy initiatives have been driven by the main concern about the revealed lower productivity records that European companies have experienced in comparison with their main competitors, namely US firms. Recent communications on European industrial policy make explicit that it is essential to increase R&D investments and knowledge diffusion to foster productivity in manufacturing industry and associated services and therefore to underpin the recovery of growth and jobs in a "knowledge based" EU economy (European Commission, 2010a and 2010b).

The aim of this report focuses on this last issue in assessing whether the economic structure of Europe is becoming more knowledge-intensive, in comparison with other European (EU, EFTA) and non-European benchmark countries (US, Japan, China). This entails the measurement of key dimension of structural change with a simple policy tool. The present work builds on and updates the results of the previous Feasibility Study on the development of composite indicators of structural change (Vertesy et al., 2012).

A previous study of Malerba et al. (2011) identified three types of indicators related to structural change: enablers, compositional and Schumpeterian. *Enablers* refer to the framework conditions in a country which could support or hinder novelty and variety creation by firms (i.e., business environment, attitudes to science and technology or the availability of venture capital). *Compositional structural change* indicators measure changes in the actual sectoral composition of the economy in terms of research and development (R&D), skills, output, exports, technologies and foreign direct investment (FDI). *Schumpeterian structural change* indicators refer to the micro level, to the dynamics of innovation and entrepreneurship at the level of firms, technologies and markets.

Based on previous empirical literature in general and the two aforementioned studies in particular, we construct a composite indicator on structural change at the country level, including indicators on R&D, skills, sectoral specialization, international specialization and internationalization. As such, this composite is a supply-oriented indicator that is largely based on past performance (the outcomes of past efforts that are already measurable in terms of actual value added and employment levels in knowledge-based activities, revealed competitive advantages, supply of skilled human resources, etc.). All these indicators are related to the overall structure of the economy and are slow to change. In order to capture short-term characteristics of structural change related to the dynamics of smaller and younger firms, future research should focus on the development of a longitudinal database collecting indicators on the share of gazelles and the share of high-growth firms in terms of employment and turnover.

Contents

1. Introduction[1]

In the last decades, the European industrial and innovation policy initiatives have been driven by the main concern about the revealed lower productivity records that European companies have experienced in comparison with their main competitors, namely US firms. Recent communications on European industrial policy make explicit that it is essential to increase R&D investments and knowledge diffusion to foster productivity in manufacturing industry and associated services and therefore to underpin the recovery of growth and jobs in a "knowledge based" EU economy (European Commission, 2010a and 2010b).

The academic literature has pointed to different causes as the main explanations of the productivity gap between US and Europe in the last decades. Among others, the quality of human capital (Gu *et al.*, 2002), the rigidity of the European labour markets (Gomez-Salvador *et al.,* 2006), the role and diffusion of ICTs (Wilson, 2009), the importance of new managerial practices and organizational investments (Gu and Wang, 2004; Bloom *et al.,* 2005; Crespi *et al.,* 2007) and the endowment of capital appeared to be the most relevant ones.

Most of these explanations can be related to a revealed technological disadvantage of the EU, ultimately constraining the demand for human capital, ICT diffusion, innovative organizational and management practices and the diffusion of innovation through embodied technology in new capital formation. Both at the aggregate and the microeconomic level, R&D expenditures are a good proxy of technological investment. Recent research results show that the gap in corporate R&D investment is one of the root causes of Europe's lag in productivity growth in comparison with respect to the US (O'Mahony and van Ark, 2003; Blanchard, 2004; O'Sullivan, 2007; Rogers, 2010).

Therefore, European innovation policy advises member countries to strength their knowledge base to remain competitive, and ask European companies to massively invest in research and innovation in order to foster a smart, sustainable and inclusive economic growth (see European Commission, 2002, 2008, 2010b).

In this context, the aim to foster structural change in the EU's specialization from traditional and scale intensive sectors towards science-based and information intensive manufacturing and service sectors (i.e. Pavitt, 1984) should be seen as a key aspect of a strategy targeting knowledge-based growth, for all member states.

The aim of this report is to assess whether the economic structure of Europe is becoming more knowledge-intensive, in comparison with other European (EU, EFTA) and non-European benchmark countries (US, Japan, China). This entails the measurement of key dimension of structural change with a simple policy tool. The present work builds on and updates the results of the previous Feasibility Study on the development of composite indicators of structural change[2].

[1] This section benefited extensively from inputs by Prof. Marco Vivarelli (Universita Cattolica del Sacro Cuore).

[2] Vertesy, D. Albrecht, D and Tarantola, S., 2012, Composite Indicators measuring structural change, to monitor the progress towards a more knowledge-intensive economy in Europe, European Commission (EUR 25279 EN).

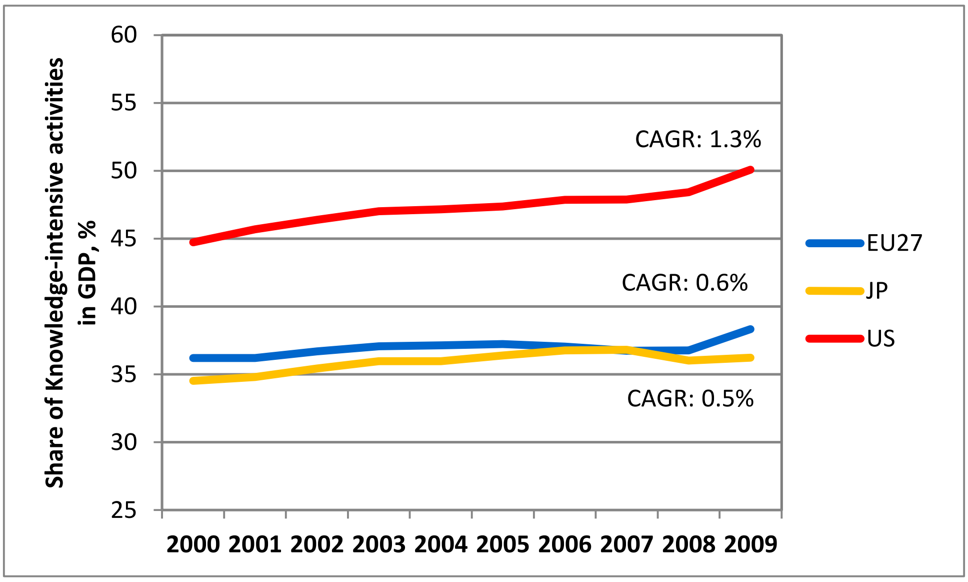
2. Measuring Structural Change

The concept of structural change refers to the long-term dynamism of the economy, through which the types and nature of existing production, consumption, trade, or research activities shift to new ones. In the course of the past centuries, the world has witnessed industrial revolutions through which agrarian dominated economies transformed into economies dominated by manufacturing industries, and subsequently the expansion of service industries. Most recently, the diffusion of information and communication technologies have changed the way products and services are developed, produced and sold, which in turn necessitates different skills from employees in a knowledge economy and require, in general, longer time spent in education.

When it comes to measuring structural change, a distinction should be made between structural change in general, which is rather difficult to measure[3], and change towards a preferred economic structure. Following the current socio-economic context and policy goals described in the introduction, a structural change towards a knowledge-based economy is the focus of this report.

For a first glance at the changing structure of European economies, one can look at changes in the size of knowledge-intensive activities in terms of value added or employment. As demonstrated by Figure 1 and Figure 2, the EU has made modest progress in the past decade in increasing its share of knowledge-intensive activities; not only is this share of knowledge-intensive activities lower by more than 10 percentage points than that of the US, but it is also increasing slower – in other words, the knowledge-intensity gap continues to increase.

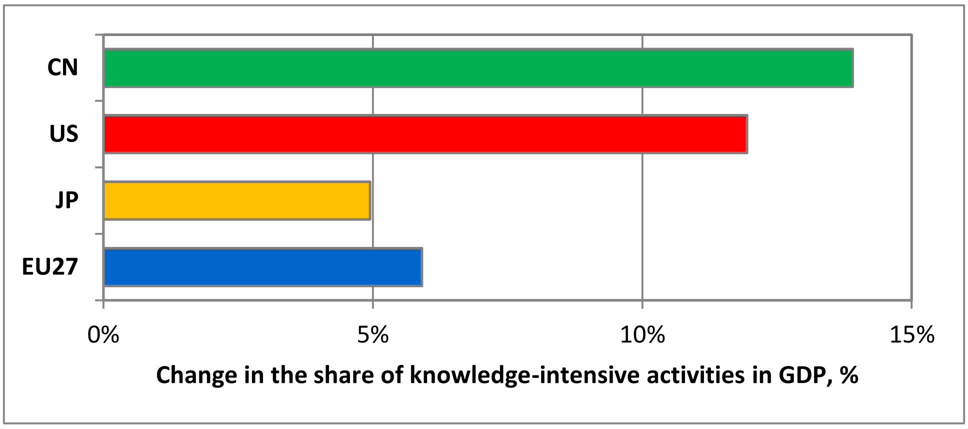
Figure 1 Value added in knowledge-intensive activities as a % of GDP, 2000-2009



Source: Computations of value added in KIA sectors by the Vienna Institute for International Economic Studies (WIIW) based on national accounts data from Eurostat, OECD, EUKLEMS, WIOD and national statistical offices.
Note: KIA sectoral definitions according to NACE Rev.2 were back-cast. CAGR indicates compound annual average growth rates for the 9-year period.

[3] "Because of its many and variegated dimensions, structural change is quite difficult to measure. And in addition, it is also quite difficult to assess in terms of desirable speed, direction and composition because it is quite difficult to evaluate desired or optimal outcomes associated with structural change. There is no ex-ante, well-defined progressive tendency in structural change that leads necessarily to superior economic performance. Indeed, structural changes may even lead to an economy that develops along a slower growth trajectory than other countries." (Malerba et al, 2011, p.3)

Figure 2 Overall change in the share of knowledge-intensive activities in GDP, 2000-09



Source: Computations of value added in KIA sectors by the Vienna Institute for International Economic Studies (WIIW) based on national accounts data from Eurostat, OECD, EUKLEMS, WIOD and national statistical offices.
Note: KIA sectoral definitions according to NACE Rev.2 were back-cast. Data for China overestimated as it excludes service sectors.

The strong performance of a knowledge-based economy (and society) entails more than domestic productive specialization in certain sectors. Knowledge-intensive activities rely on the performance of scientific and technological research and development (R&D) and the exploitation of its outcomes, which requires a highly skilled labor force and capital investments. If performed successfully, they result in increasing domestic and foreign competitiveness of knowledge-based goods, which is often associated with high-tech specialization and a greater openness of the economy. Strong performance in all these aspects creates a mutually-reinforcing mechanism that is a sustained source of growth and a higher standard of life. Monitoring structural change towards a knowledge-based economy will therefore need to take into consideration multiple aspects – which is why the use of composite indicators may be conducive.

2.1. A composite indicator on structural change

A recent report of The Expert Group on the Measurement of Innovation[4] identified three types of indicators related to structural change: enablers, compositional and Schumpeterian. *Enablers* refer to the framework conditions in a country which could support or hinder novelty and variety creation by firms (i.e., business environment, attitudes to science and technology or the availability of venture capital). *Compositional structural change* indicators measure changes in the actual sectoral composition of the economy in terms of research and development (R&D), skills, output, exports, technologies and foreign direct investment (FDI). *Schumpeterian structural change* indicators refer to the micro level, to the dynamics of innovation and entrepreneurship at the level of firms, technologies and markets. It also concluded that the compositional dimension was most quantifiable and data was most "mature", especially at the country level, as Schumpeterian dynamics involved often technology and industry-specific qualitative changes.[5] Consequently, this study focuses on

[4] Malerba F., Salter M., Saltelli A., 2011, 'Expert Group on the Measurement of Innovation: Indicators for Structural change', Brussels. Hereafter referred to as the 'Export Group Report'.
[5] There is currently an ongoing work in the context of the European Commission's Headline Innovation Indicator to measure innovative entrepreneurship in high-growth enterprises, the results of which may be potentially informative for the Schumpeterian indicators as well.

monitoring changes in the composition of the economy. (We note that devising a new framework and an alternative list of indicators through which structural change could be measured is not the aim of this report, however, some reflections are provided in the concluding section.)[6]

There is, of course, a necessary qualitative judgment to identify the target of structural change for the sake of cross-country comparison, which involves selecting a set of economic activities and sectors which are expected to grow. While the speed and direction of the decade-long shifts between industrial activities have always differed across Europe and across the world, the spread of what can be called as the knowledge economy is taking place much more simultaneously than previous changes have, and have similar characteristics across the world, making cross-country comparison more meaningful. For instance, the increased use of systematic research and development for creating, producing and diffusing goods, the reliance on highly qualified human resources, of specialization in certain technologies and increasing openness are among the common features. This study considers knowledge-intensive activities, or manufacturing and services sectors characterized by a high share of employment with tertiary education,7 as the desired outcome of structural changes.

Based on the shortlist of indicators identified by the Expert Group to measure the compositional aspects of structural change, we measure the size of the knowledge economy in five dimensions and with nine indicators, as defined in Table 1. The five dimensions express different characteristics of a knowledge-based economy:

- *Increased research intensity in the private sector and the emergence and growth of R&D as a specialized sector of the economy (R&D indicators)*.
  Motivation: R&D expenditure has found to be an important source of productivity gains and competitiveness of companies (O'Mahony and van Ark, 2003; Blanchard, 2004; Moncada-Paterno *et* al 2010, O'Sullivan, 2007; Rogers, 2010).
- *Increased demand for highly qualified human resources in the economy (Skills indicators).*
  Motivation: Alongside machines and science and technology personnel, skilled human capital is a key resource for innovative companies to translate new ideas into marketable products. The presence of highly qualified staff is an especially relevant indicator for service sectors, which constitute the largest share in European economies and which may spend less on R&D.
- *Increased economic value creation in sectors relying on highly qualified human resources (Sectoral specialization indicators)*.
  Motivation: Progress towards a more knowledge-intensive economy is typically measured by the size of a selected set of sectors in an economy measured in terms of value added (Timmer et al, 2010).

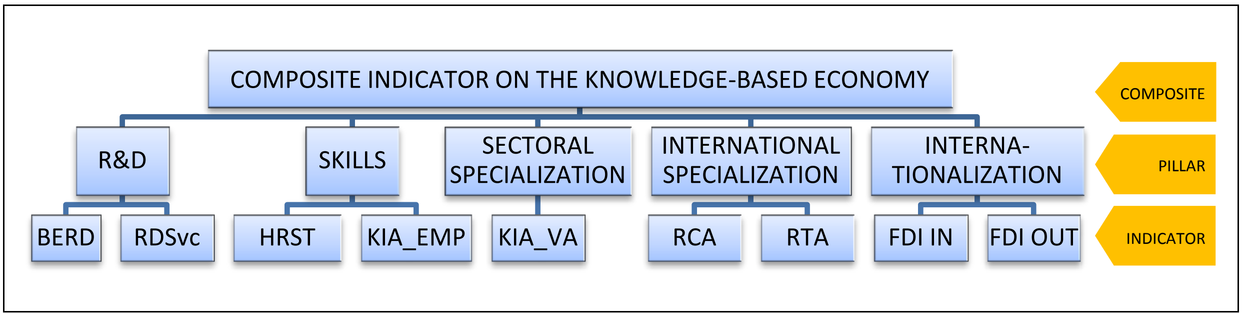
[6] There have also been previous attempts to construct related composite indicators on the knowledge economy, such as the Knowledge Economy Index by the World Bank or Saisana and Munda (2008) Knowledge Economy: measures and drivers. JRC Scientific and Technical Reports, European Commission.

[7] According to the Eurostat definition, An activity is classified as knowledge intensive if tertiary educated persons employed (according to ISCED97, levels 5+6) represent more than 33% of the total employment in that activity. The definition is built based on average number of employed persons aged 25-64 at aggregated EU-27 level in 2008 and 2009 according to NACE Rev. 2 at 2-digit, using EU Labour Force Survey data.

- *Increased specialization of countries in the development of high technologies and in exporting (medium- and) high-tech products (International specialization indicators).* Motivation: knowledge-driven structural change depends on the success of innovative companies with above-average tendency for invention of new technologies and in exporting them on the international markets.
- *Increased openness of economies in terms of foreign investments (internationalization indicators).*
  Motivation: Transnational companies and their foreign investments are key drivers of the international exchange of new ideas and technologies, innovation, and ultimately a source of structural change. This requires increased on openness of economies.

Each of the five dimensions are populated by one or two indicators, all measured at three time points to better express change over time: 2000, 2005 and 2011 (or most recent year available). Data has been collected for 40 countries, including all EU27 member states, members of EFTA and key international benchmark countries (OECD member states or BRIC countries), such as the USA, Japan, China, Israel, Brazil, India, Russia and the Republic of Korea. Even if data availability for some of the BRIC countries was more limited, we nevertheless decided to include them in the sample as they are expected to show interesting structural dynamics relevant for European economic, industrial, innovation and trade policy.

Figure 3 The architecture of the composite indicator on the knowledge-based economy



Note: See Table 1 for indicators definition

Table 1 Indicators on the size of the knowledge economy

Indicator	Definition	Source
R&D Indicators		
BERD	Business R&D expenditure as a share of GDP (%)	Eurostat/OECD
RdSvc	The share of R&D services in the economy (the share of sector NACE Rev 1.1 code K73 in the total economy, in terms of value added)	Eurostat/OECD EUKLEMS/WIOD (WIIW)
Skills Indicators		
HRST	Share of Human Resources in Science and Technology (HRST) as a share of active population (15-74) (%)	Eurostat
KIA_EMP	Share of persons employed in knowledge-intensive activities (KiAs) as a percentage of total employment.	Eurostat
Sectoral Specialization Indicator		
KIA_VA	The share of value added in knowledge-intensive activities within the total value added in a country	Eurostat/OECD EUKLEMS/WIOD (WIIW)
International Specialization Indicators		
RTA	Relative specialization in holding PCT patents in selected technology classes (Revealed Technological Advantage – RTA)	OECD
RCA	Relative specialization in the export of medium-high tech and high-tech products (Revealed Competitive Advantage – RCA)	Eurostat
Internationalization Indicators		
FDI_IN	Cumulative inward FDI stock as a share of GDP	Unctad
FDI_OUT	Cumulative outward FDI stock as a share of GDP	Unctad

These five dimensions are considered as five pillars of a composite indicator that measures the **relative size of the knowledge-based economy**. In turn, **structural change in this context is expressed as level change of this composite indicator**. The architecture of the composite indicator is shown in Figure 3.

Pillar scores were computed by taking the arithmetic average of the normalized indicators[8] within each pillar.[9] Principal component analysis confirmed that the five pillars express multiple dimensions of the same phenomena, and could therefore be aggregated into a single composite indicator, which we called the "composite indicator on the knowledge-based economy". Nevertheless, we noted the presence of compensatory effects in the R&D and International specialization pillars (see correlations between indicators in Table A3 of the Annex). For instance, countries with lower revealed comparative advantage in high-tech exports were allowed to compensate their performance with better performance in revealed technological advantage because of the arithmetic average within pillars. At the same time, countries cannot achieve as much progress unless they increase the performance in their weaker pillars as well.

[8] Indicators were normalized using the min-max method (between 10-100 in order to allow geometric aggregation), considering all three time points simultaneously for a meaningful indicator of change over time. Both FDI indicators were treated for the presence of outliers by winsorization. In case indicator scores were missing for a country, the respective averages were imputed, thus the pillar and composite scores are based on the average of the available indicators.

[9] We noted that in the case of the R&D and international specialization pillars, the correlation between the indicators was positive and significant, but relatively weak (0.36 and 0.33, respectively). In this way, countries performing stronger in one of the indicators in these pillars may compensate their weaker performance in the other indicator of the pillar.

3. Summary of the analysis on the statistical coherence of the composite indicator

The composite indicator described in this report applies the methodology described in a previous feasibility study (Vertesy *et al*, 2012) based on the conceptual framework of Malerba *et al* (2011) with the main difference being that indicators were updated to the latest year available, and in the case of KIA_VA, were improved in quality. While the focus of this report is the description of the updated results, we provide here a brief summary on data quality, the statistical coherence of the framework and the methods used for the computation of the composite indicator with the aim to describe how these properties and choices affect the results.

Data coverage for the nine indicators at three time points was very high for most of the EU Member States as well as Switzerland, Norway and Iceland (96-100%), but somewhat lower for Malta, Bulgaria, the UK, Japan, the United States and Russia (85-89%). Missing data proved to be an issue for four additional countries also included in the study, Brazil and China (both at 67%) and Israel and India (56%). As we chose to impute missing data with the average of the available indicators (or pillars, if an entire pillar was missing), we note in these latter cases that scores are the outcome of the BERD indicator as well as the internationalization and international specialization pillars. In the case of Brazil and China, we note that the skills pillar had to be entirely imputed. All the rest of the countries had at least one indicator per pillar.[10] **Outliers** were identified in the FDI_In and FDI_Out indicators, which were treated by winsorizing the top 4 and 5 in values, respectively. This concerned the positions for the latest time point of Belgium, Luxembourg and Iceland for both indicators, and Switzerland in the case of FDI_Out.

We noted that the **statistical coherence** of the conceptual framework was affected by the choice to include indicators in two of the five pillars with relatively weaker pairwise correlation. In particular, this affected the R&D and international specialization pillars.[11] Theoretically, it is easier to justify that relative weakness in RCA can be compensated by a relative strength in RTA scores (leaving the nature of advantage for countries to decide) in the international specialization pillar. It may be more difficult to justify that countries can compensate a weaker performance in BERD with a stronger performance in the R&D services sector (relative to the total economy).

We therefore **first tested** how country ranks would be affected if composite scores were computed excluding the RdSvc indicator but keeping other assumptions unchanged. The countries benefiting most from this modification are Russia, France and Luxemburg (improving by 9, 6 and 4 rank positions, respectively), while Finland, Malta and China would fall back by 4 positions. At the same time, 21 countries would shift 1 position or less.

In a **second test**, we explored how allocating scaling coefficients (or weights) to pillars could render the composite index statistically more balanced (Paruolo et al, 2013). Such scaling coefficients ranging between 0.5 and 1 were allocated in such a way that the international specialization pillar,

[10] From the indicators perspective, we note that data coverage was an issue for the HRST and RdSvc indicators with countries missing information for all years: in the former case this concerned Israel, Brazil, Russia, India, China, South Korea, Japan and the United States, while in the latter case Bulgaria, the United Kingdom, Turkey, Israel, Brazil, India and China.

[11] The Pearson correlation coefficients are presented in Table A3 of the Annex. The 0.33 and 0.36 coefficients between BERD and RdSvc, and the RTA and RCA indicators are, even if positive and significant, rather low.

which contributed least to the total variance of the composite scores, received the highest and the skills, sectoral specialization and internationalization pillars received the lowest values. As a result, the correlation between the various pillars and the composite index became more balanced, but some country ranks shifted significantly (Luxembourg, China, Malta, Israel, Spain and Norway by four positions or more) and the international specialization pillar still contributed relatively weaker to the overall scores. This suggests that in the future this inclusion of this pillar or the indicators chosen to measure international specialization might need to be reconsidered. At the same time, from a theoretical point of view, it may be argued that the imbalance itself is not necessarily problematic. Moreover, it may even be beneficial if this imbalance is in favor of the skills and sectoral specialization indicators as it reflects well structural change understood as the changing sectoral composition of an economy. In this way, the main contribution of the composite index is to "augment" the single value added and skilled employment indicators which are at the heart of the issue under investigation, by providing additional information on closely related economic outcomes. We noted that if the international specialization pillar and the information it contains is not included in the composite index, we would see a significant weakening of scores and ranks for Germany, Italy and Norway (by as much as 7, 7 and 4 positions, respectively) and improvement in the cases of Malta (by 6 positions), China (5 positions), as well as Lithuania, Israel and South Korea (by 4 positions).

4. Results

The resulting composite scores of structural change are presented in two ways (Table 2). First, we show the overall composite levels for the three time points to show the relative size of the knowledge-based economy by country in all the five pillars considered, and present the level changes of composite scores for each country, that is understood as an indicator of structural change.

Table 2 Concept and measurement of the knowledge economy

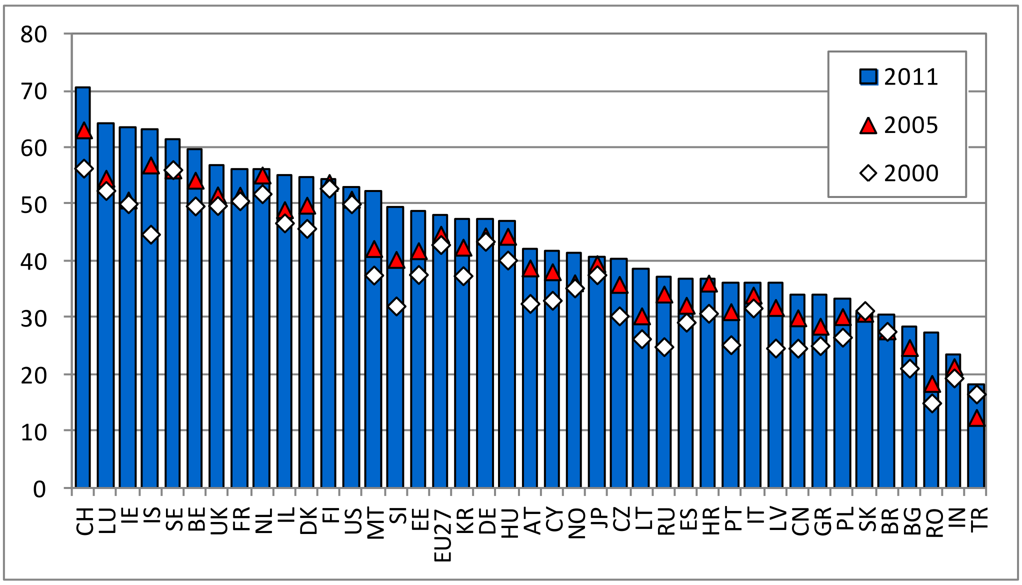
Concept	How we measure it
Relative size of the Knowledge-based economy	composite indicator scores (levels)
Progress towards a more knowledge-intensive economy	level changes in composite scores

In a following section, we compare countries in terms of pillar level dynamics in order to better understand the strengths and weaknesses of countries. Finally, some comparisons are shown key indicators that could be considered as enablers of structural change.

4.1. Analysis at the overall composite level

The resulting scores after the geometric aggregation of the five pillars described above are presented in Figure 4 for three time points. The indicators in this way show a snapshot of the size of the knowledge economy of the countries considered, which can be considered as the outcome of past structural change. At the same time, past scores are also shown to put past performances into perspective. Note that given the measurement and aggregation procedure, the performance scores should not be read as the size of the knowledge economy measured as a percentage of total performance, but rather as a ranking of countries. Furthermore, the large differences in the size of countries influence significantly their specialization and internationalization scores, which is why we find smaller countries at the top of the ranking.

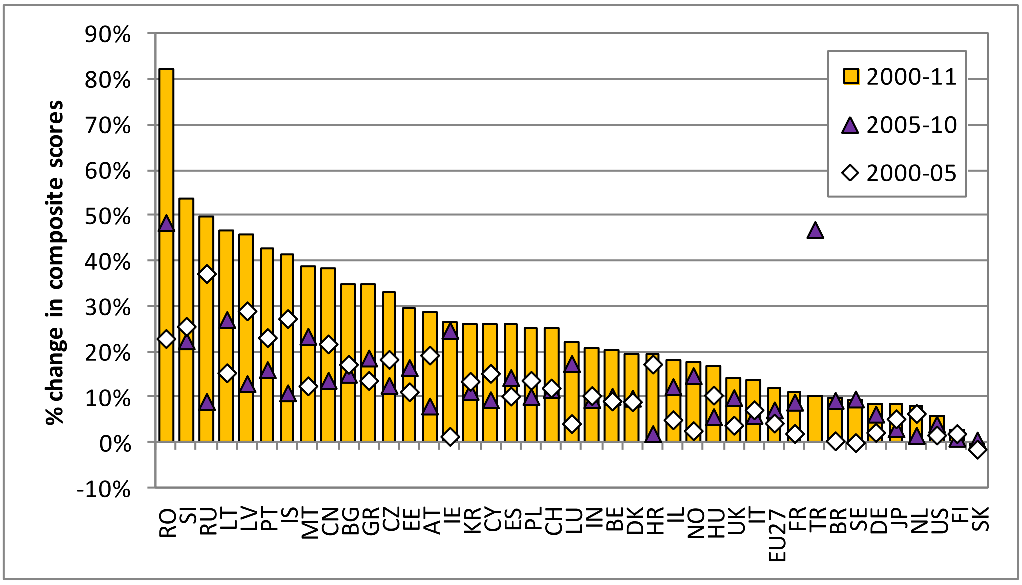
Figure 4 Composite scores on the relative size of the knowledge-based economy, 2000-2011



Source: JRC calculations

For a more direct indicator of structural change, we rank countries based on the changes of composite scores over a five and eleven year period in Figure 5. Considering the two graphs together, it is clear that countries in which the knowledge-intensive share of the economy increased relatively the most were often the ones with the lowest scores.

Figure 5 Structural change measured as change in composite scores on the knowledge economy, 2000-2011

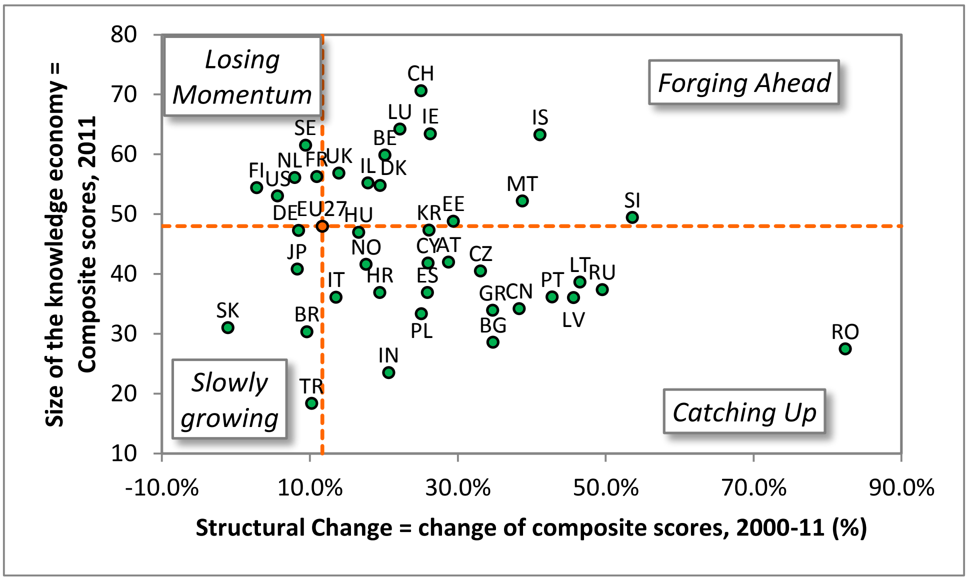


Source: JRC calculations

Plotting the indicators of the size of the knowledge economy (composite scores of 2011) against structural change over the past decade (or the growth of the composite scores, 2000-2011) gives a promising message that most of the weakest performing countries are catching up. As shown in Figure 6, EU member states with a relatively smaller sized knowledge economy, such as Romania, Bulgaria, Latvia, Lithuania, but also Mediterranean countries have shown greater growth than the EU27 in total. Among the countries that outperformed the EU27 in both dimensions, we find many of the smaller EU member states. The member state facing the most challenges in terms of catch-up is Slovakia where the size of the knowledge economy has even been shrinking over the past decade – although the 1.5% decline between 2000 and 2005 reversed after 2005, and the country achieved a modest growth of 0.5% in the past six years.[12]

Figure 6 Four Quadrants Charts on Structural Dynamics

(Size of the knowledge economy, 2011 against its growth, 2000-2011)



Note: comparison made with regards to EU27 weighted average.
Source: JRC calculations

Q2: What pillar-level dynamics drive the various country scores?

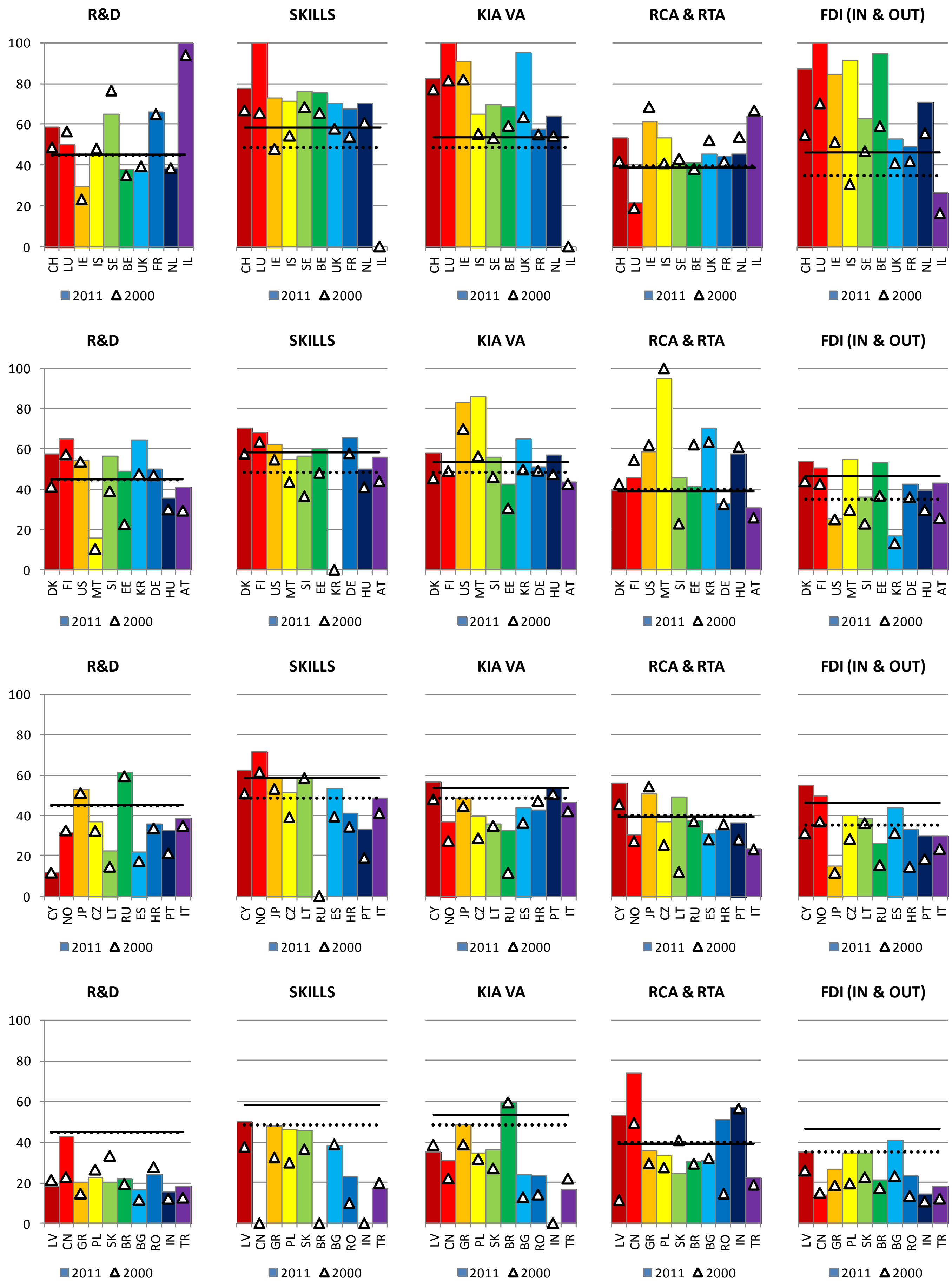
4.2. Analysis at the pillar level

As the aggregation of the pillar scores into a composite may hide pillar-level dynamics, we took the analysis one step further by comparing pillar scores across country and time. In order to benchmark countries with more similar performance against each other, the forty counties were grouped into four quartiles based on their overall composite scores (rows of Figure 7), and were each measured against the EU27 weighted average scores (straight and dotted horizontal lines in the panels of Figure 7).

An important message from the graphs are that Skills, Value added in KiA (KIA VA) and FDI pillar scores clearly distinguish the various groups of countries (the top quartile of countries have the highest scores), while both the R&D and the international specialization (RCA&RTA) pillars show more heterogeneity across the four groups.

[12] For detailed country scores and growth rates between all three time points considered, please refer to the tables of the Annex.

Figure 7 Comparison of pillar-level structural dynamics for 40 countries, at 2000 and 2011

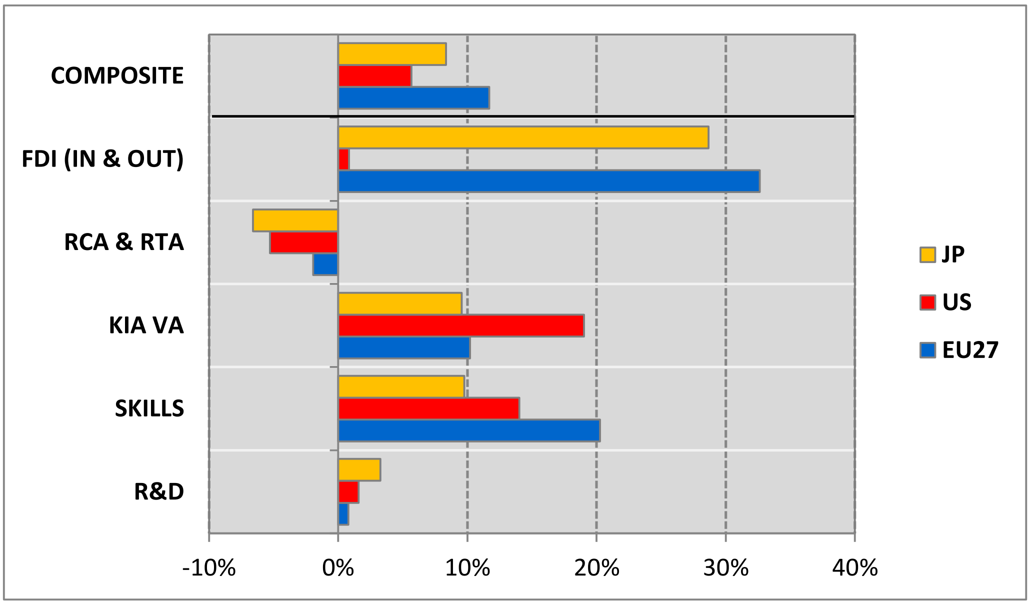


EU27 in 2011
EU27 in 2000

Note: bars indicate pillar composite scores for 2011, triangles indicate pillar composite scores for 2000. For reference, EU27 scores are shown with a continuous line in 2011 and with a dotted line in 2000.*Source:* JRC calculations

Figure 8 provides a direct global comparison of the five pillar scores of the economic "triad", the EU27, the United States and Japan over the eleven-year period between 2000 and 2011. The EU27 has witnessed the progress relatively the most in terms of skills and foreign direct investments, and declined the least in revealed comparative advantage and revealed technological advantage. At the same time, the share of value added in Knowledge-intensive activities has not grown as much as employment has (and neither as fast as it has in the US), and business R&D intensity and the size of R&D service sector (the R&D pillar) has virtually stagnated over the last decade.

Figure 8 Comparison of level changes in the five pillar and composite scores for the EU27, the United States and Japan, 2000-2011



Source: JRC calculations

5. Enablers of structural change and resulting scores

It is understood that the preconditions enabling structural change towards a more knowledge-based economy entails more than a strong domestic performance of research activities (or research excellence), but also include the social, technological and investment capabilities[13] to be able to exploit them. In addition, favorable conditions for innovative entrepreneurship are also crucial to create firms that can become the engines of knowledge-based growth. All this ensures that countries that can offer competitive locations for knowledge-based industries and can reap the first-mover advantages and higher value added which potentially allows greater employment opportunities and higher standards of life in the longer term.

Moreover, industries at the global level experience life-cycles[14]depending on the maturity of underlying technologies[15], which has an implication on the nature and type of knowledge and

[13] Abramovitz, M., 1986, Catching Up, Forging Ahead, and Falling Behind. *The Journal of Economic History*, Vol. 46, No. 2, The Tasks of Economic History (Jun., 1986), pp. 385-406.
[14] Vernon, R., 1966, 'International Investment and International Trade in the Product Life Cycle,' *Quarterly Journal of Economics*, 80, 190-207; Klepper, M, 1997, 'Industry Life Cycles', *Industrial and Corporate Change, Vol. 6 No. 1.*

innovation, or the size of enterprises that can be a driver of growth. Many of these aspects cannot be measured at the country level, but require a more in-depth sectoral disaggregation which is beyond the scope of this present report. With these considerations, based on the expert group report, we consider the key enablers of structural change as:

- Institutional framework conditions for innovation (ease of doing business)
- Finance and support
- Human resources

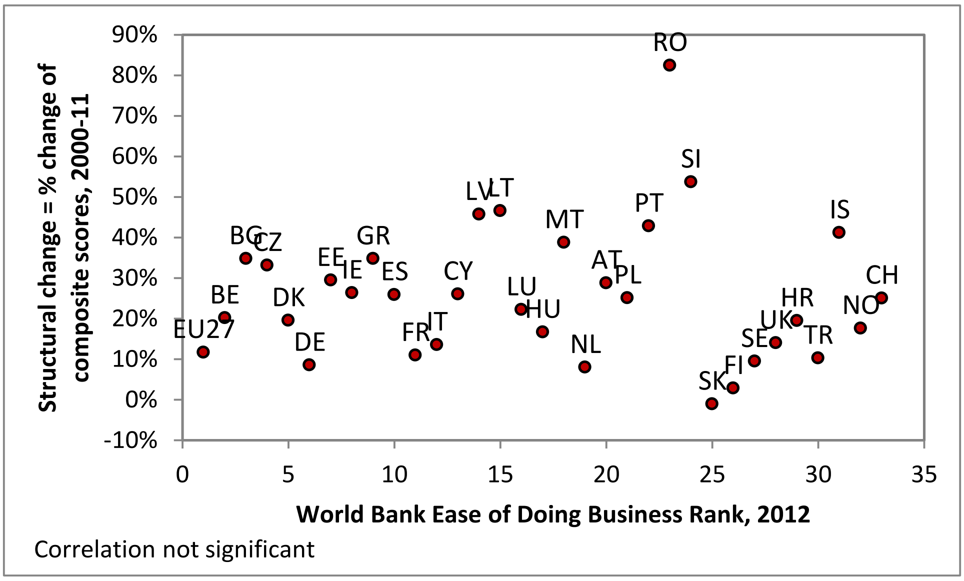
With regards to institutional framework conditions, we can rely on the World Bank Ease of doing business survey results, while for the latter two dimensions the Innovation Union Scoreboard (IUS) provides statistical data for many recent years. However, it is rather unlikely that the framework conditions measured this way influence long-term dynamics, and more likely to influence Schumpeterian dynamics – what, for the moment, is not measured here.

Below, we present scatter plots on the correlation between these three dimensions of enablers of structural change and our composite scores.

Q3: Is a more business-friendly environment favorable to structural change?

It is difficult to conclude from Figure 9whether a more business-friendly environment is conducive to structural change. Either measured through changes in composite scores (as shown in the figure) or as levels (not shown here), we find no association between structural change (or the size of the knowledge economy) and country rankings in terms of ease of doing business.

Figure 9 Structural change (2000-11) plotted against Ease of doing business ranks of countries (2012)



Source: JRC calculations; World Bank Doing business survey online database, 2012

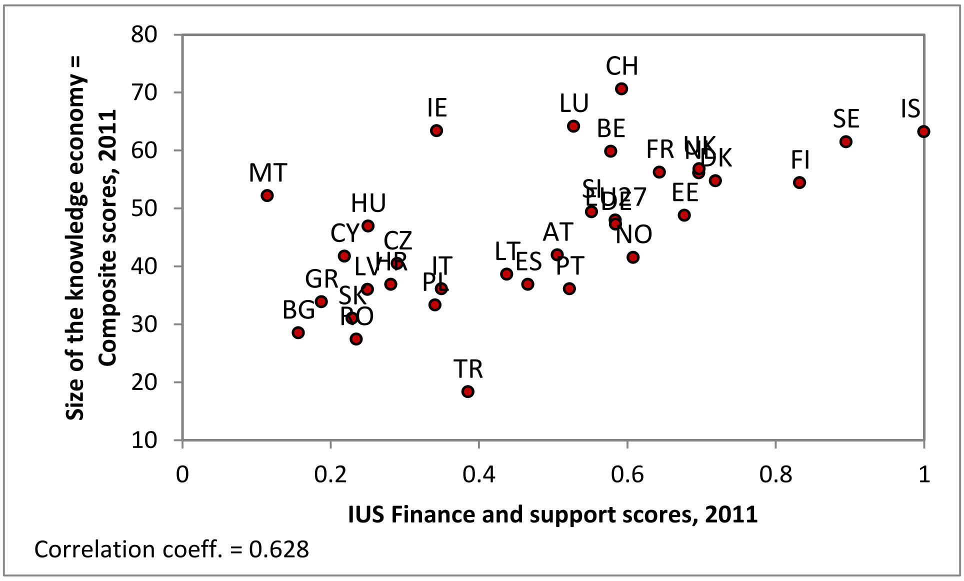
[15] Malerba, F., & Orsenigo, L., 1996, "Schumpeterian patterns of innovation are technology-specific". *Research policy*, 25(3), 451-478.; Breschi, Stefano, Franco Malerba, and Luigi Orsenigo., 2000, "Technological regimes and Schumpeterian patterns of innovation." *The Economic Journal* 110.463 (2000): 388-410.

Q4: Is a greater availability of finance associated with a larger size of knowledge economy?

In Figure 10, the size of the knowledge economy (composite scores of 2011) are compared against the 2011 Innovation Union pillar scores on “Finance and support”.[16] These scores, derived from public R&D expenditure and venture capital data, are relatively strongly and positively correlated with the size of the knowledge economy. Yet we do note some interesting patterns, such as the relatively similar IUS finance and support scores for Turkey and Ireland are associated with very different scores with regards to the size of the knowledge economy.

At the same time, when measured against level changes of the composite (or structural change – which is not shown here), we find a negative, although not significant correlation.

Figure 10 The size of the knowledge economy plotted against Finance and support scores of IUS 2011



Source: JRC calculations; Innovation Union Scoreboard (IUS), 2011

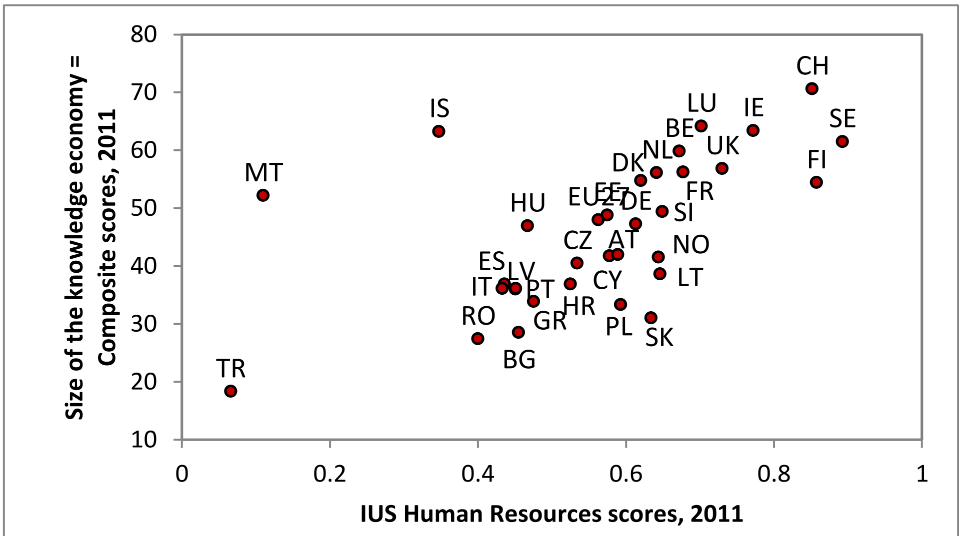
Q5: Is a greater availability of highly skilled human resources with a larger size of knowledge economy?

The “human resources” pillar of the 2011 IUS report (which measures new doctorate graduates, population having completed tertiary education, and youth with upper secondary level education) can similarly be contrasted with the size of the knowledge economy, as shown in Figure 11. Once again, we find a positive, although a bit lower correlation between the two indicators, which is not surprising given the fact that both the skills and the sectoral specialization pillars of our composite are measuring knowledge intensity based on tertiary educated human resources.

When the IUS human resources scores are measured against level changes of the composite (or structural change – which is not shown here), we find once again a negative, not significant correlation.

[16] The 2011 Innovation Union Scoreboard (European Commission, DG-ENTR, 2011) for accessing data referring to years closer to the final time point considered for the composite indicator. A selection of any other neighboring year would not have any significant effect on the conclusions drawn in this section.

Figure 11 Human resources and the size of the knowledge economy



Source: JRC calculations; Innovation Union Scoreboard (IUS), 2011

In sum, this analysis of enablers of structural change implies that it is important to distinguish the different types of structural dynamics: the slow-changing size of the knowledge economy, and the entrepreneurship-based creative destruction, which potentially shows more annual fluctuations.

6. Conclusion and avenues for future work

As discussed earlier, structural change can be measured in many ways; what was presented here is a supply-oriented indicator that is largely based on past performance (the outcomes of past efforts that are already measurable in terms of actual value added and employment levels in knowledge-based activities, revealed competitive advantages, supply of skilled human resources, etc.). All these indicators are related to the overall structure of the economy and are slow to change – for instance, Business R&D expenditures are higher for countries that host a number of large firms engaged in high-tech activities, which firms also employ more skilled resources, generate value added and competitiveness; and large firms also have the power to keep their stronger positions in an economy. Consequently, another indicator would be needed if one was to measure a different kind of structural change at the micro level, characteristic of smaller, younger firms generating this other type of structural dynamics (often referred to as "Schumpeter Mark I"). Within this context, studies from Stam and Garnsey (2008) and the OECD (2009) focusing on entrepreneurship in the knowledge economy and collecting employment-based and firm-based indicators to measure entrepreneurship and its performance should receive particular attention and follow-up in the forthcoming years. This latter study collects among others, indicators on the share of gazelles and the share of high-growth firms in terms of employment and turnover. The creation of a longitudinal database including this type of indicators would allow obtaining more thorough empirical evidence on the dynamics of structural change. In addition, comparing country (or regional) performance in this aspect would be an interesting direction for further investigation, necessitating firm-level studies, taking into account specific industry as well as institutional contexts (Marcotte, 2013).

There can also be ways for further refinement of our current indicator of structural change. For instance, with a stronger focus on productivity, or using more information on inter-sectoral relationships, by exploiting new datasets and information from sources such as the World Input-Output Database (WIOD); OECD's Bilateral Trade by End-Use database.

7. References

Blanchard, O. (2004). 'The economic future of Europe.' *Journal of Economic Perspectives* 8, 3-26.

Bloom, N., Sadun, R., Van Reenen, J. (2005). 'It ain't what you do, it's the way that you do I.T. Testing explanations of productivity growth using US affiliates.' Centre for Economic Performance, London School of Economics, *mimeo.*

Crespi, F., Pianta, M. (2008). 'Diversity in innovation and productivity in Europe.' *Journal of Evolutionary Economics* 18, 529-45.

European Commission (2002). 'More research for Europe. Towards 3% of GDP', COM(2002) 499 final (Brussels).

European Commission (2008). 'Analysis of the 2007 EU Industrial R&D Investment Scoreboard' (Luxembourg).

European Commission (2010a). 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.' Europe 2020 Flagship Initiative Innovation Union. SEC(2010) 1161.

European Commission (2010b). 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.' An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage. SEC(2010) 1272. SEC(2010) 1276.

Gomez-Salvador, R., Stocker, A.M., Turunen, J. (2006). 'Labour productivity developments in the Euro Area.' European Central Bank Occasional Paper, 53.

Gu, W., Kaci, M., Maynard, J-P., Sillamaa, M-A. (2002). 'The changing composition of the Canadian workforce and its impact on productivity growth,' in *Productivity Growth in Canada*, eds. J.R. Baldwin, and T.M. Harchaoui (Ottawa: Statistics Canada).

Gu, W., Wang, W. (2004). 'Information technology and productivity growth: evidence from Canadian industries,' in Economic Growth in Canada and the United States in the Information Age. Industry Canada Research Monograph Series. Industry Canada Research Publications Program (Ottawa).

Marcotte, C. (2013). 'Measuring entrepreneurship at the country level: A review and research agenda', Entrepreneurship & Regional Development: An International Journal, 25(3-4).

Moncada-Paterno-Castello, P., Ciupagea, C., Smith, K., Tubke, A., Tubbs, M. (2010). 'Does Europe perform too little corporate R&D? A comparison of EU and non-EU corporate R&D performance,' *Research Policy*, 39(4), 523–536.

OECD. (2009). 'Measuring entrepreneurship: A collection of indicators, 2009 edition. OECD-Eurostat Entrepreneurship Indicators Programme'. www.oecd.org/statistics/measuringentrepreneurship, Accessed Oct. 10, 2013.

O'Mahony, M., van Ark, B., eds. (2003). '*EU Productivity and Competitiveness: An Industry Perspective. Can Europe Resume the Catching-up Process?'* (Luxembourg: European Commission).

Ortega-Argilés, R., Piva, M., Vivarelli, M. (2013). 'The Transatlantic Productivity Gap: Is R&D the Main Culprit?', Canadian Journal of Economics, forthcoming.

O'Sullivan, M. (2007). '*The EU's R&D Deficit and Innovation Policy.' Policy Brief of the Expert Group "Knowledge for Growth*" (Brussels: European Commission).

Pavitt, K. (1984). 'Sectoral patterns of technical change: towards a taxonomy and a theory.' *Research Policy* 13, 343-73.

Rogers, M. (2010). 'R&D and productivity: using UK firm-level data to inform policy.' *Empirica* 37, 329-59.

Stam, E., Garnsey, E. (2008). ‘Entrepreneurship in the Knowledge Economy.’ In: Bessant, J. and Venables, T. (eds) Creating Wealth From Knowledge. Meeting the Innovation Challenge, Cheltenham: Edward Elgar. pp. 145-173.

Timmer, M.P., Inklaar, R., O’Mahony, M., van Ark, B. (2010). ‘Economic Growth in Europe. A Comparative Industry Perspective’ (Cambridge: Cambridge University Press).

Vertesy, D., Albrecht, D., Tarantola, S. (2012). ‘*Composite Indicators measuring structural change, to monitor the progress towards a more knowledge-intensive economy in Europe’*, European Commission (EUR 25279 EN).

Wilson, D.J. (2009). ‘IT and beyond: the contribution of heterogeneous capital to productivity.’ *Journal of Business and Economic Statistics* 27, 52-70.

Annexes

Table A1 Composite scores and score changes for 40 countries and the EU27, 2000-2011

Country		Composite Scores (Size of the knowledge economy)				Composite Scores changes (%) ("Structural change")		
		2000	2005	2011		2000-05	2005-11	2000-11
Austria	**AT**	32.6	38.8	41.9	**AT**	19.2%	8.0%	28.8%
Belgium	**BE**	49.8	54.3	59.8	**BE**	9.1%	10.1%	20.2%
Bulgaria	**BG**	21.2	24.8	28.5	**BG**	17.2%	15.0%	34.8%
Cyprus	**CY**	33.1	38.2	41.8	**CY**	15.2%	9.4%	26.0%
Czech Republic	**CZ**	30.4	35.9	40.4	**CZ**	18.3%	12.6%	33.1%
Germany	**DE**	43.5	44.5	47.2	**DE**	2.2%	6.2%	8.5%
Denmark	**DK**	45.8	49.9	54.8	**DK**	8.9%	9.7%	19.5%
Estonia	**EE**	37.7	41.9	48.8	**EE**	11.1%	16.5%	29.4%
Greece	**GR**	25.1	28.6	33.9	**GR**	13.6%	18.6%	34.7%
Spain	**ES**	29.3	32.2	36.9	**ES**	10.2%	14.3%	25.9%
Finland	**FI**	52.9	53.9	54.4	**FI**	1.9%	0.9%	2.8%
France	**FR**	50.7	51.7	56.2	**FR**	1.9%	8.8%	11.0%
Hungary	**HU**	40.2	44.4	46.9	**HU**	10.4%	5.6%	16.7%
Ireland	**IE**	50.2	50.8	63.4	**IE**	1.3%	24.7%	26.3%
Italy	**IT**	31.8	34.1	36.1	**IT**	7.2%	5.9%	13.5%
Lithuania	**LT**	26.3	30.4	38.6	**LT**	15.3%	27.1%	46.6%
Luxembourg	**LU**	52.5	54.7	64.2	**LU**	4.1%	17.4%	22.2%
Latvia	**LV**	24.7	31.9	36.0	**LV**	29.0%	12.9%	45.7%
Malta	**MT**	37.6	42.3	52.2	**MT**	12.5%	23.4%	38.8%
Netherlands	**NL**	51.9	55.2	56.1	**NL**	6.4%	1.5%	8.0%
Poland	**PL**	26.6	30.3	33.3	**PL**	13.6%	10.1%	25.1%
Portugal	**PT**	25.3	31.1	36.1	**PT**	23.1%	16.0%	42.8%
Romania	**RO**	15.0	18.5	27.4	**RO**	22.9%	48.5%	82.4%
Sweden	**SE**	56.2	56.1	61.5	**SE**	-0.1%	9.5%	9.5%
Slovenia	**SI**	32.1	40.3	49.4	**SI**	25.6%	22.4%	53.7%
Slovakia	**SK**	31.3	30.8	31.0	**SK**	-1.5%	0.5%	-1.0%
United Kingdom	**UK**	49.8	51.7	56.8	**UK**	3.8%	9.8%	14.0%
EU-27	**EU27**	43.0	44.8	48.0	**EU27**	4.2%	7.1%	11.7%
Croatia	**HR**	30.8	36.2	36.8	**HR**	17.3%	1.9%	19.5%
Turkey	**TR**	16.6	12.5	18.3	**TR**	-25.0%	46.9%	10.3%
Switzerland	**CH**	56.4	63.2	70.6	**CH**	12.0%	11.7%	25.1%
Iceland	**IS**	44.8	57.0	63.2	**IS**	27.3%	10.9%	41.2%
Norway	**NO**	35.3	36.2	41.5	**NO**	2.6%	14.7%	17.6%
Israel	**IL**	46.8	49.1	55.2	**IL**	5.0%	12.3%	17.9%
Brazil	**BR**	27.6	27.7	30.3	**BR**	0.3%	9.2%	9.6%
Russia	**RU**	24.9	34.2	37.3	**RU**	37.2%	9.0%	49.6%
India	**IN**	19.4	21.4	23.4	**IN**	10.3%	9.4%	20.7%
China	**CN**	24.7	30.0	34.2	**CN**	21.7%	13.7%	38.3%
Rep. of Korea	**KR**	37.5	42.5	47.3	**KR**	13.4%	11.2%	26.1%
Japan	**JP**	37.6	39.6	40.8	**JP**	5.2%	3.0%	8.3%
United States	**US**	50.2	51.0	53.0	**US**	1.6%	4.0%	5.7%

Source: JRC Calculations

Table A2 Normalized Indicator Scores for the three time points

		Indicator scores normalized on a 10-100 scale																										
		BERD	BERD	BERD	RDSVC	RDSVC	RDSVC	HRST	HRST	HRST	KIA_EMP	KIA_EMP	KIA_EMP	KIA_VA	KIA_VA	KIA_VA	RTA	RTA	RTA	RCA	RCA	RCA	FDI_In	FDI_In	FDI_In	FDI_Out	FDI_Out	FDI_Out
		T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2
Country	Code	(2000)	(2005)	(2011)	(2000)	(2005)	(2010)	(2000)	(2005)	(2010)	(2001)	(2006)	(2011)	(2000)	(2005)	(2010)	(2000)	(2005)	(2009)	(2000)	(2005)	(2009)	(2000)	(2005)	(2010)	(2000)	(2005)	(2010)
Austria	**AT**	41.9	53.4	57.3	16.9	22.1	24.4	41.4	56.7	59.3	46.8	48.7	52.3	42.6	43.9	43.6	27.1	32.0	34.3	24.7	26.1	26.8	18.9	25.2	35.0	16.8	22.5	34.1
Belgium	**BE**	45.6	40.9	44.3	24.3	29.7	31.4	67.7	77.2	84.0	63.4	66.4	67.2	59.3	62.7	68.7	56.6	60.3	58.6	19.5	19.7	23.8	58.5	68.0	100.0	51.1	77.6	100.0
Bulgaria	**BG**	11.6	11.3	16.5	n/a	n/a	n/a	37.9	43.0	44.0	39.7	34.9	32.9	12.7	22.1	23.7	53.3	51.0	44.9	10.6	12.7	16.5	21.6	37.4	66.9	10.0	10.1	11.6
Cyprus	**CY**	10.0	11.0	10.8	13.2	13.2	12.6	52.6	60.7	72.8	49.1	54.7	52.5	47.9	51.0	56.5	79.8	n/a	69.0	11.3	56.6	43.0	27.5	38.7	53.9	13.1	21.2	37.8
Czech Republic	**CZ**	26.9	31.1	37.6	37.6	33.2	35.6	43.5	51.2	59.1	34.6	36.9	42.9	28.6	34.6	39.3	31.8	47.3	40.5	18.9	26.8	33.2	30.9	36.7	47.4	10.6	11.4	13.9
Germany	**DE**	53.9	53.9	58.1	40.0	37.2	42.2	64.9	68.4	73.0	50.8	55.3	58.1	49.2	49.4	50.8	35.4	33.1	34.0	29.7	31.8	32.0	17.8	19.4	21.8	25.2	27.8	33.3
Denmark	**DK**	47.7	52.4	63.0	34.7	33.5	51.9	61.2	75.3	78.4	54.1	55.8	62.1	45.3	48.5	58.1	57.4	59.8	47.1	28.0	32.3	31.0	36.3	35.8	36.2	34.3	36.7	46.8
Estonia	**EE**	12.3	19.6	47.4	32.9	38.9	50.4	61.4	73.3	74.0	34.9	38.6	46.0	30.5	30.4	42.4	84.9	80.1	67.8	39.5	25.1	15.3	36.6	57.0	60.1	12.3	17.3	26.2
Greece	**GR**	12.6	13.6	13.1	16.6	21.7	27.9	27.4	38.4	46.0	37.3	44.9	49.6	38.7	43.7	48.2	41.0	35.1	51.4	18.0	17.2	19.5	15.9	16.5	16.2	12.4	12.9	17.4
Spain	**ES**	21.4	24.3	26.9	13.1	14.4	16.3	46.5	58.6	60.5	32.2	36.0	46.2	36.3	36.1	43.7	38.9	39.5	44.8	17.1	16.9	16.9	25.1	29.3	36.0	21.8	24.3	34.6
Finland	**FI**	70.3	72.7	78.1	44.4	49.5	52.3	74.2	73.3	80.5	52.8	55.8	56.3	48.9	47.8	46.5	67.4	67.8	61.6	41.6	42.7	29.4	21.0	25.8	30.3	32.7	32.2	40.5
France	**FR**	43.5	42.8	45.9	86.3	76.6	86.2	52.1	64.4	71.9	55.5	59.3	63.0	54.9	55.7	57.6	48.1	44.3	48.7	35.1	33.2	40.4	26.6	33.7	33.2	47.1	40.6	42.8
Hungary	**HU**	18.1	19.4	28.2	41.8	45.7	43.2	39.3	45.1	48.4	42.8	47.9	51.6	47.4	57.7	56.8	80.9	74.0	66.4	41.2	44.2	48.8	38.2	41.8	50.7	11.4	13.7	18.2
Ireland	**IE**	29.5	30.0	39.1	16.8	19.2	20.3	43.0	58.8	74.9	52.7	55.2	70.8	81.9	76.5	90.9	69.4	67.5	74.0	67.3	56.9	48.6	85.6	56.4	79.4	25.2	37.2	100.0
Italy	**IT**	22.2	23.0	26.4	47.4	48.2	50.1	36.0	45.8	48.8	45.9	47.7	48.5	41.9	44.8	46.3	26.2	26.9	27.0	20.1	19.1	20.1	15.9	17.2	18.8	18.2	17.2	22.6
Lithuania	**LT**	12.1	12.6	14.9	17.0	14.0	29.3	77.0	59.3	70.2	40.0	34.8	46.5	34.7	30.2	35.6	n/a	69.5	78.9	11.9	13.9	19.1	21.2	27.8	31.2	10.0	11.4	12.9
Luxembourg	**LU**	48.5	43.8	34.2	64.5	58.4	66.5	57.9	71.2	100.0	73.3	93.2	100.0	81.4	90.7	100.0	10.0	14.0	22.5	27.7	23.6	20.7	100.0	77.2	100.0	52.8	56.2	100.0
Latvia	**LV**	13.4	14.7	13.6	29.3	17.9	23.1	42.8	47.4	58.1	32.4	35.4	41.8	38.5	36.5	35.3	n/a	80.2	88.5	11.5	13.2	17.4	25.0	27.5	35.6	10.0	10.8	11.8
Malta	**MT**	10.3	18.6	21.4	n/a	10.4	10.0	34.0	37.9	44.4	53.3	60.7	65.7	56.3	61.5	85.9	n/a	n/a	n/a	100.0	85.3	94.8	42.8	51.4	100.0	12.5	18.7	19.8
Netherlands	**NL**	36.5	35.0	36.5	40.5	42.2	40.7	68.1	77.0	83.3	53.1	56.0	56.7	54.3	61.0	63.9	69.4	62.8	59.6	37.9	38.8	30.9	46.4	53.3	53.9	52.2	63.7	75.8
Poland	**PL**	14.7	13.4	14.7	38.2	35.7	29.6	27.4	37.9	54.4	32.3	32.6	38.4	31.5	36.3	34.5	43.0	51.0	50.3	11.9	12.8	17.0	21.1	26.9	34.4	10.2	11.0	14.3
Portugal	**PT**	13.9	16.5	26.6	28.4	28.6	38.3	10.7	19.8	26.0	27.1	34.5	40.2	50.5	58.6	53.1	40.0	50.8	58.6	15.8	19.0	13.6	25.4	28.8	37.9	18.9	21.6	25.5
Romania	**RO**	15.2	13.9	13.1	40.1	26.8	34.8	10.0	19.5	25.8	10.0	16.9	20.4	14.1	12.5	23.2	n/a	37.9	79.1	14.6	13.2	22.4	20.3	24.6	34.8	10.1	10.0	10.4
Sweden	**SE**	84.9	76.0	69.5	68.2	66.8	60.2	72.1	74.4	81.2	64.7	66.3	70.6	53.2	56.7	69.6	52.4	48.5	55.0	33.6	29.3	26.9	31.6	36.6	54.0	36.5	39.7	52.8
Slovenia	**SI**	29.0	30.8	56.3	49.0	47.7	56.3	38.8	53.7	62.8	34.2	42.7	49.6	45.9	49.3	56.0	31.2	61.1	72.3	14.6	15.5	19.4	17.8	21.3	27.3	11.9	14.8	18.3
Slovakia	**SK**	19.9	15.2	15.2	46.5	36.9	25.8	34.0	41.6	48.8	38.8	38.6	42.9	27.0	31.0	36.2	69.0	38.7	30.4	12.6	18.4	18.1	23.0	38.3	43.1	10.9	10.6	11.9
United Kingdom	**UK**	39.4	36.0	37.0	n/a	n/a	n/a	53.7	61.9	70.9	61.8	65.8	69.9	63.5	73.8	94.8	63.9	61.1	57.8	40.1	39.2	32.6	26.7	30.9	39.6	42.3	37.9	48.4
EU-27	**EU27**	40.2	38.6	41.5	49.1	46.3	48.5	47.4	56.5	63.0	49.7	50.5	53.8	48.6	51.2	53.6	44.7	42.1	42.6	34.8	36.5	35.3	25.4	29.5	35.6	31.9	32.2	40.3
Croatia	**HR**	19.4	18.1	17.5	47.8	54.5	54.1	n/a	33.7	42.6	34.4	35.6	39.1	47.1	41.4	42.6	53.8	75.2	45.1	17.3	20.7	20.7	17.0	28.4	43.0	11.9	12.3	13.7
Turkey	**TR**	12.6	13.9	18.1	n/a	n/a	n/a	n/a	n/a	19.1	19.9	10.2	15.0	21.9	10.0	16.3	24.3	19.3	34.3	13.6	10.0	10.6	13.6	18.0	24.2	10.6	10.8	11.5
Switzerland	**CH**	57.3	64.7	65.9	40.0	42.8	51.6	75.8	80.7	90.5	57.8	62.7	65.2	76.9	86.3	82.3	47.0	53.3	53.4	36.7	43.6	53.6	29.5	35.8	70.8	59.0	71.2	100.0
Iceland	**IS**	47.7	45.9	51.3	48.4	46.0	38.9	49.1	62.8	74.0	59.6	65.4	68.1	55.3	63.9	64.8	71.1	70.7	86.4	10.5	19.0	20.3	20.9	51.2	100.0	21.9	100.0	100.0
Norway	**NO**	33.0	29.8	31.1	32.0	25.7	31.4	70.2	74.9	80.9	52.7	55.8	62.5	27.3	29.5	36.8	42.0	43.4	45.8	12.4	12.4	14.4	19.9	24.2	33.7	20.7	26.3	34.8
Israel	**IL**	93.9	98.0	100.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	89.7	88.1	87.7	43.7	27.3	40.5	18.9	22.8	25.6	13.8	19.1	26.8
Brazil	**BR**	19.4	18.1	21.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	59.4	59.8	59.7	35.0	41.9	42.4	23.6	18.8	18.2	20.5	21.4	28.3	14.2	14.7	14.7
Russia	**RU**	27.9	27.7	26.4	90.8	100.0	96.1	n/a	n/a	n/a	n/a	n/a	n/a	11.5	26.2	32.8	60.5	65.3	63.8	13.3	10.5	10.6	16.6	23.2	28.8	14.0	20.1	23.1
India	**IN**	12.1	14.9	15.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	97.6	100.0	93.8	15.3	15.0	20.3	11.4	12.4	16.3	10.1	10.5	12.9
China	**CN**	22.7	32.4	42.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	22.0	26.5	30.9	66.5	83.2	88.7	32.4	54.6	59.3	18.9	16.3	15.4	11.1	11.2	12.7
Rep. of Korea	**KR**	52.9	64.6	81.5	42.3	45.3	47.5	n/a	n/a	n/a	n/a	n/a	n/a	49.8	60.0	65.1	73.4	80.4	81.3	53.5	56.4	58.9	14.2	16.6	16.7	12.0	12.3	17.2
Japan	**JP**	64.9	74.5	73.4	37.3	32.2	32.1	n/a	n/a	n/a	53.1	57.6	58.3	44.5	49.1	48.7	61.8	60.4	61.0	46.8	42.5	40.4	10.0	10.7	11.7	13.1	14.4	18.0
United States	**US**	61.0	55.2	57.9	46.2	49.6	51.0	n/a	n/a	n/a	54.6	58.4	62.3	69.9	76.5	83.2	75.4	75.5	76.9	48.7	47.8	40.6	25.7	22.4	23.0	24.3	25.2	27.4

Source: JRC calculations

Table A3 Correlation coefficients between the indicators

	BERD	RDSVC	HRST	KIA_EMP	KIA_VA	RTA	RCA	FDI_In	FDI_Out
BERD	1	0.356	0.625	0.599	0.448	0.153	0.318	0.008	0.369
RDSVC	0.356	1	0.229	0.332	0.071	-0.044	-0.110	-0.057	0.167
HRST	0.625	0.229	1	0.734	0.486	0.124	0.139	0.376	0.665
KIA_EMP	0.599	0.332	0.734	1	0.824	0.046	0.414	0.510	0.705
KIA_VA	0.448	0.071	0.486	0.824	1	0.057	0.489	0.530	0.650
RTA	0.153	-0.044	0.124	0.046	0.057	1	0.333	-0.066	-0.055
RCA	0.318	-0.110	0.139	0.414	0.489	0.333	1	0.235	0.128
FDI_In	0.008	-0.057	0.376	0.510	0.530	-0.066	0.235	1	0.654
FDI_Out	0.369	0.167	0.665	0.705	0.650	-0.055	0.128	0.654	1

Note: Data for all three time points considered simultaneously, N=123; For the description of the indicators, please refer to Table 1.

European Commission
EUR 26409 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Update on the Composite Indicators of Structural Change towards a More Knowledge-Intensive Economy
Authors: Daniel Vertesy and Vincent van Roy

Luxembourg: Publications Office of the European Union

2013 – 22 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424

ISBN 978-92-79-35009-2

doi: 10.2788/51665

Abstract
This report aims at assessing whether the economic structure of Europe is becoming more knowledge-intensive, in comparison with other countries (EU, EFTA and non-European benchmarks US, Japan, China). This entails the measurement of key dimension of structural change with a simple policy tool. The present work builds on and updates the results of the previous Feasibility Study on the development of composite indicators of structural change (Vertesy et al., 2012). It also builds on a previous study by Malerba et al. (2011) that identified indicators measuring changes in the actual sectoral composition of the economy.
In this study we construct a composite indicator on structural change at the country level, including indicators on R&D, skills, sectoral specialization, international specialization and internationalization. This composite is a supply-oriented indicator that is largely based on past performance (the outcomes of past efforts that are already measurable in terms of actual value added and employment levels in knowledge-based activities, revealed competitive advantages, supply of skilled human resources, etc.). All these indicators are related to the overall structure of the economy and are slow to change. In order to capture short-term characteristics of structural change related to the dynamics of smaller and younger firms, future research should focus on the development of a longitudinal database collecting indicators on the share of gazelles and the share of high-growth firms in terms of employment and turnover.

LB-NA-26409-EN-N

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

Publications Office

ISBN 978-92-79-35009-2