Knowledge Economy Indicators

Workpackage 1

Defining the Knowledge-Based Economy: Final Synthesis Report

Deliverable 1.5

2008

List of contributors:
Anthony Arundel, Adriana van Cruysen, Wendy Hansen, Minna Kanerva, René Kemp, MERIT

Main responsibility:
Anthony Arundel, Adriana van Cruysen, Minna Kanerva, MERIT

C1S8-CT-2004-502529 KEI

The project is supported by European Commission by funding from the Sixth Framework Programme for Research.

http://europa.eu.int/comm/research/index_en.cfm
http://europa.eu.int/comm/resarch/fp6/ssp/kei_en.htm
http://www.corids.lu/citizens/kick_off3.htm
http://kei.puplicstatistics.net/

Table of contents

1. Introduction 1
2. Approaches to classifying indicators for a KBE 2
   2.1 Characteristics and drivers 3
      2.1.1 ICT and generic technology 4
      2.1.2 Human resources and skills 5
      2.1.3 Knowledge production 5
      2.1.4 Entrepreneurship and creative destruction 6
      2.1.5 Organisational change 7
   2.2 Performance outcomes 7
      2.2.1 Economic growth and productivity 8
      2.2.2 Social impacts 9
      2.2.3 Environment 11
3. Variations in knowledge-based economies 12
   3.1 The geography of the KBE 13
   3.2 Sectors 13
      3.2.1 The public sector 14
      3.2.2 The volunteer non-profit sector 15
   3.3 Indicator requirements 15
4. Future challenges for a knowledge-based economy 18
   4.1 Global production chains 18
   4.2 The changing environment for innovation strategies 19
   4.3 Demographic change and demand 20
      4.3.1 Scenario on innovation demand 21
   4.4 The supply of human capital 23
      4.4.1 Scenario on the supply of scientists and engineers 26
   4.5 New technologies 29
      4.5.1 Eco-innovation scenario 29
   4.6 Future challenges for a KBE – Indicator requirements 31
5. Policies for a knowledge-based economy 34
   5.1 Evolution of European KBE policies 35
      5.1.1 Innovation policy 35
      5.1.2 Education policy 36
      5.1.3 ICT policy 37
   5.2 OECD and US perspectives on KBE policy 37
      5.2.1 The OECD perspective 37
      5.2.2 The US perspective 38
   5.3 The national policy context within Europe 39
      5.3.1 ICT investment and use 40
      5.3.2 Human resources 40

© http://kei.pulicstatistics.net – May 2008

5.3.3 Knowledge production..40
5.3.4 Entrepreneurship and creative destruction..40
5.3.5 Structural and organizational change..41
5.4 National innovation systems...41
6. Current and emerging policy needs and priorities 43
7. Conclusions 44
References 45
Annex A - KBE indicator needs for future development.....................................50
Annex B – Indicators for measuring some KBE challenges...............................52

1. Introduction

The goal of the KEI (Knowledge Economy Indicators) project is to identify potential indicators for measuring the drivers, characteristics, and key outputs of a knowledge based economy (KBE)[1] and to develop methodologies for evaluating indicators and constructing composite indices.

This synthesis report summarises the results of four KEI reports on identifying indicators for a KBE:

1. The state of the art of the knowledge-based economy (June 2007)
2. Future challenges for a knowledge-based economy (June 2007)
3. Policies for a knowledge-based economy (August 2007)
4. Policies and trend scenarios for a knowledge-based economy: supply of scientists and engineers, innovation demand, and environmental innovation (Spring, 2007).

The existing literature was used to identify the state-of-the-art in terms of different perspectives on the characteristics and drivers of a KBE, indicator availability, and conceptual approaches to creating classes of related KBE indicators. We develop a structure for classifying the main drivers of a KBE in order to reduce the number of potential indicators to a manageable set of key indicators. We also provide an overview of KBE indicators for the business, public, and volunteer non-profit sectors. We further identify five main challenges that could influence a KBE in the future: global production chains, changing environment for innovation strategies, demographic change and its effect on demand, the supply of human capital and technology shifts. Based on these five challenges, summaries of three scenarios for policy are provided, and the types of indicators that would be necessary to track progress are identified.

This report discusses the different policies that are needed to promote and derive benefit from a knowledge economy, both within Europe, in the United States and at the OECD level. Within Europe, an analysis of structural, social and institutional factors leads to the identification of different types of National Innovation Systems (NIS), suggesting that the innovative capability of a country depends on structural conditions such as the make-up of its national industry, the contribution of SMEs to economic output, and demand for innovative products.[2] In addition, innovative capability can be influenced by social and institutional factors such as a receptiveness to new ideas on the part of the population, entrepreneurship, and social cohesion, each of which could require specific types of policies to address existing weaknesses and build on existing strengths. The route to a KBE may vary depending on starting differences in structural, social, and institutional characteristics of a country. Taking these differences into account, policy scenarios are useful for identifying strengths, weaknesses, and possible policy actions of relevance.

Finally, apart from using existing sources to pinpoint current policies that are relevant to promoting a KBE, we interviewed policy analysts in a selection of EU member states and in

[1] The only notable difference between the 'knowledge economy' and the 'knowledge-based economy' is that the former focuses on knowledge-intensive sectors, while the latter extends the concepts to all sectors of economic activity. We view the knowledge economy as much broader than a focus on knowledge-intensive sectors and so we use the definition of the knowledge-based economy that considers changes taking place across all sectors. However, since the term 'knowledge-based economy' is rather long, we sometimes use the simpler term of a 'knowledge economy', redefined here to include all economic sectors.
[2] See TrendChart (2003).

several competitor countries. The interviews - summarised in this report - explore the impact of future technical and social developments on policies to promote a KBE. New technologies include biotechnology over the short-term, and the "hydrogen economy" and nanotechnology over the longer-term. On the social front, Europe is facing changes due to the ageing of the workforce and the growing competitiveness of India and China, which could provide a major challenge to future European competitiveness that far exceeds the challenge presented by the US.

2. Approaches to classifying indicators for a KBE

There is an extensive social and economic literature of relevance to the concept of a KBE. The variety of approaches and viewpoints can be grouped into two main perspectives on the relationship between the ideal of a 'knowledge economy' and the reality of where we are today. The first perspective is economic and focuses on the effects of a KBE on economic growth and productivity.[3] The second is social and evaluates the effect of economic changes on society.[4] Nevertheless, similar themes run through both perspectives.

An evaluation of the KBE needs to adopt a cautious and critical approach, as there is an enormous amount of hype around the concept. For example, many of the economic analyses of the KBE accentuate the differences between the 'old' economy and the 'new' economy, with multiple examples of complete 180 degree changes from the old to the new economy. As an example, human capital is the new scarce resource in the knowledge economy compared to financial capital in the old economy, while innovation is thought to be continuous and systemic instead of linear. There is also a strong bias in the literature towards a positive social view of the KBE, with many of its characteristics perceived to be better and more humanistic.

Yet, we still don't know if the KBE is qualitative change in modern economies, or simply a continuation of business as usual. A consistent problem with many perspectives on the KBE is a lack of supporting data or a tendency to over interpret data that are available (Godin, 2004). Without good indicators, we won't know which features of the KBE are true and which are simply wishful thinking.

A large number of studies have assembled or identified indicators of relevance to a knowledge economy.[5] As part of the evaluation of the state of the art, we looked at eight studies on a KBE that assembled indicators (see Table 1). As there are hundreds of potentially relevant indicators, they are often classified into related themes. Two categories of indicators are in widespread use:

1. Characteristics and drivers of a knowledge economy
2. Output or performance indicators.[6]

Each of these categories is evaluated in the remainder of Section 2.

---

[3] See e.g. OECD (1996), OECD (2001a), EC (2003b), EC (2002b), EC (2003a), Smith (2002), or DeVol et al. (2004).

[4] See e.g. EC (2002b), or ABS (2002).

[5] See, for example, DG INFOS (2003), DG Enterprise (2004), Atkinson and Coduri (2002), ABS (2002), or Naumanen (2004).

[6] Other approaches have also adopted a 'pillar' concept instead of drivers, where a pillar implies a foundation that underlies a knowledge economy. For example, World Bank (2002) identifies four pillars: (1) a supportive economic and institutional regime to provide incentives for the use of existing and new knowledge and entrepreneurship, (2) an educated and skilled population to create, share and use knowledge, (3) a dynamic information infrastructure to communicate, disseminate, and process information, and (4) an efficient innovation system of firms, research centres, universities, consultants, and other organizations to tap into the stock of global knowledge.

Table 1. Eight key studies on KBE

Study	Included indicators
DeVol et al., 2004: State Technology and Science Index, Milken Institute	Provides five classes of indicators: R&D inputs, risk capital and infrastructure, human capital investment, technology and science workforce, and technology concentration
Australian Bureau of Statistics (ABS), 2002: Measuring a knowledge-based economy and society	Three classes of indicators for drivers: innovation and entrepreneurship, human capital, ICT
Progressive Policy Institute (PPI), 2002: The State New Economy Index, Washington, DC	Five classes of indicators: knowledge jobs, globalization, economic dynamism and competition, digital economy, technological innovation capacity
Room, G., 2004: The scope of the new economy. NESIS final report	Four classes of indicators: microeconomic, innovation, digital economy, public investments
OECD, 2001a: The new economy – Beyond the hype	Four classes of indicators: ICT, innovation and technology diffusion, human capital, firm creation and entrepreneurship
European Commission, 2005: Towards a European Research Area: Key Figures 2003-2004	Two classes of indicators: investment in a KBE and performance of a KBE
OECD, 2003: Science, Technology and Industry Scoreboard)	Three classes of indicators: investment in knowledge, investment in ICT, and trends in trade and investment flows
DG Enterprise, 2004: European Innovation Scoreboard	Four classes of indicators: human resources, creation of new knowledge, transmission and application of knowledge, innovation finance, output and markets

2.1 Characteristics and drivers

A common denominator in the many KBE perspectives is that innovation, science and technology, and information and communication technologies (ICT) are central features and a cause of increases in economic growth and productivity. Change is emphasized, resulting in a reconfiguration of economic, social and political relationships (Room, 2004).

Different theories to explain modern economies tend to stress a similar set of factors, although the level of importance given to each of them differs and not all factors are deemed important from each perspective.[7] An overview of the factors according to each perspective produces five main characteristics or drivers:

1. *ICT investment and use*: The influence of ICT production and diffusion on opening up new areas of investment and increasing productivity growth;
2. *Human resources*: The crucial role of human resources, particularly the highly skilled;
3. *Knowledge production*: Quantitative and qualitative change in knowledge production, including R&D and creativity;
4. *Entrepreneurship*: Greater levels of entrepreneurship and creative destruction, partly in response to rapid technological change and opportunities for innovation;

[7] The Room (2004) report provides a useful overview of each of these perspectives on modern economies.

5. *Structural and organizational change*: Far-reaching structural change, due to organisational innovation and the impact of the internationalisation of production and knowledge generation.

Not all studies on indicators use precisely this set of five classes, but most use similar categories or their indicators can be readily assigned to one of these classes, indicating a general consensus on the main characteristics and drivers for a KBE. The theories of the 'knowledge-based economy' include most of the above drivers, with a focus on the first four, providing a more complete coverage of the large changes that could be occurring in modern economies.[8]

The fifth factor, far-reaching structural and organisational change, is attracting increasing attention, although it is not included in several of the studies listed in Table 1. This is probably due to a lack of reliable, comparable and relevant indicators. Many of the features of modern economies cannot, however, be fully explained without an evaluation of structural and socio-political change.

Another weakness is in the treatment of globalisation indicators. Very few are included in the reviewed studies. The few cited generally refer to foreign direct investment (FDI) or trade in high technology goods. Both of these two indicators are too general to be relevant as drivers of a KBE and neither are useful measures of the types of deep structural changes that characterise modern economies. However, trade is an appropriate output measure.

Typical views of the forces driving the KBE include (1) rapid continuous change, (2) the increasing value of intellectual capital as a strategic factor, and (3) globalization in R&D, technology, production, and finance. But this system of classifying drivers raises two issues. The first relates to the extent that these forces are drivers of a KBE instead of the output of a KBE, and the second relates to relevant groupings of indicators for each of these three classes. The answer to the first issue is that some of these forces are both drivers of techno-economic change and the result of such change, in positive reinforcement loops. As drivers, different classification systems are possible, particularly in respect to the second question on the availability of indicators. Data availability may also force us to use less than ideal classification schemes.

The following is a brief look into the current thinking on the five main characteristics and drivers of a KBE.

2.1.1 ICT and generic technology

Many of the different perspectives of a knowledge economy view ICT as the principal driver of a fundamental techno-economic shift towards a KBE. But the major influence of ICT in a KBE is not through the ICT hardware sector (computer and chip manufacture, telecommunications equipment etc.) that accounts for few percentage points of economic output and employment in most OECD countries, but through its diffusion across modern economies and the opportunities that it creates for more efficiently reorganising production processes and for creating new types of goods and services.

In the 1990s, it was commonly believed that countries needed to have ICT hardware producing sectors, termed a 'leading' or strategic sector, in order to remain competitive. This view, however, began to lose favour in the late 1990s and early 2000s due to studies that found that part of the differences in productivity growth between countries was not due to

[8] Contextual factors, or background macroeconomic conditions, are not included here because they apply equally to all economies, as opposed to only for a KBE.

ICT producing sectors, but to the ability of firms in ICT using sectors to efficiently adapt ICT to their own specific circumstances.

Indicators for ICT are essential for evaluating and measuring a KBE, and these indicators should capture both the production of ICT hardware and software and their application throughout an economy. It may also be worthwhile to group sectors into the main ICT producing sectors, the ICT using sectors, and sectors where ICT applications may be limited (if any such sectors exist).

2.1.2 Human resources and skills

The skills and knowledge of people are of central importance to innovation and to economic and productivity growth, with a well-educated and highly-skilled work force essential for success in the KBE. Yet a focus on a highly-skilled group of elite 'knowledge workers' could be a mistake, as a much wider group of workers contribute to and are essential to the functioning of a KBE. However, many of the skilled occupations are poorly covered, or even ignored, in policy discussions on human resources or labour market skills for a KBE, with potentially negative consequences.

Typically a form of 'lip service' has been given to addressing the human element of the KBE. Much of the data on human resources still rest in traditional approaches: occupations are still classified as high skill or medium skill, despite diversification of skills within occupations and across sectors.[9] Another limitation is the reliance upon 'formal' education indicators, without considering the role of life-long learning in an environment that is changing rapidly in response to market pressures and the introduction of ICTs and other new technologies. There is also a worldwide trend towards greater mobility of the highly-skilled work force. As a result, there is an increased need for indicators of the stocks and flows of human resources, as well as a requirement for more knowledge on the causes, benefits and risks of international mobility.

2.1.3 Knowledge production

Knowledge production and its effective use are the core features of a KBE and pre-requisites to all types of innovation, including product, process, organisational, and marketing innovation. Knowledge production is an essential requirement, but by itself changes nothing, as shown by the debate over the 'European paradox', where Europe is believed to out-perform the US in the production of new knowledge, measured through scientific publications, but lags behind in the commercial exploitation or use of this knowledge base.[10] This illustrates that the 'use' of knowledge is not so simple; it requires several different types of knowledge.

Lundvall and Johnson (1994) identified four types of knowledge: know *why (*knowledge about principles and laws), know *what (*knowledge about facts), know *how (*the ability to do something) and know *who* (knowledge about who knows what). Knowledge production and its effective application require competencies in all four types of knowledge, although with different emphasis. R&D data, the most widely used source of indicators for knowledge production, does not, in practice, distinguish between the different types of knowledge. Therefore, other indicators are necessary to provide more information on these different types of knowledge.

Other methods of classifying knowledge are also relevant to the development of indicators for a KBE. These include the difference between *intangible* and *tangible* knowledge, *codified* and *tacit* knowledge (Cowan et al., 2000; Lundvall and Johnson, 1994), *generic* and *specific*

[9] The utility of comparing such data is limited, unless all countries are using an identical set of classification criteria, which is not the case.
[10] This view has lately been criticized; see e.g. Dosi et al. (2005).

knowledge (Nelson, 1989) and *individual* (or personal) knowledge and *collective* knowledge (Lundvall and Johnson, 1994).

An extension of the individual/collective dichotomy concerns learning. Knowledge is needed for learning, which in turn is needed for obtaining additional knowledge. An important distinction is between individual learning and organisational learning. Although it is individuals that learn, they do so within organizational settings, or social groupings of individuals. Institutional forms, such as the R&D division of a firm, can stabilize and transmit new knowledge from learning.

Several of the theoretical concepts of knowledge are probably very difficult to measure, and consequently there are probably no useful indicators for these characteristics of knowledge. An example is 'tacit' knowledge. Suitable proxies can be developed for other characteristics of knowledge. For example, the diffusion of embedded knowledge (collective form of tacit knowledge[11]) can be proxied through investment in new machinery and equipment.

However, without inquisitive people and appropriate institutional structures to support their work, there would be very little new knowledge or application of existing knowledge in new ways. In addition to the educational infrastructure and other institutions that shape "the system of industrial relations" (the financial system, the state structure, the forms of competiton, and the modes of inter-firm relationships) (Coriat and Weinstein, 2002), there are also socio-cultural influences that encourage individuals, entrepreneurs and employees to actively look for opportunities for innovation and to acquire the tools to successfully implement them. Consequently, "softer" indicators to measure these socio-cultural factors are of relevance.[12]

There are many potential indicators for knowledge production. However, many of the indicators for the type of knowledge available and the socio-cultural factors that may underpin knowledge production have not been used in scoreboards of the KBE. This is unfortunate, since these factors provide crucial support to innovative capabilities and constitute an essential pre-condition for a KBE.

2.1.4 Entrepreneurship and creative destruction

Innovation is inherently risky. Acceptance of risk taking (or an entrepreneurial attitude) should increase the number of attempts at developing innovative products and services and firms to deliver them. On the flip side of the creation of new firms, products and services is their destruction or exit, due to the introduction of superior products or services or more efficient firms.

Policy assumes that an economy that creates more new start-ups will generate more successes than an economy that creates only a few new start-ups. But there is little empirical data to show that greater entrepreneurship, in terms of the number of firms established in a given time period, is linked to higher levels of innovation. As noted by Parker (2005), this is a crude approach to economic growth and risks socially inefficient overinvestment in new projects that are doomed to fail. The same problem applies to policy attempts to increase the supply of venture capital, on the assumption that a lack of venture capital reflects inefficient financial markets rather than a lack of good ideas deserving investment[13]. In both cases, there is a need

[11] See Lam (1998) for a classification system that combines the characteristics of individual versus collective knowledge and codified versus tacit knowledge.
[12] A Trend Chart (2003) report on these 'softer' factors identified four socio-cultural factors: receptiveness to new ideas on the part of the population, social equity, entrepreneurial attitudes, and social capital, including trust.
[13] See Pisano (2006) for examples of this problem from biotechnology.

for more research on the factors that improve the probability of success and indicators to track them.

There are three main methods for measuring entrepreneurship and creative destruction. The first is based on public opinion surveys of attitudes towards risk or towards owning a firm. The second method is based on indicators at the firm level and includes measures of the cost of establishing a business (firm creation) and measures of 'churn', or firm entry and exits within a defined time period. The third common measure of entrepreneurship is the supply of venture capital or similar risk-taking investment, such as business angels (Naumanen, 2004) or IPOs.

2.1.5 Organisational change

Organisational change has long been the poor cousin of innovation research. However, there has been a renaissance of interest, in large part driven by research showing a link between organisational change and the economic benefits from investing in ICT.

Organisational innovation is relevant to a KBE in two ways. First, the ability of firms to innovate depends on organisational forms that create an environment where innovative activities can flourish. Second, the ability of a firm to maximize the value-added of its product and process innovations can also depend on organisational change.

Current thinking identifies three main types of organisational change related to (1) workplace organisation (just in time, quality management, team working, flatter organisations etc.), (2) business practices (knowledge management systems, education and training etc.) and (3) external relations (outsourcing, networking). Some organisational innovations can involve simultaneous changes to each of these three types. Organisational innovation also includes new business forms, such as start-ups supported by venture capital, requiring timely indicators for entry, exit, growth and firm survival.

Indicators are needed for each of these main forms of organisational innovation. A particular challenge is to obtain measures of the prevalence and depth of organisational forms that integrate management and logistics throughout the entire global value-added chain from suppliers to the end consumer. Therefore, indicators for organisational innovation may need to be linked to indicators of globalization.

As with the development of knowledge, the types of organisational forms that are feasible depend on socio-cultural factors, such as social trust and social capital.[14] Innovation cannot be solely explained by the combination of tangible forms of capital, but also requires a combination of intangible forms of capital, with social capital among them (Landry et al., 2000). Unfortunately, data on social capital for the EU is limited to national population data on interpersonal trust. There are no EU-wide indicators for aspects of social capital such as networks.

2.2 Performance outcomes

The eight KBE studies examined for this project included several output or performance indicators. We divide these indicators into three main classes: economic impacts, social impacts, and environmental impacts, although very few of the studies include the last two classes.

The KBE has been linked to expected beneficial effects on economic growth and productivity, incomes, environmental sustainability, social cohesion, and gender equality. These positive

[14] Social capital is defined by the OECD as 'networks together with shared norms, values and understanding that facilitate cooperation within or among groups' (OECD, 2001b: p. 41).

benefits are often linked to the diffusion of ICT to 'ICT using' sectors, organisational change, and more efficient human capital due to higher educational levels, although all five drivers of a KBE are expected to lead to growth. This section looks at the evidence for a positive effect of the KBE on each of three types of outcomes: economic growth and productivity, social well-being, and the environment.

2.2.1 Economic growth and productivity

The economic growth and productivity growth rates are key output measures for a KBE. The effect of KBE factors on these two measures is difficult to evaluate because there are many different drivers of growth and productivity, as well as barriers.

The OECD (2001a) has reduced the list of drivers of growth and productivity to four main factors, although the first three involve a wide range of drivers:

1. ICT
2. Human capital
3. Sound macro-economic management
4. Venture capital

All of the five characteristics or drivers of a knowledge-based economy (ICT, human resources, knowledge production, entrepreneurship, and organisational change) have been positively correlated with MFP (multifactor productivity) growth, although methodologies establishing the influence of the factors on economic growth and productivity have their own limitations.[15]

ICT, productivity and organizational change

The OECD report (2001a) shows an increase in the contribution of ICT to the GDP growth in several countries, but not all results in the report on the contribution of ICT to productivity are consistent: a large ICT sector does not guarantee MFP growth and also does not appear to be necessary for productivity growth.

More in-depth attempts at understanding the contribution of ICT to productivity growth are found in the 2000 Fall issue of the *Journal of Economic Perspectives.* The findings show marked sectoral differences in the effect of ICT on productivity growth, a result that has been confirmed in more recent work. According to Gordon (2000), ICT-based productivity growth is limited to the 12% of the economy involved in manufacturing durable goods, but means little to the 88% of the economy outside of durable manufacturing, although it is unclear why ICT does not have a more positive impact on productivity in the service sectors in this study.

A growing literature has evaluated the productivity effects of ICT investment combined with organisational change, including new organisational forms in response to ICT investment, and investment in complementary intangible assets such as software and retraining.[16] There is strong evidence that organisational change and complementary assets (software investments, retraining, hiring in of consultants etc.) are important in financial terms and important for getting productivity gains out of physical investments. However, there is uncertainty about the exact size of the productivity gains from ICT: initial benefits may be small or even

[15] Also, simple correlations can give spurious answers that are not due to a causal relationship between two factors. For example, a positive correlation between job mobility and MFP is probably not due to a direct link between low job tenure and productivity growth, which would actually be surprising, because firms are less likely to invest in training with high rates of turnover. Instead, the correlation could be due to job mobility acting as a proxy for creative destruction and churn.

[16] See e.g. Brynjolfsson and Hitt (2000) or Brynjolfsson et al. (1997).

negative, but positive effects occur when companies move along the learning curve and implement appropriate forms of organisation. Whether ICT is the fuel of growth of the past ten years is doubtful, and as Gordon (2000) argues, its impact on growth may be far less than that of the great inventions of the past: the steam engine, electric motor, chemicals and new materials. To understand economic growth, we have to look beyond ICT.

2.2.2 Social impacts

The social impacts of economic change, including those linked to a knowledge economy, are likely to reach far beyond a simple goal of adequate housing, education, and health for all. They include effects on income equality, happiness, life and job satisfaction, gender equality, and environmental sustainability.

An important issue is related to work-life balance - Europeans tend to take more time as leisure, while Americans work more (Blanchard, 2004). A crucial question for policy is if the KBE is neutral in terms of the choice between leisure and work, or biased towards more work or more leisure? Furthermore, should policy encourage one option over another, such as a preference for leisure over work (Layard, 2003)? Similar concerns are raised in respect to income dispersion, other measures of wellbeing, and gender equality.

Income dispersion

A KBE, by definition, requires an increasing number of highly skilled workers. Changes to trade patterns and the location of manufacturing have led to a decline in well-paid but comparatively low-skilled jobs. In some countries these have been replaced by low skilled low paid jobs. One result is that within a specific sector, knowledge workers defined by skills have higher average incomes than many other workers, with the disparity increasing over time (see e.g. Sanders and Ter Weel, 2000).

Employment opportunities for skilled and unskilled workers have been going in different directions, with an increase in demand for skilled workers in most OECD countries during the last decades (e.g. Machin and Van Reenen, 1998; and Hollanders and Ter Weel, 2002) and a decrease in demand for many categories of low-skilled workers. Moreover, the increasing economic importance of the service sectors is changing the demand patterns for the low skilled: workers with poor social communication skills and adaptability are suffering the greatest job losses because ICT based automation (and the requirement of complementary skills) or off shoring reduces demand for routine and codifiable work, not only in industry but increasingly in services.

Happiness

The large structural changes in modern economies in the past few decades and an increase in per capita income have had little effect on happiness (see e.g. Layard, 2003).[17] Nevertheless, the issue of happiness can be strongly influenced by several of the main characteristics of a KBE, for example, entrepreneurship (increase in happiness for some individuals) and creative destruction (decrease in happiness from loss of employment or job stability) (Layard, 2003). Another example concerns the role of social trust in knowledge production and organizational change. Trust has been decreasing over time in many European countries, which could reduce the effectiveness of networks and organizational forms that require higher trust levels.

The pressures of globalization can also increase the pace of work, stress, and unemployment, all of which can decrease happiness.

[17] One possible explanation is that there would have been an increase in happiness associated with an increase in income, in the absence of several negative trends: such as higher rates of alcoholism and crime. However, there are marked differences by income, with more happiness in the top quartile than in the bottom quartile.

Social cohesion

Technological change make life more stimulating, cosmopolitan, and prosperous for some, and more precarious and uncertain for others (Ritzen, 2001). Among the vulnerable groups are young people. According to Brewer (2004), youth poverty and exclusion are widespread and increasing. Today, young people seeking work are two to three times more likely than older generations to be unemployed. Youth unemployment has serious effects on income and the development of skills through work experience and on-the-job training. Other social costs include poorer health, breakdown of families, increased crime, and of course, the loss of human capital.

The Council of Europe (2005) states that economic growth would make it easier to achieve social cohesion. Social protection systems, as well as maintaining their traditional role of replacing income, must assist people to move from welfare dependence to active participation in the economy — a KBE where investment in human resources is one of the most crucial areas of investment for future economic growth.

Some of the issues advancing or inhibiting social cohesion include:

- *ICT and work access:* Europe has significantly increased internet use over the past decade and has one of the highest levels of use of digital telephony in the world (EC, 2001). Employment prospects for groups with low employment participation rates, in particular women, older workers and those with disabilities, can be improved if work is accessible in local communities through flexible work arrangements, facilitated by IT. Yet teleworking rates in 2000 were still low in most European countries and the rates were consistently higher among men than among women (Eurobarometer, November 2000).

- *Income disparities and the nature of work:* While growing in the recent past, disparities between skilled and unskilled workers may shrink in the future (Greenwood, 1997). A predicted outcome of the KBE is a change in the nature of work and in working relationships (see e.g. Ter Weel and Kemp, 2000). Changes include a mix of both improvements, such as greater workplace autonomy, and declines in the quality of life, such as a deterioration in the work-life balance. Some of the changes, such as an increase in computer and communication skills are ICT related, while others are not.

- *ICT and skills:* Labour markets may be becoming increasingly disadvantageous for unskilled workers (ILO, 2003). At the same time, ICTs can expand access to training to deprived population groups, improving social cohesion. The potential of ICT in education, training and daily life is enourmous, and especially so for developing countries and disadvantaged groups, such as the elderly and disabled populations. However, there are challenges: skills and access need further development, resources need to be invested in new learner-based techniques of education and training, and the ICT infrastructure will need strengthening.[18] These challenges are particularly formidable in developing countries.

- *The informal sector:* With the restructuring and rationalisation of the public sector and the deregulation of labour markets in the private sector, the informal sector has grown in size in the developed countries, and with it, has grown concern about its role and function (ILO, 2000). Displaced workers from both the public and private sectors have been forced to seek or create work opportunities in the informal sector, and in most cases the opportunities are of lower quality than the majority of formal sector jobs. The ILO

[18] Also, indicators need to be developed on employment afforded to special interest groups like the disabled and the elderly, as well as on how developments in a KBE are granting (or not granting) more freedom and independence for such special interest groups.

identifies the need to measure the informal sector, as well as the challenge of comparability at the international level, as a priority.

Women and equality

Although more research on the gender implications of a KBE is necessary, one possible outcome is that shifting patterns of ICT intensity and demand for higher educational levels could increase opportunities for women (Menzies, 1998), as well as increase opportunity costs for those women choosing not to work in order to care for children (OECD, 2002).

In the OECD area, the gender gap in educational attainment is narrowing and better positioning women for labour force participation. A higher percentage of women than men complete university in many countries, particularly in the social sciences, which are pivotal areas for skills in the KBE. The participation rates for women in SMEs and innovation-intensive industries has also been increasing (OECD, 2002), although, a greater percentage of men are in 'knowledge occupations' compared with women (Drolet 2000).

More women are studying traditionally male specialisations such as mathematics, although they are still seriously under-represented. There is underused potential of women not only in scientific careers, but also in the boardrooms of most European companies, which continue to be male-dominated. There is still a significant gender gap in salaries and a visible lack of women in the top jobs, whereas women continue to be overrepresented in clerical occupations, teching, sales jobs and life-science/health jobs (OECD, 2002; US Census Bureau, 2004). There are also marked differences in terms of salary between sectors: higher pay differentials occur between science, engineering and technical (SET) occupations and non-SET occupations.

The OECD (2002) identifies two obstacles for women to achieve equal participation in the labor market: level of education and presence of children. Women are still typically responsible for the family unit, located in the home country, creating obstacles for them to engage in transnational mobility. Once in work, women and men participate in job-related training at fairly equal rates, but men may receive more financial support from their employers. Consequently, training can exacerbate wage differentials between genders, since it generally has a positive impact on future earnings and productivity.

On the other hand, the KBE may contribute to gender equality by increasingly asking for qualities more typical of women – responsibility, availability, personal involvement, sharing, and a less authoritarian approach. Such qualities were identified as key barriers to women's advancement some twenty-five years ago, however, now they are considered necessary to transform organisations in the KBE (Conference Board of Europe, 2005). Similarly, Kofman (2003) and Dobson et al. (2001) observe some changes in the international labour flows suggesting that the differences between men and women, especially among mobile skilled workers, may decrease in the future.

2.2.3 Environment

There has been a long debate on the impact of ICT on the environment. ICT is often viewed as 'green' because it is not polluting, it can facilitate recycling and cleaner production, and it improves public decision-making and public policy for the environment. This view of ICT as being inherently green and greatly contributing to environmental sustainability is far too optimistic. ICT can also be employed in ways that produce environmental harm: it facilitates long-range air travel, and ICT-based manufacturing methods lead to shorter product life cycles (Sonntag, 2003) that can increase product turnover and consumer waste.

The full potential of ICT for environmental sustainability is not utilized. ICT could, for example, be used more efficiently to improve public transport, organise traffic, as well as reduce car-based transport. Better information at lower cost thanks to ICT could also lead to better environmental policy.

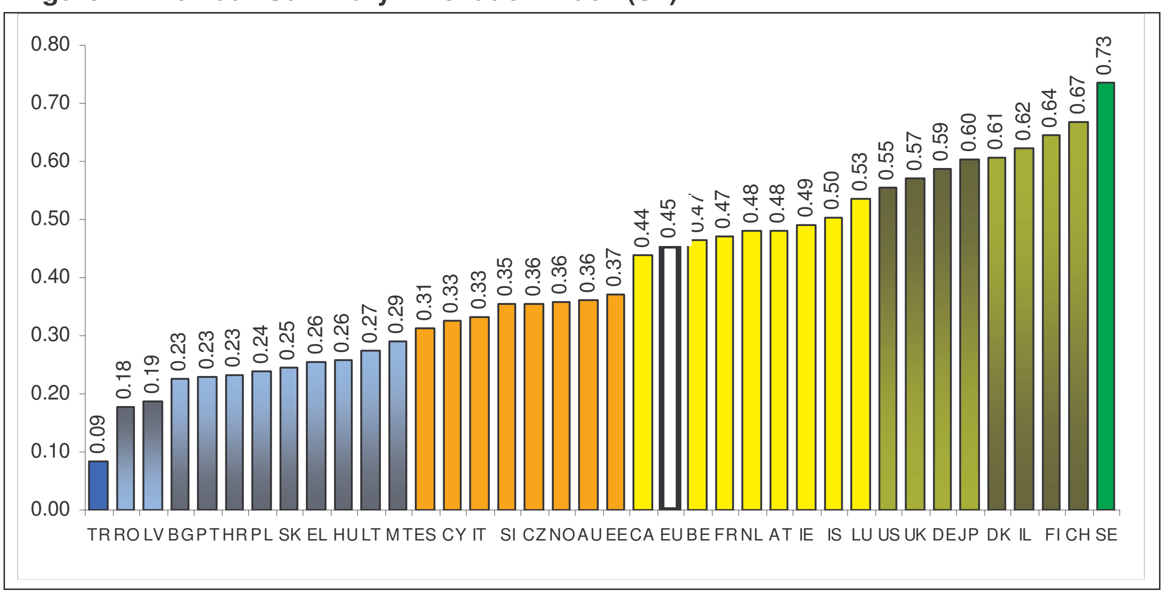
The focus on knowledge (intangible and 'weightless') hides the material aspects of KBEs: in almost all economies, direct material consumption (DMC) per capita has increased, at the same time that economies have become more knowledge intensive, even though there are large opportunities for improving the efficiency with which resources are used. Environmental innovation benefits economies while saving the environment. However, it requires not only engineering knowledge about problems and solutions, but also organisational and managerial knowledge and knowledge about markets, as well as a change in attitudes: environment must not be viewed as a burden by firms.

3. Variations in knowledge-based economies

A key characteristic of a knowledge economy is a lack of uniformity, with large differences in the characteristics and drivers across countries (Trend Chart, 2005; Inno Metrics, 2008), regions within specific countries (OECD, 2005a; Florida, 2005), and among economic sectors. These include differences in investment in ICT, the supply of skilled human resources, the production of new knowledge, entrepreneurship and the rate of adoption of new organisational forms.

As an example, Figure 1 gives the 2007 results of the Summary Innovation Index (SII) from European Innovation Scoreboard, which includes many indicators of relevance to a KBE. Within Europe, national innovative performance ranges from a low of 0.18 in Romania (RO) to a high of 0.73 in Sweden (SE).

Figure 1. The 2007 Summary Innovation Index (SII)



Note: The SII is a relational scale that can vary from a low of 0 (the country has the lowest observed performance on all 24 indicators) to a maximum value of 1.0 (the country has the highest observed performance on all 24 indicators).

3.1 The geography of the KBE

One of the main issues for comparing KBE performance across countries is the effect of national institutional factors, including different national systems of innovation, versus differences that are due to national industrial distributions. For example, a country with many firms active in pharmaceuticals and other high technology sectors will perform better on many science, technology and innovation indicators than a country that is highly competitive in food, textiles, and forestry. Research to date, although limited, indicates that sector differences account for a large percentage of national variations in business R&D investments (Evangelista et al, 1997) and in innovation outcomes (Calvert et al, 1996), as would be expected. Other characteristics of a knowledge economy, such as total investment in ICT as a percentage of GDP, show far less variation across countries, because ICT investment is relevant to all sectors.

Another important issue is the impact of globalisation and the challenge to develop indicators that consider the effects of increasing globalisation on the main characteristics of a KBE. A key example of globalisation concerns is the location of R&D abroad.

3.2 Sectors

A study by Beckstead and Gellatly (2004) indicates that the KBE is multidimensional rather than defined by sectors producing advanced technologies. The KBE includes all sectors that place a premium on knowledge creation. The results of Beckstead and Gellatly showed a dynamic growth in many sectors that are not traditionally classified as high technology (e.g. financial and business sectors). A second finding was that high levels of urbanization, often linked to emergent technology industries, were not unique to technology-based environments. A third finding was that using the high-knowledge classifications to examine the characteristics of the work force showed that the high-knowledge sectors placed more emphasis on university education than did technology-based industries. Many of the high-knowledge sectors also had large concentrations of women in knowledge occupations.

Even though all sectors are important players in a KBE, the characteristics of the development and use of knowledge varies by sector. For example, investment in R&D varies substantially by sector. Of interest to a KBE, R&D intensities increased rapidly between the first and second halves of the 1990s in many low technology sectors, whereas there were declines in several high technology sectors. Even so, large differences remain.

A key characteristic of the KBE is sectoral change, or the shift from manufacturing towards services. The percentage of knowledge workers is probably higher in services than in manufacturing, but it does not necessarily mean that services are more knowledge intensive than manufacturing. Even though services are more *labour*-intensive compared to manufacturing, a direct comparison of the knowledge intensity of different sectors should also include an indicator for the amount of knowledge embodied in capital goods. It is possible that some sectors with high levels of skilled labour could have low levels of embodied knowledge, and vice versa.

According to Wolf (2005), there is increasing interaction between the manufacturing and services sector in today's economy: the share of services that is necessary for or complementary to manufacturing goods production has increased, and many service activities that were originally classified within the manufacturing sector have been contracted out to specialised service providers, or provided by newly created spin-off firms from a manufacturing firm. Moreover, the sector classification of a firm can shift from manufacturing to services, depending on the activities of its employees. All can create problems for many indicators based on industrial classification systems, such as employment, value-added, labour productivity, and R&D spending, and distort international comparisons.[19]

Wolf recommends against considering services separately from manufacturing industries, given the complex interactions between them. His results underline the fact that there are serious measurement problems that can lead to biased measures of productivity growth and other conditions in both sectors.

3.2.1 The public sector

The public sector can contribute to the knowledge economy through the provision of services to the public and through programmes to support the drivers of a KBE, such as educational programmes to supply skilled human capital. A major innovation in the provision of public services is to provide internet portals for many government activities (e.g. tax returns, social welfare programmes). Consequently, in order to discuss indicators on the contributions or implications of the internet (and other ICT) on public sector programme delivery one must first consider access to the internet, including variations according to variables such as gender, age, education, employment and qualifying factors for government programmes.

E-education: The OECD's *Education at a Glance* (OECD, 2003a) reveals considerable variation in students' access to new technologies (from 25% to over 90%), which is an important indicator. A second useful indicator is internet use by students.

The development of learning and up-skilling, and the need for life-long learning must also be considered. Apart from the building of 'virtual universities', a number of concrete activities are underway to improve access to on-line skills development for citizens of all ages and abilities (including the disabled). E-learning also facilitates employee training.

Consequently, apart from indicators of formal levels of education, there is a need to develop indicators for changes to the skills of workers and citizens that occur through other types of education and learning, as well as impact measures (e.g. composite indicators for learning and performance) for policy and strategic planning.

E-government services: Although there is still a lot of variation between countries, government ICT spending across Europe is substantially increasing. For example, more and more public administrations are adopting virtual private networks (VPNs), permitting low-cost secure sharing of information among government employees and external contacts. Furthermore, governments continue to expand services offered through electronic access, although there is evidence to suggest that governments develop e-services most rapidly for revenue generating activities, as compared with knowledge-sharing purposes. Citizens' use of the internet for public authority exchanges also varies greatly between countries. E-technology seems to have made few fundamental changes in government. Instead, it may be more the case of doing the same 'old' things with new tools (e.g. tax returns on-line as an option to hardcopy forms). Moreover, online sophistication of public service provision is still more developed for businesses than for private citizens (Cap Gemini, 2005).[20]

E-participation in governance: Web-based technologies can provide the opportunity for governments to increase the participation of citizens in the democratic process. It would be difficult but useful to have indicators on the extent to which the internet and other ICT technologies have been drawing citizens to take part in governance.

[19] This is part of the explanation for a large disparity in business R&D expenditures in the service sector between the US and the EU.

[20] The Cap Gemini (2005) report puts the overall share of fully transactional on-line public services at 40%, with EU-15 at 46% and EU-10 at 29%.

The results of a UN study (UN, 2003), carried out to develop an *e-participation* index to gauge differences in on-line strategies and approaches to citizens' involvement, suggest that the status of e-government today is more a reflection of inherited capacities in the area of infrastructure, human capital, institutions and policy focus than a determination of governments to seize new technological opportunities to support a change in governance.

Public science: The science system[21] carries out a key function in the KBE, including knowledge production, transmission and transfer. The problem is how to reconcile its traditional function of producing new knowledge through basic research and educating new scientists and engineers with its newer role, one of collaboration with industry (OECD, 1996). The economic and social losses from a decline in open science could outweigh the economic and social gains of collaboration, particularly if private interests can influence research goals and outputs and if knowledge is increasingly privatized. However, the EU can influence private-public science interactions, since a significant proportion of them is directly supported by European policy. Some relevant indicators are available,[22] but an assessment of whether or not the socio-economic benefits of collaboration outweigh the possible losses would require indicators on the uptake of open science by firms and quality measures for public research outputs that are and are not protected by IPR.

3.2.2 The volunteer non-profit sector

The volunteer sector is a knowledge-intensive sector and its most important asset is knowledge. It contributes to economic performance, the political health and direction of a country, and to the quality of life of citizens (Burt and Taylor, 1999).

Even though ICTs have the potential to transform internal governance in the volunteer non-profit sector, evidence from the UK (Burt and Taylor, 1999) suggests that the sector is not exploiting the opportunities available. ICTs can also increase the capacity of volunteer organisations with tight budgets and improve programme effectiveness (IM/IT Canada, 2002). It will be important to develop indicators of the impact of ICTs on the operations and activities of the non-profit sector and gauge the benefits for citizens. One key indicator is the measure of the uptake and application of ICTs in volunteer non-profit organisations.

3.3 Indicator requirements

Certain aspects of the KBE are covered by a rich data set. These areas have benefited from established surveys based on a traditional approach to measurement that persists in KBE indicator development (e.g. indicators of business performance, R&D activities and patents). Other aspects of indicator development for a KBE are in their infancy. This includes composite indicators based on summarizing several component indices. Composite indices can be used to generate a 'constellation' of events (Australian Bureau of Statistics, 2003). Taken together, a group of indicators can 'collectively' give early warning signals for a decline in performance. Of note, the value of a composite index depends on the quality of the component indicators, which can suffer from the limits of data collection, in particular timeliness and consistency of scope and coverage.[23]

The above review of KBE characteristics and drivers of the KBE has pointed to a number of existing indicators that can inform policy questions of relevance to a KBE, as well as a number of new or improved indicators that should be gathered. There is also a need to revisit existing composite indicators and to develop new composite indices. Figure 2 presents a

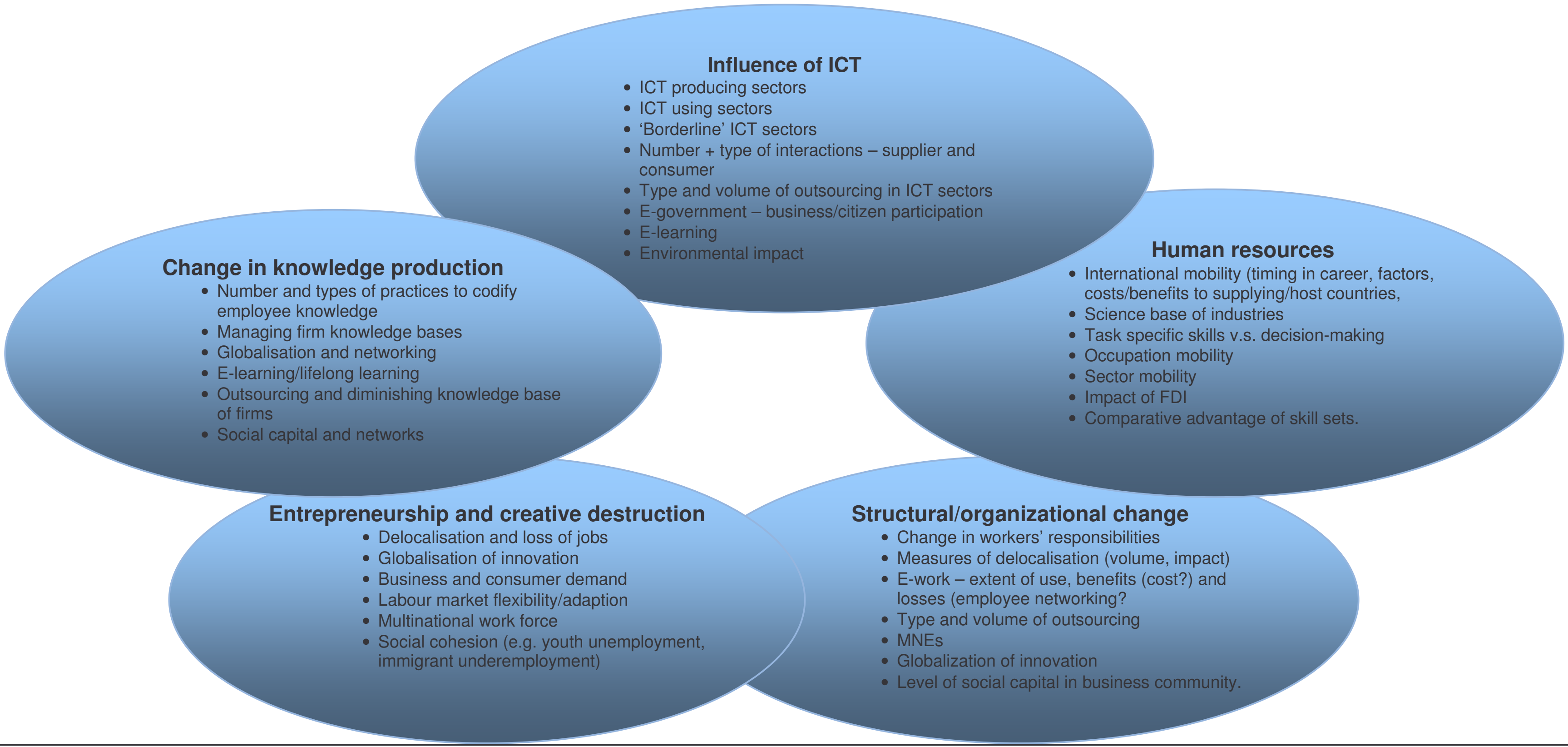
---

[21] The science system essentially consists of public research laboratories and institutes of higher education.
[22] Available indicators include share of firms that collaborate with universities and patenting by public science.
[23] One problem is that composite indices suffer from the 'black boxing' problem, in which problems of comparability and accuracy with the original data become invisible (Godin, 2005: Ch. 9).

number of indicators grouped under the five characteristics and drivers of a KBE. A broader overview of indicator needs is presented in Annex A.

In the KBE, different segments of the economy grow or decline, different players gain or lose their importance, emerge or disappear. Ways of learning, producing and exchanging knowledge are different than in previous economies and continue to change. While the role of ICT in the KBE is undeniable, indicators are required for factors that reconfigure economic, social and political relationships. On the other hand, how much of the KBE is truly different or new and driven by technology's power to make things for business and people better, versus how much is it business as usual, but simply with new tools?

Figure 2. Indicators for a KBE.[24]



[24] It is impossible to assign all indicators to only one category within a classification scheme, as there are many cross-connections among them. For example, several of the needed indicators for work structure and organizational change shown in Figure 2 are also measures of the influence of ICT on production and diffusion. Similarly, e-government indicators will have to consider ICT diffusion as well as lifelong learning (e.g. ability of citizens to realize benefits of ICT) and work place innovation.

4. Future challenges for a knowledge-based economy[25]

Not only has there been a general lack of progress towards reaching the Lisbon goals of Europe becoming a more dynamic and competitive knowledge-based economy, but challenges are actually increasing over time, due to demographic changes, increasing competition from China in high value-added goods and from India in services, and the continuing dominance of the United States in KBE sectors such as ICT and biotechnology (Kok, 2004; Patel et al, 2008).

There are a number of major structural changes occurring on a global level that are relevant to knowledge-based economies and that will alter the environment for innovation and competition over the next few decades, and consequently, influence the types of indicators that European policy makers and academics will need to be able to effectively evaluate and respond to future challenges. These major structural changes include:

1. Increasingly global production chains for goods and services, leading to changes in the location of comparative advantages.
2. The development of new centres of knowledge and innovative activities.
3. Demographic changes including increases in the average life span.
4. Changes in stocks and flows of skilled workers.
5. Technological shifts driven by new technology or environmental requirements.

This section examines these five challenges and the types of indicators that will be required to track structural changes over time. We also briefly discuss three related scenarios on demand for innovation, supply of skilled human resources and environmental. The goal of these scenarios is to assess the relevance of existing indicators and to suggest new indicators where necessary.

4.1 Global production chains

The first structural change consists of major shifts in the location of comparative advantage for the production of both manufactured goods and services. While China accounts for a growing share of manufactures, India is developing strengths in services such as software development, clinical trials, and call centres.

Over the short to medium term of up to 20 years, firms in developed countries are likely to respond to cost competition from India and China by increased delocalisation of production, including the production of high technology products, such as ICT or aerospace equipment. Such shifts in the location of production have been made possible by ICT, innovation in organizational forms and logistics,[26] and low transportation costs. Innovative firms rely on cross-national production networks and create value from the efficient use of global supply chains, thanks to globalization and the increasing modularisation of standard components (Zysman, 2004).

New types of indicators to inform policy options and private investment decisions are needed. Although MNEs are important actors in the innovation process, their role needs to be better understood. Statistics related to MNEs are usually limited to the national level and country to country comparisons, creating incomplete data and unclear profiles on their

[25] Parts of this section are based on Arundel et al. (2006). We would also like to acknowledge comments from Asterios Chatziparadeisis.

[26] Organisational and logistical innovations are likely to increase in value. This is one reason why the ability of firms to exploit value-added at every possible link in the production and distribution chain could become a key feature of a knowledge-based economy (Keita, 2004).

activities, including the location of their innovation investments around the world. Due to a lack of official statistics, little is known about the extent and real impact of delocalisation of production. Further work is required to identify employment effects, including types of employment affected (e.g. knowledge creation vs. application); occupations most affected (e.g. different skill levels and fields of specialization), and wage differentials for the same occupation between the source country and the off-shored location, plus rates of salary growth abroad.[27]

A crucial point about current changes in the location of comparative advantage is that it won't last. Sooner or later, increasing productivity and wealth in India, China and other developing countries will result in currency realignments that will reduce the disparities in wages and incomes that drive off-shoring strategies based on seeking lower wage costs in manufacturing and the provision of services. An often forgotten point is that the advantages of distant, low-cost production are slim. Even a 10% increase in shipping costs can reduce the cost advantage of producing some goods in China to zero. The rapid increase in the cost of petroleum products after 2006, if sustained, could lead to a shift in some manufacturing in China to locations closer to major markets.

4.2 The changing environment for innovation strategies

Outsourcing and delocalisation of production are not new phenomena. However, data suggest that countries such as India and China are likely to increasingly compete not only on the basis of low wages, but also on their innovation capabilities (see e.g. Schaaper, 2004), including in knowledge intensive sectors, such as software, capital goods and ICT manufacturing. American FDI or suppliers to American firms in these two countries also appear to be increasingly responsible for developing patentable innovations for their parent firm, suggesting that both China and India are capable of turning FDI into a mechanism for developing innovative capabilities (see Puga and Trefler, 2007). One consequence is that it could be increasingly difficult for high-wage countries to compete on the basis of "continual innovation" (Krugman, 1979).

The development of innovative capabilities in China and India could drive firms to increasingly develop R&D centres in these two countries. First, firms can take advantage of local pools of inexpensive but highly skilled labour; second, they can seek specialized expertise that is not available in their home countries and third, they can establish R&D labs in foreign markets to adapt current products to local tastes or develop new products that meet local demand.

The OECD estimate that about 20% of total jobs in the EU could be off-shored, including many of the 'knowledge jobs' of the future gives pause for thought. This is already occurring in some sectors, such as software development in India, and the establishment of research centres in China by telecommunication and biotechnology firms. To date, we lack reliable statistics on both the extent to which innovation activities such as R&D are being globalized, and more importantly, the innovation capabilities of the research centres that have been established by multinational firms in developing countries. We do not know if these centres are performing leading-edge research or largely adapting products to local markets.[28]

---

[27] The OECD has estimated (see van Welsum and Vickery, 2004) that a high percentage of EU employment is susceptible to delocalisation (nearly 20% for 2003). The features of occupations with a high 'delocalisation potential' include intensive use of ICT, output that can be traded or transmitted using ICT, high information or knowledge content, and work that does not necessarily require face-to-face contact. These features would cover a high proportion of the well-paid jobs in the KBE that are supposed to replace losses in manufacturing employment.

[28] Of the three reasons for establishing R&D centres abroad, only the first can be construed as true delocalisation or offshoring.

According to Zysman (2004), competitive advantages provided by innovation could decline as an increasing share of firms base their competitive strategies on innovation, driven both by an increasing awareness of innovation by firms based in developed countries and by an increase in the use of innovation by firms based in developing countries. Greater competition could reduce the ability of innovative activities to provide the excess rents that drive profits and investment. This could produce a paradox whereby policy efforts to encourage more creative innovation, as with the 3% R&D intensity goal for Europe, result in declines to the private returns from innovation.

However, three factors could mitigate the reduction in profits from increasing competition over innovation. The first factor concerns the location and costs of innovation activities. With R&D becoming more of a commodity, it can be purchased from universities, start ups and spin-offs, or from cheaper R&D centres in developing countries.[29] The second factor is that firms can more aggressively manage intellectual property to profit from their investments in innovation, for example through patenting. Market differentiation strategies based on design (Vinodrai et al, 2007), trademarks and branding could also become more important.[30] Third, firms can introduce strategies to improve the efficiency of innovation, such as the number of new innovations per unit of R&D spending. The organisation of innovation itself is changing and these changes can improve the productivity of innovation. IT has driven down the costs of experimentation, and globalisation has reduced the cost of research collaboration and the cost of outsourcing. Firms have decreased the role of stand-alone central labs and increased their use of linkages such as networks, alliances and formal and informal relations. Such linkages could be producing basic structural changes that improve research productivity and allow innovation systems to adapt to new conditions, as well as reduce uncertainty, share costs and knowledge, and bring innovative products and services more quickly to the market. Indicators to track and understand these dynamics are important for policies that support this experimentation while retaining a competitive environment.

The efficacy of these three counter strategies to improve the profitability of innovation depends on favourable technological opportunities, or the R&D and engineering costs of developing new innovations versus the expected earnings from these innovations. There are no reliable data for technological opportunity, but the opportunities are believed to be highest during the early years of a new technology, lowest during its mid life, and to increase as the technology matures.

4.3 Demographic change and demand

The third major structural change is a demographic increase in the average age in many developed countries. This change has two impacts on a KBE: first, on the market demand for innovative products, and second, on the supply of highly skilled individuals (discussed in the next section).[31]

---

[29] Although this might not work in many sectors due to the nature of knowledge in general, it can work in sectors such as pharmaceuticals (contracting out R&D services for clinical trials) or office equipment manufacturers (obtaining the results of R&D 'embodied' in components).

[30] In affluent societies, design is an increasingly important method of product differentiation that is useful across all sectors. A dependence of brands also creates risks, as when a brand is associated with irresponsible environmental production or exploitation of workers. Conversely, brands can be used to advertise socially responsible environmental and employment practices.

[31] The issue of pensions and whether a shrinking labour force can support a growing non-active population are not discussed here. These topics are often discussed in an alarmist way, and they depend for their solution on a higher birth rate, immigration rate or, perhaps most importantly, labour force participation rate, as recognised by ECOFIN (2005).

Research consistently shows that the adoption rate for innovative consumer products and services is inversely proportional to age and positively correlated with income. Demographic change leading to large increase in the population share of older age cohorts could reduce aggregate domestic demand for innovative goods and services. Assuming that a sophisticated domestic market plays a role in national innovative capabilities, an aging population with low levels of interest in innovation could reduce the innovative capabilities of the home market.[32] These factors could lead firms based in countries with aging populations to seek both markets and research facilities in more youthful countries.[33]

Another development that could be affected by changing demographics is user-centred innovation.[34] The actual economic importance of user-centred demand in either lowering innovation costs for firms or influencing the direction of innovation is unknown, but insofar as user-centred innovation occurs through the internet, the low internet access rates among older age cohorts could be a concern. Conversely, the internet permits firms to get global feedback for their products and services.

Because consumer demand can constitute an important incentive or constraint in shaping the innovative activity carried out by private firms, data on the value that innovation generates for customers is needed. Moreover, with a possible increase in user-centred innovation, the location where innovation takes place changes. This requires integrating customer requirements and ideas through organisational innovation (customer-related processes are integrated with sales, delivery, inventory management and so forth). Attention needs to be given to the role of suppliers, customers and interactions among them. This means developing indicators of innovation processes that look at those interactions by using new technologies.[35]

4.3.1 Scenario on innovation demand

In the KBE, productivity and economic growth are largely related to innovation. Not only does competition drives innovation, enabling firms to reduce production costs, but there are other more complex factors driving product innovation, including both technology push and market demand factors.

Firms invest in product innovation based on current or expected demand for innovative goods and services. Without a current or potential market, innovation activity may be compromised. The market can be other firms (business to business), individual consumers, governments, or export markets.

Demand is one of the two main drivers of innovation (the other is the supply of technological opportunities). Consequently, several policy actions, apart from the creation of a single European market, can influence innovation. The innovation demand scenario identifies indicators that could be used to evaluate national differences in demand factors and find out how policy could influence demand in a way that would stimulate innovative activity.

The scenario examines three main factors that have an impact on demand for innovations: domestic demand, foreign demand and the role of government. Moreover, domestic demand

[32] This is one of the four main points of Porter's diamond for national innovative capability. However, there is little empirical evidence to support the role of sophisticated domestic consumers, aside from a few case studies that suffer from a selection bias, such as an example by Beise (2001) for the telecom sector.
[33] This phenomenon is not restricted to developed countries. China's one child policy will leave a similar legacy in the future, with a rapid increase in the average age of China's population.
[34] For example, custom designs can be outsourced to users via innovation toolkits, and individual users can better combine and coordinate their innovation-related efforts through the internet (von Hippel, 2005).
[35] One possibility is to introduce new questions in innovation surveys or in surveys of ICT usage.

was further divided into quality and quantity aspects. We then tried to identify key demand indicators that are currently available, as well as new indicators that should be developed to better assess demand conditions in a given country. Proposed indicators that may have an impact on demand were first correlated with innovation activity output indicators and then with each other.

The results indicate that demand conditions are influenced not only by the quality of domestic demand, such as the existence of lead users or sophisticated buyers, but also by quantitative aspects such as the numbers of consumers in domestic markets. Sophisticated buyers consist of highly skilled and educated adult with high disposable incomes and an interest in purchasing innovative products.

Demand can also be created if firms make use of sophisticated marketing tools to capture or create customer needs and desires. Unfortunately, it was not possible to measure the effect of advertising on demand due to a lack of data.

Not only is domestic demand relevant for local firms, but also foreign demand. Reaching new markets can be decisive for firms that lack large domestic markets. Domestic markets may not be large enough to permit firms to recoup their investments in innovation.

Government also plays an important role, not only by consuming innovative products through procurement, but also by creating regulations and standards that can increase demand through reducing uncertainty and improving quality.

In summary, the demand scenario identified the indicators listed in Table 2 as relevant for assessing innovation demand conditions.

Table 2. Relevant innovation demand indicators

Indicator	Details	Relevance
Part I. Available indicators		
1. Quality of domestic demand		
Intensity of local competition	Index values (1 to 7) measuring whether competition in the local market is limited or intense (survey data).	Intense competition by producers both drives down prices and provides product differentiation, enabling consumers to select on optimum products/services.
Extent of market dominance	Index values (1 to 7) measuring whether corporate activity at national level is dominated by few firms or spread across many firms (survey data).	Another measure of the development of lead markets (see above).
Buyer sophistication	Index values (1 to 7) measuring whether buyers focus more on price or quality of products and services (survey data).	Preferences of individual consumers for innovative products are a key demand factor. Sophisticated buyers are the first to adopt new products.
Population (aged 24 to 65 years) with tertiary education	Number of persons (by age class) with some form of post-secondary education per 100 population.	Educated consumers are more likely to be comfortable with new ideas, demand sophisticated and novel products and services, and evaluate different options.
Quality of educational system	Index values (1 to 7) measuring whether national education systems meet the needs of competitive economies (survey data).	Another measure of education levels and quality (see above).
Brain drain	Index values (1 to 7) measuring whether talented people tend to leave to pursue opportunities in other countries or remain in their home country (survey data).	Lack of domestic opportunities for talented graduates can seriously affect national innovation systems and reduce the influence of lead buyers in creating sophisticated demand.
Euro creativity index	Measure of national competitiveness – composite indicator based on several indices measuring talent, technology and tolerance.	Innovative firm clusters tend to form in an environment with values and attitudes that facilitate the attraction of talent, also through immigration.
Gender empowerment measure	Gender inequality measure for political and economic participation and decision-making power, and power over economic resources.	Used as a proxy for income equality between men and women. More demand tends to be created when buying power is distributed among more heterogeneous population.

Indicator	Details	Relevance
2. Quantity of domestic demand		
Youth share of the population	Ratio of the share of population under 30 to the share of the population 65 and over.	Large numbers of young people tend to either create more innovation demand, or conversely correlate with lower incomes and lower levels of demand.
Degree of customer orientation	Index values (1 to 7) measuring whether firms are responsive to customers and customer retention (survey data).	High customer orientation can turn firms towards user based or assisted innovation, which can be expected to increase overall innovation.
3. Foreign demand		
Breadth of international markets	Index values (1 to 7) measuring whether exporting firms sell in a small or large number of foreign markets (survey data).	A large number of foreign markets potentially increase demand for innovation by domestic firms.
4. Public sector demand		
Demanding regulatory standards	Index values (1 to 7) measuring stringency of national standards on product/service quality and of energy and other regulations (survey data) .	Stringency of regulations and standards can have a positive effect on demand by reducing uncertainty.
Government procurement for advanced technology products	Index values (1 to 7) measuring whether government purchase decisions for advanced technology are based solely on price or also on technological performance and innovativeness (survey data).	Focus on performance and innovativeness is likely to further increase demand for innovation.
Part II. Potentially relevant, but missing indicators		
1. Quality of domestic demand		
Demand differences at sectoral level	No data currently available.	Innovation activity is sector oriented; therefore, measurement of sector specific demand conditions would be important.
Effect of demand structure (polypsony, oligopsony)	No data currently available.	Demand structure (many buyers vs. only a few buyers) is considered relevant for innovative activity.
Role of niche markets	No data currently available.	Existence of niche markets considered important for many new and sophisticated products (but can also be a sign of income inequalities).
2. Quantity of domestic demand		
Impact of marketing of innovative products on demand	No data currently available.	Marketing is a demand driver, but it is not known how effectively it can be used to create demand for innovation products. Adding new questions on marketing to the CIS could help to overcome this limitation.
3. Foreign demand		
Role of replacing inadequate domestic markets with foreign markets	The only currently available foreign demand indicator on the breadth of international markets does not fully capture this aspect.	Firms can use foreign markets as lead markets or as a source of sophisticated consumers.

The scenario also noted the existence of large gaps in indicator availability. As can be seen from Table 2, these missing indicators include measures of the different effects of demand by sector, demand structure (monopsony, polypsony and oligopsony), the role of niche markets, the ability of firms to use foreign markets to replace limited domestic markets and the impact of advertisement in creating demand.

4.4 The supply of human capital

At the heart of a KBE are people who use, develop and adapt innovations and technology. As demand for talent increases and as innovative networks increasingly cross borders, this segment of the labour force has become increasingly global.

Several countries are able to attract large numbers of foreign university students, who in many cases stay on and become researchers or otherwise add to the domestic pool of talent.

The pattern during the 1990s consisted of a net inflow of the highly skilled into the United States, both from developed and developing countries. In some supplier countries, the loss of university graduates was partially compensated by inflows from developing countries, resulting in a global circulation of human capital.

However, developed countries, particularly the United States, face a potential decline in the global inflow of skilled workers, as a consequence of increasing economic opportunities at home for the highly skilled. This could have substantial impacts on the innovative capabilities of developed countries. In fact, the ability of developed countries to attract and compete for students in the global market could already be declining and this decline could either speed up, or force up wages. The supply of PhD candidates to the United States from the major source region of East Asia (mostly China), peaked in 1996, and then started to decline, while the number of PhDs produced by China took off in 1996, and educational opportunities have further increased in China with the establishment of Chinese branches of Western universities. It is likely that the two trends are linked, with the decline in the flow of PhD students to the US from East Asia due to increasing educational opportunities at home. These declines have also intensified recently, possibly in response to stricter visa requirements after 2001.

The decline in foreign student applications in the United States could benefit Europe, if foreign students turn to Europe for university placement. In contrast, Europe could also be feeling the effects of an increase in educational opportunities in 'donor' countries (India, China etc.). As a consequence, Europe could find it increasingly difficult to rely on immigration for skilled workers in terms of the European growth and jobs strategy. Another problem is the current declining interest in science among students that has been observed in many European countries. An alternative solution to both problems is to increase the indigenous supply of tertiary students and new doctorates from under-exploited segments of the population, including women or older age cohorts. This might also be necessary to overcome the decline in the supply of students due to low birth rates over the past decades in developed countries. Furthermore, the need for highly skilled individuals could partly be met through lifelong learning.

The European policy community believes that there is a need for greater mobility among the highly skilled. Mobility does not only take place between public science and private industry and across national borders, but it extends to flows of skilled employees from one firm to another. There are two economic justifications for greater mobility. First, the movement of highly skilled personnel can act as a powerful 'vector for sharing knowledge' and as an 'instrument of information and technology transfer'. International mobility is assumed to be a positive factor that promotes scientific excellence and benefits both training and careers (Harfi, 2004).[36] But so far, we do not know the optimum level of mobility (there must be an upper limit),[37] nor do we know enough about the most effective forms of mobility: temporary, long-term, or networking via the internet, or the comparative value of other channels for exchanging ideas and knowledge. The second economic benefit from mobility is that both the supply and demand for specialized, highly-skilled labour can be very small within a single country. This can lead to mismatches in supply and demand, resulting in

[36] The theoretical justification for personal mobility (defined as a move of six months or more) is based on the distinction between tacit and codified knowledge, with tacit knowledge requiring personal contact for transmission, although it does not necessarily require face-to-face contact.

[37] The models of Haupt and Janeba (2004) for mobility and Cowan and Jonard (2004) for networking find that the optimum level of each is well below the maximum possible. Wickramasekara (2003) suggests that returnees from developed to developing countries need to have 10 to 15 years experience abroad to provide benefits to their home country, but this is partly based on the time needed to acquire entrepreneurial and networking skills.

either a failure to fully use the skills of scientists and engineers, or the abandonment of promising research projects, due a lack of human resources. Encouraging mobility, through reducing barriers to the movement of the highly skilled within Europe, can help improve the match between the supply and demand of human capital.[38]

In the European context, mobility needs to be separated into two components: flows within the EU and flows between the EU and countries outside the EU. European policy favours intra-EU mobility because of concerns that skilled Europeans who go abroad (mostly to the US) will not return and bring back useful knowledge that could benefit the European economy. We also lack empirical data that might show that useful knowledge is returning to Europe via networking. Furthermore, there is no information on what those who choose to return mean for the EU.

One possible result is a net loss to some European countries, particularly those with generous education systems that could be subsidizing non EU countries. However, it is also possible that many of the highly skilled scientists that left Europe would have languished in Europe through a lack of opportunities, or through a failure to work with other leading scientists. In theory, the knowledge produced by skilled European researchers abroad could return to Europe in embodied form, for example in ICT hardware, software, or pharmaceuticals.

Another area that requires more investigation relates to the numbers of doctorates that are necessary for efficient innovation, compared to other skilled individuals. This could vary by field of science or sector of application

There is a belief that the KBE is all about high technology and advanced education degrees. But innovation is not dependent only on tertiary education: technicians and technologists are part of research teams; skilled trades (e.g. technicians and technologists) are an essential part of the network of S&E researchers, and engineering and production teams are essential to the diffusion of new technology. This misconception has influenced the available data on human resources: currently, data are based either on the identification of knowledge-intensive occupations or, more commonly, on the level of education. Occupational data are often unreliable because an occupational category can combine low and high skilled tasks. Using the level of educational attainment has several limitations: the definition is limited to formal education and excludes workers' knowledge and life-long learning, and educational attainment does not necessarily capture all formal training. A more dynamic view of skills would be useful. Because demand for highly skilled human capital occurs across all sectors and not just within the traditional 'high-tech' and education sectors (Beckstead and Vinodrai, 2003), indicators for the demand for and deployment of human resources across all industries are required. One way to expand our knowledge is to explore the activities of knowledge workers. For example, what are the knowledge flows from academia to industry, and how do the activities of knowledge workers vary among low, medium and high-technology intensive sectors?

The quantitative goals of the Lisbon and Barcelona summits to improve R&D intensities and the competitiveness of the European economy will require better data on the pipeline that produces indigenous researchers, on the success with attracting highly skilled immigrants, as well as on the stocks and flows of the highly skilled. The necessary indicators also include better data on the demographics of skills by age and gender and among immigrant and non-immigrant populations. Moreover, data on values and priorities of students that choose a foreign country to conduct their studies would be helpful in assessing their potential

[38] This second justification for mobility depends on the size of the labour market and the opportunities for productive research. For example, the very low level of international mobility from the US suggests that the US economy is large enough to provide ample opportunities for its own highly-skilled individuals.

participation in the European education system and their contribution to the European workforce.

4.4.1 Scenario on the supply of scientists and engineers

A key resource of a KBE is its stock of highly educated human resources, particularly scientists and engineers (S&Es) active in research.

The EU goal of increasing the average R&D intensity from approximately 2% of GDP to 3% of GDP would require a large increase in the stock of European researchers, including science graduates with Bachelors or Masters degrees, and PhDs and engineers. The scenario used simulations to evaluate the effects of different factors on the supply of human resources over the next ten years. The purpose of the exercise was to identify the key indicators in terms of increasing the supply, as well as to highlight the need for new or improved indicators.

Possible influences on the flows and stocks of S&Es include not only national level domestic policies, population trends, industry structure, employment rates, and international mobility of both students and S&E personnel, but also conditions within countries outside the EU, such as China, India and the United States.

The main factors that influence the stocks of S&Es are related to domestic higher education in the EU, international student mobility, other factors that can increase the stock of European S&Es (life-long learning, employment growth, mobility within S&E field, workers moving back to the field, new bachelors, masters and PhDs taking more S&E jobs, improved working conditions, foreign immigration) and main loss channels to this supply (outsourcing R&D, flows to jobs outside S&E fields, EU emigration, death and retirement) .

Nearly 90% of the total impact in our simulation exercise was due to five key indicators, with more than 50% from the top two:

- Increasing average retirement age in the EU
- Increasing proportion of students choosing S&E studies[39]
- Increasing proportion of S&E graduates getting S&E employment
- Bringing in more scientists and engineers from countries like China and India (or even the United States)
- Increasing proportion of women studying S&E fields.

Other indicators had a lower impact, but were also relevant: keeping non-EU students working in the EU after graduation, reducing unemployment in S&E fields, retaining EU S&Es and getting more Chinese and Indian students to choose the EU for their studies.

In addition to the indicators used in the simulations, there are other useful and desirable indicators that could be collected. However, in the case of many of these indicators, greater detail is required than what has been available, at least until recently. A significant issue is related to having enough consistency between countries, both in terms of what data are collected and how indicators are defined. These factors are particularly important for international mobility data. Some identified indicators are presented in Table 3.

[39] A rough estimate obtained from literature was used in our simulations for this proportion – 65% (Teichler, 2002). Much more data would need to be collected on this topic.

Table 3. Relevant indicators for the supply of scientists and engineers

Indicator	Details	Relevance
Part I. Available indicators		
1. Stock of HRST		
Age of retirement	Average exit age from the labour force in the EU-25 used as a proxy for scientists and engineers.	According to the simulation exercise, the largest contribution to increased numbers of S&Es and researchers could be found from a moderate increase the average retirement age in the EU.
Unemployment rates	Unemployment rates for HRST in EU-25 used as a proxy for unemployed scientists and engineers.	A moderate reduction in unemployment among S&Es and researchers in the EU would have a small, but significant impact on the numbers of S&Es and researchers.
2. Domestic and foreign students and graduates		
Students in S&E fields at universities	Students at ISCED levels 5a and 6 enrolled in S&E fields as a percentage of all students.	Increasing the numbers of university students choosing S&E studies even slightly could have a major impact on the numbers of scientists and engineers.
Enrolments of female students in S&E fields at universities	Female students at ISCED levels 5a and 6 enrolled in S&E fields as a proportion of all S&E students.	A reasonable increase in female university students choosing studies in S&E fields would produce a moderate increase in the numbers of scientists and engineers.
Chinese and Indian foreign students	Number of foreign students in the EU-25 at ISCED levels 5a and 6 by citizenship and the overall proportion of S&E students used as a proxy for foreign S&E students in the EU.	A relatively large increase in the numbers of Chinese and Indian S&E students in the EU would have a small impact on the numbers of scientists and engineers in the EU.
Foreign university graduates	Number of S&E graduates at ISCED levels 5a and 6 and number of foreign students at ISCED levels 5a and 6 used as a proxy for foreign graduates in S&E.	A large increase in non-EU S&E students working in S&E fields in the EU after graduation would produce a small, but significant increase in the numbers of scientists and engineers in the EU.
3. Inward EU mobility		
Scientists and engineers 'produced' in the US, China and India	Number of scientists and engineers graduating annually in the US, China and India.	Potential pool for EU recruitment of scientists and engineers.
4. Outward EU mobility		
EU HRST graduates working in the US	Number of EU nationals holding temporary (HRST) H-1B visas in the US and the overall proportion of S&Es among HRST used as a proxy for EU scientists and engineers working in the US.	Successful efforts to keep EU nationals working in S&E within EU borders would produce a small positive impact on the numbers of scientists and engineers.
Part II. Potentially relevant, but currently inadequate indicators		
1. Stock of HRST		
Educational background of researchers	Currently Eurostat collects data on the educational background of S&Es, but does not collect such data on researchers.	Assessing the origin of researchers would be important.
Age distribution of HRST, S&Es and researchers	Currently data on the age distribution of HRST and S&Es are collected, but the age brackets are too wide, especially at the higher end.	Accurately assessing historic and future trends in the stocks, including losses to retirement would be important.

Indicator	Details	Relevance
Further careers of EU graduates – e.g. in 1, 5 and 10 years after graduation	There are a number of country studies focusing on graduate careers, and at least one study covering several countries (CHEERS), but no EU level data collection has taken place so far, although there are some current plans for this.	It would be important to estimate the contribution of S&E graduates to the S&E fields of work and R&D in the EU, and the contribution of graduates in other fields to the S&E stock, and the careers of the large proportion (possibly a third) of S&E graduates, who do not end up working in S&E**.**
Further careers and locations of non-EU graduates	There is currently no EU wide collection of such data.	Estimating the contribution of international S&E graduates to the stock of S&Es and researchers in Europe (vs. outside Europe) would be relevant.
2. Domestic and foreign students and graduates		
High school pupils studying S&E subjects by gender	Currently, there are data for the overall ISCED97 level 3, but a further breakdown would be required.	Accurately assessing the potential contribution of such pupils to university enrolments in S&E fields would be relevant.
S&E students in higher education	These data are collected, but there are inconsistencies between countries in counting university students, especially at the PhD level.	Accurately estimating the potential contribution of S&E graduates to S&E fields and research performed in the EU would be important.
Survival rates in education by field of study and gender	Survival rates are currently collected by the OECD, but not by field of study.	Obtaining such data on the difficulties in S&E fields vs. other fields in getting students to graduate, and the differences in the rates of female/male students finishing their studies would be relevant.
Mature students by educational field, age and gender	Eurostat currently collects data on mature students by age *or* by field of study, but not combined by age *and* field of study.	Assessing the potential contribution of mature S&E graduates to the S&E fields of work in the EU would be relevant.
Foreign students and graduates by nationality, gender and field of study	Foreign student data is not currently available by field of study form Eurostat. There are also still inconsistencies in how international students are defined and counted, or not counted as is often the case. Graduate numbers are not currently collected by foreign/non-EU vs. domestic/EU basis.	Accurately estimating the contribution of non-EU students to the stock of S&Es and researchers in Europe would be important.
Quality indicator for EU universities/S&E programs	Currently, there are two main worldwide indices (the 'Shanghai Index' and the Times Higher Education Supplement rankings), which are, however, based on different criteria and give different results.	Assessing the relevance of university/program quality on e.g. enrolment rates of EU or non-EU students would be important.
3. Inward EU mobility		
Immigrants by educational background and gender	There are great inconsistencies in how immigrants are defined and counted. Some countries collect data on the educational background of immigrants, but most do not. There are some recent developments to improve data availability.	Obtaining accurate data on the flows of immigrants and their potential contribution to the stock of S&Es and researchers would be relevant.
Employment rates of immigrants by gender	There are some data on this, but not adequate enough across countries.	Obtaining such data would help in assessing the contribution of immigration to the stock of S&Es and researchers. Currently, highly educated female immigrants have greater difficulties in getting appropriate employment than their male counterparts.
Relevance of educational background of immigrants to current employment	Such data are mostly not collected.	Getting such estimates would be relevant for assessing the potential contribution of immigration to the stock of S&Es and researchers.
4. Outward EU mobility		
Data on outward mobility of S&E graduates and personnel	Adequate exit data are not currently widely collected in EU member states.	Assessing the true 'brain drain' from Europe would be important.

4.5 New technologies

Major technological shifts are difficult to predict. They could occur through the development of new generic technologies such as biotechnology or nanotechnology, in response to rapidly increasing demand for food, mineral, fibre, and energy resources, or from environmental imperatives to counteract unsustainable exploitation of the world's resources (Millennium Ecosystem Assessment, 2005). Regardless of the cause, technological shifts can increase demand for investment in research and the skills to use new technology. For example, science and technology will need to move forward in several energy related fronts (mainly to counter climate change and growing demand for oil from countries such as China and India), which will require innovation in the resource sectors and in how energy is used across all sectors.

Biotechnology is widely viewed as an emerging generic technology, although its economic impact is likely to be far less than that of ICT (Arundel, 2003). Nevertheless, the application of biotechnology to agriculture and industry could have major economic effects, in addition to social and environmental benefits. Obtaining these benefits will require a long-term research strategy, which may increasingly take place in major developing countries, rather than in the original biotechnology leaders of the US and Europe.

Shifts in technology can also result from changes in public support for research, such as the change occurring in the US through an increase in public support for life sciences, including biotechnology, and a decline in support for technology fields (engineering, physical sciences, maths and computer science). This shift in priorities is controversial, partly due to the long lag times before life sciences R&D results in commercial products (AEA, 2005).

The future growth of all types of economic activity will require materials and energy. Whereas developed countries are investing heavily in innovation, China has realised the importance of resources and is currently investing large amounts of money in the exploitation and purchase of natural resources worldwide. Growing resource scarcity is likely to produce significant rents in the future for the owners of commodities.

4.5.1 Eco-innovation scenario

A key technological shift is towards environmental or eco-innovation. Environmental innovation will make economies more efficient and sustainable by encouraging and facilitating the use of fewer material or energy inputs per unit of output. In this respect, environmental innovation replaces material inputs with. Environmental innovation and eco-technologies can thus be considered the link between the EU's sustainable development strategy and the Lisbon agenda to make the Union the world's "most competitive and dynamic knowledge-driven economy".

The main goal of this scenario was to explore and identify relevant indicators for environmental innovation that could be used to develop innovation policy for all economic sectors, as well as for the field of environmental technologies.

What makes a group of indicators generally relevant depends on how well the available *input* indicators correlate with, and are causally related to, the desired *output* indicators. Innovation input indicators usually include activities that support innovation, such as R&D, patents, or investment, and outputs include indicators on results of innovation expenditures, such as sales or profits from, or trade in innovative products. In the case of environmental innovation, we can consider additional *pressures*, for example, environmental regulation or public opinion, which may affect the level of inputs. Moreover, certain organisational or management changes can influence the level of eco-innovation inputs. We call such indicators *facilitators*. Finally, the eco-innovation output indicators relate to desired environmental *effects*, such as fewer material resources consumed, or less pollution or greenhouse gases generated.

In total, 45 potential indicators were investigated.[40] These included indicators of environmentally beneficial innovation that can take place anywhere in an economy and innovation in the environmental goods and services sector (EGSS).

The analysis identified eleven key available indicators for measuring innovation with environmental benefits (See Table 4).[41] The second part of Table 4 lists four missing indicators.

Table 4. Relevant indicators for environmental innovation

Indicator	Details	Relevance
Part I. Available indicators		
1. Pressures		
Environmental regulatory regime index (ERRI) or something similar on the stringency, clarity and stability of environmental regulations	Index data obtained from surveys on: Environmental regulatory regimes; stringency of environmental regulations; or clarity and stability of regulations. Not yet consistently available on an annual basis.	Important pressure factor, although captures only regulation related eco-innovation (but across sectors).
2. Inputs		
Eco-innovation related publications in specialized journals	Publications in 'environment/ecology' in the EU-25 per 100,000 capita.	Potentially good indicator, but mostly only captures (intentional) product innovation, and may not do so evenly.
Eco-innovation related patent counts in the EGSS, or outside it	Patent counts in the EGSS based on priority dates of patent applications (included here: environmental technology, wind energy, fuel cell technology) – national indices relative to population size used. Existing patent databases should be further developed to allow for easier access to eco-innovation related patents.	Fairly established eco-innovation indicator, which also captured diffusion, but up-to-now mostly confined to the EGSS. Also, focus only on product innovation.
3. Outputs		
Intermediate material inputs (IIM) or intermediate energy inputs (IIE)	IIM – material inputs at current purchasers' prices per GDP (NACE A to O); IIE – energy inputs at current purchasers' prices per GDP (NACE A to O). Data collection is not yet annual or EU-wide.	Also intermediate input. Measures an important factor in the eco-innovation process between inputs, outputs and effects. Captures also unintentional eco-innovation.
Exports in EU eco-industry products to large developing economies, such as China and India	EGSS exports in EU as share of total EU exports to China and India. Further refinement of EGSS product code lists or product classification systems would be important (efforts underway at the World Bank).	Potentially a good indicator, also measuring diffusion. Confined to the EGSS and product innovation.
Relative world shares (RWS), or revealed comparative advantage (RCA)	RWS – relative position of a nation in international trade in EGS (export orientation); RCA – EGS export-import ratio compared to the pattern of all traded goods.	Not as sensitive to the EGSS product code list issue discussed above. Include some measure of diffusion. Confined to the EGSS and product innovation.

[40] The 45 indicators were divided into the five different types mentioned above: pressures, facilitators, inputs, outputs and effects. The correlation analysis included 39 indicators for which there were national level data available for the EU countries (sectoral level data were in many cases not available). Pearson correlation coefficients were calculated for relationships between different types of eco-innovation indicators, e.g. between innovation pressures and inputs, or between outputs and environmental effects.

[41] These included: different types of indicators (pressures, inputs, etc); intentional and unintentional eco-innovation; intentional eco-innovation within the EGSS, but also elsewhere in the economy; and different types of innovation (product, process, etc).

Indicator	Details	Relevance
4. Effects		
Energy intensity of the economy	Gross inland consumption of energy divided by GDP, kgoe (kilogram of oil equivalent) per 1000 euro.	Important effect indicator on energy use. Measures also effects from unintentional eco-innovation. To be used as one of the key indicators.
Resource productivity of the economy	GDP per direct material consumption (DMC), euro/kg. Currently, no annual data is available.	Important effect indicator. Measures also effects from unintentional eco-innovation, as well as decoupling of economic growth from resource use.
Effects from product or process innovation in terms of reduced materials and energy per produced unit, or highly improved environmental impact	Survey data, weighted by share of innovative firms. The data are collected at a detailed sectoral level. Environmental effects are currently combined with health and safety effects in the questionnaire.	Potentially valuable indicators. These indicators should also capture unintentional eco-innovation across sectors, as well as process innovation. Further development of the CIS survey, and an improvement in response rates desirable.
Weighted emissions of greenhouse gases	Million tonnes of CO2 equivalent per capita for the EU-25.	Important effect indicator for the future. Measures also effects from unintentional eco-innovation. To be used as one of the key indicators, although a longer time lag may still be needed to see the effects from intentional eco-innovation to reduce greenhouse gases.
Weighted emissions of acidifying pollutants	1 000 tonnes of acid equivalent per GDP for the EU-25.	Important effect indicator. Measures also effects from unintentional eco-innovation, although to a lesser extent, as most pollution reductions are made to meet regulations. To be used as one of the key indicators.
Part II. Potentially relevant, but currently inadequate or missing indicators		
1. Pressures		
Venture capital for firms in the EGSS	No data currently available at the European level. There may, however, be some EU data available from European Venture Capital Association (EVCA) in the near future.	Important pressure factor, although confined to the EGSS.
2. Inputs		
Business environmental R&D, as a share of total business expenditure on R&D (BERD)	No data are available at the European level (for a large enough number of countries).	Although R&D data are generally considered far from innovation outputs, this could be a useful eco-innovation indicator, with a link to regulation. Data collection should be further developed.
3. Outputs		
Sales or profits from environmentally beneficial innovation across sectors	No data are available at an international level.	Potentially very valuable indicator, as would measure eco-innovation across sectors (including unintentional eco-innovation). Data collection should be developed. The topic could be included in the CIS.
Foreign direct investment in EGSS (outside the EU)	FDI data are only available by very aggregate sectors, and therefore identification of EGSS not possible at the moment.	Potentially a good indicator, and would also measure diffusion. However, this indicator is confined to the EGSS.

Table 4 includes recommendations for improving environmental innovation indicators. In addition, some question on eco-innovation should be added to the Community Innovation Survey. An overall recommendation is to develop indicators at the sector level.

4.6 Future challenges for a KBE – Indicator requirements

The five main structural changes described earlier in this section will influence the types of indicators that are required over the short and medium term future to track the KBE.[42]

[42] Apart from these five major structural changes, other possible factors include cultural changes with secular individualism increasingly conflicting with religious conservatism. Moreover, systems of governance could

Some of the key indicators of relevance to structural change are already available. However, there are several areas where indicators are lacking. These include:

- Organizational innovation and logistics, including value-added chains[43]
- Globalization of innovation activities
- Demand for innovative products
- The global circulation of human resources, including different types of skills
- New technologies, material and energy efficiencies

Table 5 maps some indicator requirements to track future challenges against the five main characteristics and drivers of a KBE. Indicators are marked differently depending on their availability (see note under Table 5). Additionally, Annex B offers an overview of indicators required for measuring some of the future challenges discussed in this Section, including indicators which are currently not available or require further improvement.

---

shift towards self- regulation and network management. Some of the trends towards globalization create political opposition that could alter current trends, or consumer actions might influence some outcomes. Major political upheaval in rapidly developing countries such as China or India could have substantial impacts on global value chains and the location of innovation activities. However, with the caveat that it is impossible to accurately predict the future, we suspect that the five changes outlined above will continue to affect Europe, although new trends could also develop.

[43] The fifth CIS survey (CIS 2006) and the sixth CIS survey (to be implemented in 2009) will provide data on logistics and organisational innovation.

Table 5. Indicator requirements for future challenges by the characteristics of a KBE.

Challenges	KBE characteristics				
	Production & diffusion of ICT	**Skilled human resources**	**Knowledge production: R&D & creativity**	**Entrepreneurship & creative destruction**	**Structural & organisational change**
Global production chains		*Employment effects of delocalisation of production by occupation type*	Prevalence of market differentiation strategies using industrial design and trademarks	*Spin-offs and new subsidy creation abroad by domestic firms*	*Use of consumer-supplier integrated production chains* Percent of firms by sector that have moved some production off shore (either directly or via contracting out)
Innovation strategies			Expenditures on R&D abroad *Capabilities of foreign R&D centres owned by MNES* **Innovation collaboration outside the EU (CIS)**		*Technological opportunities*
Demographic change		**Numbers of new entrants into S&E fields of study** **Re-skilling/life long learning by age cohorts**		Demand for innovative products by age cohorts (Eurobarometer) Technology use rates by age cohorts: i.e. for internet	**Employment participation rate by age and sex**
Human capital	Transfer of embodied knowledge to Europe from Europeans working abroad	Immigration and emigration of scientific, engineering and technically skilled, by age and gender Interest in science among young age cohorts by gender *International mobility indicators for the skilled*	Effectiveness of different methods of transmitting knowledge (PACE) *Mobility between public science and industry* *Educational attainment levels for innovation by sector*		
Emerging technology		Availability of skilled workers in emerging fields	Measures of growth of emerging areas: patents, bibliometrics, etc.	New firm establishment rates in developing fields	*Technological opportunities in emerging fields*

Key: **Bold** = indicators available; Normal font = One-off indicators available or data should be available for constructing an indicator; *Italics* = No indicators available or data sources unknown. Blank cells indicate that there are no current data needs, or the relationship is not relevant.

5. Policies for a knowledge-based economy

For policy makers in industrialized economies, the development of a KBE is viewed as essential for economic growth in the face of increased competition from lower cost countries in both basic manufacturing and in higher skilled services and production. European countries not only face the challenge posed by competition from these emerging countries (e.g. China and India), but also continue to face pressure from countries such as the United States and Japan, two countries identified as the major competitors in European policy documents since 1995.

In addition to existing policies to promote ICT use, R&D, and education, a broad range of policies are relevant to the goal of supporting a KBE. These include policies to promote organizational and "presentational" innovation and "soft" parameters such as human creativity (Florida, 2005) and human resource management. The goal is to develop policy based on concrete evidence. The challenges include a lack of empirical evidence for present developments in the KBE, as well as the need to address future trends and uncertainty. Good policy making must also incorporate political, economic, and cultural contexts.

A few challenges for policy development need to be taken into account. First, policy tends to focus on goals and outcomes – such as the 3% R&D intensity goal agreed in Lisbon and Barcelona - that are easy to measure because adequate data and indicators are readily available. This contrasts with a lack of data and indicators for other KBE goals. This disparity between data and indicator availability could distract the policy community from pursuing other important policies for encouraging growth in a KBE.

A second challenge for evidence-based policy is to measure the effect of government programmes on policy goals when large numbers of factors can influence outcomes. Identifying the effect of factors requires a variety of indicators, many of which may be unavailable, except as one-off indicators collected in a single survey at a single point in time. Such problems can occur for measuring a number of policies relevant to a KBE, such as promoting the use of patents and other IPR, public sector innovation or improved quality of human capital.[44]

A third challenge is that policy formulation must address the way we want our economies and society to look in the future. Consequently, policy making requires indicators of relevance to medium- and long-term goals. A key limitation with any discussion of policy is the time-lag inherent in policy formulation and implementation and in the timeliness of data and indicators to measure policy outcomes.[45] In many cases, policy is learning from the past to plan for the future.

In order to address the policy challenges of a KBE, we need to consider policy from two dimensions. First, what policies are currently in place, and are they capable of meeting current challenges? Second, can policies be designed with sufficient flexibility to adapt to possible future challenges? This section focuses on policies currently in place and evaluates the relevance of some of the key national and European policies for promoting a KBE.[46]

[44] The past decade of pro patent policies provides an example of the difficulties in assessing the effectiveness of policy. The number of patent applications has been declining, rather than increasing. Is this indicative of a failure of policy or caused by some other reason, such as changes in technological opportunities, the efficiency of IPR or the strategic value of patents to firms?

[45] For example, current indicators for scientific publications and patenting measure the effect of past R&D efforts and past policies to promote research. The time lag between research and publication is some three to five years. Thus, the effect of current policies to promote research may not be visible in the publication record for five years, and even longer for other outputs such as a new stream of innovations.

[46] The second dimension regarding future challenges was discussed in Section 4.

Policy builds on previous perceived challenges and opportunities. We therefore first review the evolution of some European policies, before looking at the differences between European, OECD and US policy responses to the five main characteristics of a KBE. We also provide a short overview of national European policies. Finally, in Section 6, we present some key findings of the interviews with policy and decision makers on needs for current and future indicators.

5.1 Evolution of European KBE policies

Apart from supporting supra-national cooperative research programmes (such as the Framework Programmes or EUREKA), the European Commission plays an important role in KBE policy through its efforts to identify relevant policies (such as in innovation, education and ICT), set EU-wide goals, and provide a forum for setting standards.

5.1.1 Innovation policy

The EU has had an official innovation policy since the 1995 Green Paper on Innovation, which has been followed by a number of revisions and new documents since then, such as the *Draft Action Plan* (2005) by DG Enterprise.

Additionally, the EU has had a policy supporting science and technology through its framework programme for two decades with the aim of fostering collaboration between European researchers. At the Lisbon Council in 2000, the foundations for a European Research Area (ERA) were finally laid, bringing the Union closer to a common science and technology policy. A report (EC, 2000) responding to the goals set by the Lisbon Council also recognised the need for relevant indicators, and consequently included the pilot edition of the European Innovation Scoreboard (EIS). The most recent EIS was published in February 2008.

The various EU plans have coalesced to form a coherent strategy to address the major issues at stake for innovation in enterprises: to develop knowledge by fostering research, to enhance entrepreneurial spirit in Europe and identify business opportunities, and finally to bring these and other elements (such as human capital, finance and innovation-friendly regulation) together to facilitate innovation in enterprises and to exploit market opportunities for innovative goods and services.

The differences in the main themes of European innovation policy since 1995 have been more of a repackaging of similar ideas than new directions. But a new development in the *Draft Action Plan* of 2005 that was not identified in previous EC documents on innovation is a focus on organisational innovation and presentational innovation, such as trademarks, brands, and design.[47] Technological innovation represents the traditional innovation perspective, but organizational and presentational innovations are new developments within innovation policy. Similarly, innovation policy has recognized the importance of innovation in the service sector and in the provision of services by both manufacturing and service sector firms.

This broadened innovation perspective could have major policy implications. Given intense competition from low-cost manufacturers in developing countries, competitive gains achievable through productivity improvements from incremental, technical innovation are declining. Conversely, the competitive capabilities of European firms could increasingly

---

[47] The *Draft Action Plan* also attaches great importance to a better regulatory environment and improvement of the market for knowledge, and it places enterprises at the centre of innovation policy. It targets all sectors including services, manufacturing and traditional sectors such as agriculture, and takes into account the all-embracing nature of innovation. It also refocuses on the importance of the diffusion of innovations, which has been down-played by the Lisbon/Barcelona target of 3% R&D intensity.

depend on far-reaching productivity gains through "soft" parameters such as organizational innovation and human resource management, and on the exploitation of presentational innovation. Presentational innovations have little to do with technical innovation per se, but they are powerful tools that enable firms to appropriate their investments in technical innovation by creating product differentiation.

5.1.2 Education policy

In Europe, education is seen as a democratic good available to all. European education policy faces three major challenges due to (1) an increase in demand for tertiary education, (2) globalization, and (3) increased competition.[48]

Increasing demand

Although the population share of the school-age cohort is stagnant or dropping in many countries in Europe, the demand for higher education is growing, as the share of adults pursuing education has increased. Education systems will also need to respond to changing economic and social conditions, such as a need for new sets of skills and life-long learning.

Increasing enrolment will create problems for European governments that fail to allocate adequate resources to tertiary education or which are reluctant to explore alternative funding mechanisms. At the same time, universities operating in a KBE will be expected to improve efficiency through reorganization and more effective management, distributing responsibilities among national, regional and local authorities.

Globalisation

The decline in the importance of geographical distance combined with increasing demand is turning higher education into an 'export' industry. A possible spin-off benefit is that the best foreign students can frequently be induced to stay, providing a remedy to the shortage of highly skilled people.

The 'export' potential of an education system depends on the quality of instruction, educational opportunities in the source country, and the ease of obtaining student visas. On the other hand, China has been working to increase educational opportunities at home, which is both reducing the number of Chinese seeking higher education abroad and attracting international students to China.[49]

Competition

Greater human mobility creates competition for the best students, research grants, and staff. Europe is ahead on some indicators, while lagging on others. For example, the output of S&T PhDs (per 1000 population) in the EU-15 between 1996 and 2000 was consistently higher than in the US or in Japan (EC, 2002a). On the other hand, the EU lags behind the US in the number of top universities, Nobel-prize winners and scientific publications.[50]

China is currently expanding its universities at a speed well ahead of India. The number of undergraduates, as well as doctorates has been rapidly increasing, with the majority of doctorate degrees awarded in engineering, natural sciences and medicine.[51] In response to higher educational levels among competitors, several European countries have set goals to increase the output of tertiary-educated individuals.

---

[48] Many of the factors that constitute major challenges for European education system were also incorporated in the scenario on the supply of S&Es, discussed in Section 4.
[49] The number of foreign students in China doubled between 1998 and 2002, reaching 86,000 students (OECD, 2004).
[50] The last of these three examples is based on the S&T Indicator Scoreboard , 2002.
[51] See Wyckoff and Schaaper, 2005.

EU policy response

The European Commission has been active in promoting:

- Skill upgrading to meet industry requirements, by promoting and developing vocational education and training in the EU[52]
- Tertiary education standards and qualifications, by improving tertiary educational attainment, access to higher education and research performance[53] [54]
- Mobility of the highly-skilled, by promoting programmes such as the Erasmus initiative to encourage young people to study in other European countries.

On the drawback side, it is not merely the supply of technically trained personnel that matter, but the match between industry requirements and the output of the higher education system. Some of the EC's proposed reforms fail to address the requirements of the private sector and instead reflect political conditions.[55]

5.1.3 ICT policy

The European policy level can help define the framework conditions for ICT and e-business development, among other things through knowledge sharing. In order for this to happen, issues such as IPR protection need to be resolved. The Commission's new initiative INNOVA encompasses innovation-financing networks, standards and innovation and cluster networks at a sectoral level (see http://www.europe-innova.org).[56]

Furthermore, the EC's perspective on e-government emphasizes the use of ICT in public services and the importance of equal access, transparency and accountability. The aim of European e-government is to provide world-class public administrations as a tool for pursuing the Lisbon strategy.

5.2 OECD and US perspectives on KBE policy

This section summarizes the OECD and US policy responses to the main characteristics of a KBE.

5.2.1 The OECD perspective

Most European national governments use the OECD's findings as a benchmark, as a tool for peer review, and to identify good practices. The OECD report *The New Economy: Beyond the Hype* (OECD, 2001a) offers a large set of policy recommendations for the KBE, which constitute the consensus view of OECD countries that will be followed by most governments. The recommendations fall into five categories, which are briefly covered below:

---

[52] A current proposal is to introduce an integrated credit system for life-long learning covering all methods of learning and providing a way of measuring and comparing learning achievements, and transferring them from one institute to another.

[53] Some EU-US comparisons: tertiary educational attainment is currently at only 21% in the EU, compared to 38% in the US, EU youth attendance is currently at 52%, compared to 81% in the US, and in the EU, only 5.5 per 1000 employees go into research, as opposed to 9.0 per 1000 employees in the US.

[54] Actions here include the Bologna process, intended to increase transparency, enhance mobility and increase competition among EU universities, a proposal to introduce a European Doctorate, intended to encourage joint education and research, and the European Qualifications Framework.

[55] Examples here include a suggested requirement of fluency in three languages for EU university students (EC, 1995), and the failure of the Commission to ensure that professional diplomas are transferable among EU member states.

[56] Other examples of EU policies for knowledge diffusion include Technology Incubator Managers, Academic Network, Proton Europe, InvestorNet and the pan-European Business Platform Gate2Growth.

- *Promotion of ICT*: increasing the use of ICT (as opposed to ICT manufacturing) to improve productivity and innovation by increasing competition; building confidence among businesses and consumers; and prioritising e-government and regulatory reform.
- *Improvement of the innovation climate*: prioritising the funding of basic research; improving the effectiveness of government funding for innovation by focusing on areas with high economic or social benefits; increasing the use of competitive funding and evaluation in supporting public research; ensuring that IPR regimes for public research strike a balance between diffusion of knowledge and its application by the private sector; and finally, removing barriers and regulations limiting effective interaction between universities, firms and public laboratories to improve the flow of knowledge and workers.
- *Enhancement of human capital*: investing in high-quality early education and childcare; improving completion rates for basic and vocational education by reducing dropout rates and improving ICT and reading literacy; improving school-to-work transition; strengthening the links between higher education and the labour market; providing wider training opportunities, particularly for adults and workers to participate in higher education; and lastly, reducing obstacles to workplace changes and giving workers a greater voice.
- *Promotion of entrepreneurship and start-ups*: promoting access to financing by reforming regulations and fiscal provisions; minimizing regulatory impediments to firm entry and exit; reviewing regularly all policies to prevent the accretion of programmes that hamper firm growth or slow the exit of uncompetitive firms; and encouraging an entrepreneurial spirit in society through education and provision of managerial training.
- *Strengthening economic and social fundamentals*: preserving macroeconomic stability; maintaining openness to trade and competition; mobilising labour resources; and addressing the redistributive implications of structural change.[57]

5.2.2 The US perspective

The Department of Commerce plays a key role in economic and business policy in the US and internationally. Its current 2004-2009 strategic work plan *American Jobs, American Values* identifies three main strategic goals: to provide the information and tools to maximize US competitiveness and enable economic growth for American industries, workers and consumers; to foster science and technological leadership by protecting intellectual property, enhancing technical standards, and advancing the measurement of science; and to observe, protect and manage the Earth's resources to promote environmental stewardship.

The following is a brief description of some of the key policies and initiatives underway in the US along the same outline as for the OECD:

- *Promotion of ICT and e-government*:[58] advocating US standards in global markets; increasing internet access across the country, including addressing access problems in rural communities and households (e.g. low income households); and increasing use of IT in small businesses.

---

[57] This last recommendation applies equally to all modern economies and contains little that is specifically relevant to a KBE.

[58] While some governments are considering e-government as a way of putting forms in another format, the US is intent on using the technology to its fullest potential to provide a wide range of services and information to citizens. The US 'E-Government Act of 2002' is intended to establish a comprehensive framework for information and security standards for government services.

- *Improvement of the innovation climate*: promoting opportunities for US companies abroad, establishing regional competitiveness to stimulate economic development; providing funding for technical assistance to regions for the formulation of innovation-based economic development strategies; coordinating and consolidating workforce development programs with economic development initiatives to drive innovation-based economic growth; ensuring growth in innovation by providing additional funding to train workers for jobs in industries that are creating jobs; and finally, increasing federal R&D funding.
- *Enhancement of human capital*: increasing funding for colleges for training workers in demand; encouraging SMEs to use ICT for flexible and low cost training; issuing more permits to bring in highly skilled foreign scientists, engineers and managers; ensuring that children are 'not left behind' by improving primary and secondary school attendance and by raising the level of education and children's interest in education; and improving student achievement by replacing a culture of compliance with a culture of achievement.
- *Promotion of entrepreneurship and start-ups*: increasing use of IT in small businesses; making the government 'friendlier' to small businesses; setting up Small Business Administration to help businesses; setting up offices for female entrepreneurs; promoting venture capital by facilitating access to private capital and lastly creating a business gateway website to provide access to federal agencies.
- *Strengthening of economic and social fundamentals*: shifting the Federal system for community assistance from providing economic development assistance to providing results-oriented competitive grants; promoting access to and expansion of ICT and telecommunications to the benefit of education, health and welfare both in the US and around the world, including cooperating with international agencies, eliminating unnecessary regulations overseas and supporting the privatization of state-owned firms.

One of the strengths of current US policy is the determination to advance policy through horizontal cooperation. The above policy initiatives and actions describe a federal government that is consolidating and repositioning itself for a KBE.

5.3 The national policy context within Europe

The evolution of national policies vary in coherence and focus. In the 1980s, national innovation policies often focused on supporting a few innovative leaders or 'national champions' via direct economic subsidies for R&D. During the 1990s, innovation policies in many EU countries shifted in response to three factors: (1) the need to reduce direct R&D subsidies to firms both for budgetary reasons and to satisfy European competition policy, (2) the adoption of evolutionary theories and system views of the innovation process and (3) the widespread conviction that European firms failed to translate European strengths in basic research into economically successful innovations (the European 'paradox').

From the late 1990s until 2003, KBE policy in many EU countries has gone through a period of readjustment to bring policies for the private and public sectors into alignment, by partly increasing support for technology-specific networks and clusters and through a concerted effort in many EU countries to increase linkages between the public research sector and private firms.

The discussion below of some of the main types of policies currently in use in the EU is structured around the five main characteristics, or drivers, of a KBE.[59] Section 5.4 explores another key issue of relevance to KBE policies: do countries share similar national innovation systems?

5.3.1 ICT investment and use

ICT policies have evolved over the last decade from policies to promote the adoption of IT to more nuanced policies, including the support of internet related activities. ICT is increasingly seen as a driver for innovation not only in operations, but for organizational innovation.[60] As an example, e-business provides a pathway to innovation and productivity improvements by providing new ways of doing business. It also creates new opportunities in presentational innovation.

Only the Scandinavian countries currently have integrated policies to promote e-business. Although innovations in e-business can both improve the outputs of the R&D process and provide a tool for investment and modernization of SMEs, most European countries distinguish between these two aspects of innovation. The result is two different policy sets, typically dealt with by two different ministries.

5.3.2 Human resources

Most European countries are currently trying out different solutions to funding an increasingly crowded public tertiary education sector. National governments face the dilemma of either restricting access or increasing funding. Restricting access to S&E programmes will conflict with European goals to increase R&D levels and competitiveness within a KBE. New ways of funding tertiary education include introducing student fees, forging partnerships with private enterprises, or possibly improving efficiency through promoting mergers between universities. The result of current trends might be a new European educational structure with a few elite research institutions and a range of more specialized ones. However, policies on higher education differ among the European countries. Presently, four main policy initiatives are in use in the EU-25: life-long learning programmes; methods to increase the domestic supply of scientists and engineers; immigration policies to attract highly skilled immigrants; and support for post-docs.

5.3.3 Knowledge production

All EU national governments support knowledge production through direct or indirect (tax instruments) policies to support R&D, both in the public and private sector. In addition, there are three other types of national policies of relevance to knowledge production: policies to improve the innovative capabilities of firms, usually SMEs that lack internal research capabilities; policies to support research collaboration between private firms; and programmes to encourage linkages between the public research sector and private firms.

5.3.4 Entrepreneurship and creative destruction

Programs to support entrepreneurship include subsidies for venture capital and educational programs to support entrepreneurial and business training in engineering and science faculties as part of a wish to build a culture of entrepreneurship.

---

[59] A major source for the identification of relevant national policies is the INNO-Policy Trend Chart website (http://www.proinno-europe.eu/trendchart). Many examples of relevant policies can be found in the TrendChart report *Innovation Policy in Europe 2004* (TrendChart, 2004), available at http://www.trendchart.org/annualreports/report2004/Innovation_policy_europe_2004.pdf, or in the KEI work package 1 sub report WP1.3 on KBE policies.

[60] See Marwaha et al, 2005.

Policymakers in Europe are aware of the need for entrepreneurship and increased efficiency in start-up promotion and financing of new business ventures. There has been a notable success for start-ups, with European start-up formation by universities exceeding that of the United States. The problem is that there are no data for tracking the growth of start-ups.

On the assumption that private venture capital cannot meet demand due to information asymmetries, several countries subsidize venture capital, for example, Sweden, France and Italy.

The issue of creative destruction is sensitive in a Europe marked by structural unemployment. The not yet mature ICT sector might prove a wise place to start. For productive and profitable use of ICT, wide-ranging changes in the organisation, management and location of activities are needed. This would involve the entry and exit of firms as well as the hiring and firing of labour. A UK report entitled 'i2010 – Responding to the Challenge'[61] recommends the implementation of e-government initiatives that focus on the *quality* of services to promote ICT use, rather than the *quantity* of services offered.

5.3.5 Structural and organizational change

Despite the importance of organisational innovation for business survival in a competitive environment, there are few national policy initiatives in this area. The most widespread organisational innovation is the introduction of teamwork, as well as the ISO9000 organisational standard. In addition to organisational innovations such a Total Quality management, Just-In-Time, and Customer Service Management systems, there is a need for national policy support for the implementation of organisational solutions to the challenges of increasing globalisation. Again, the level of awareness varies among the different members states.

5.4 National innovation systems

The direct function of government and policy makers to influence national innovation system (NIS)[62] is through policy formulation and resource allocation, specialized advisory functions, and regulation.

With 27 member states, The European Union by definition has 27 unique national innovation systems. Although each NIS is unique, European member states share similar characteristics and innovative capabilities.[63] Given these similarities, it should be possible to identify policy mixes that should function reasonably well among countries with a similar NIS.

Using national data on factors related to innovation capabilities, a recent TrendChart report used cluster analysis to classify EU member states into four similar groups, which are approximately ranked in order of innovative performance (see Table 6).[64] The analysis is based on indicators that are relevant to all five of the main KBE characteristics.

[61] This report was for the i2010 conference held in London in September 2005, as the main ICT strategy event during the UK's Presidency of the EU.
[62] The phrase 'national innovation system' (NIS) refers to the interactions among participating institutions, organisations and firms within a country. A NIS encompasses both cooperative and competitive interactions. Within a NIS there is no single entity with the power to control the workings of the system, but there are many which exert significant influence.
[63] For example, countries share similar industrial structures (e.g. tourism and agriculture in Portugal and Greece, or advanced ICT manufacturing in Finland and Sweden) or preferred innovation modes (e.g. in-house R&D in Finland and Sweden, or innovation through acquired technology in Portugal and Greece).
[64] This clustering is different from the one done for the S&E supply scenario discussed in Section 4.4.1.

Table 6. Trend Chart cluster results for innovation

Cluster description	EU countries within cluster
Leaders	Finland, Sweden, Denmark
Intermediate (followers)	Austria, Belgium, Netherlands, UK, Germany, France, Italy
Trailing	Spain, Lithuania, Slovenia, Czech Republic, Hungary, Slovakia
Laggards	Estonia, Greece, Latvia, Poland, Portugal

Source: Innovation Strengths and Weaknesses, European Trend Chart on Innovation, 2005, available at http://www.trendchart.org/scoreboards/scoreboard2005/pdf/EIS 2005 Innovation Strengths and Weaknesses.pdf

Peer countries can share many similar features that are of relevance to policy:

1. The leading group of countries share characteristics such as highly educated populations, high levels of social cohesion, above average levels of high tech value-added, and creative, R&D based innovation. They also share similar approaches to policies, such as an integrated approach to innovation and education policy and a stress on collaboration and life-long learning.

2. The intermediate or follower countries are a more diverse group, in terms of their industrial structures and approaches to innovation. In respect to policy, the main difference with the leading countries is greater difficulty in developing integrated policy approaches to the demands of a KBE, which could be why there is greater variation in performance on the factors included in the cluster analysis. The lack of integrated policy approaches is partly due to the economic complexity of the larger EU member states (all of which are in this cluster).

3. The trailing countries, including many of the new member states, have invested in public infrastructure, education and public-sector R&D, but are still lagging well behind on private sector activities of relevance to a KBE, such as business R&D, innovation and entrepreneurship. They consequently face a major policy challenge in getting private firms to invest in training, innovation, ICT adoption, and organisational changes.[65]

4. The laggard countries differ from the trailing countries by a tendency to perform poorly on both public and private sector characteristics of importance to a KBE.

Identifying countries that share similar characteristics can help guide the development of suitable policies and targets over the short and medium term. Sound indicators on national innovation characteristics are essential for assisting policymakers. As an example, policies to support the Barcelona 3% R&D intensity target must take differences in industrial structure into consideration.

The long-term perspective is a different matter. Here, the goal of policy might be to encourage shifts in industrial structure. The ability of lagging countries to develop new economic sectors where firms compete on the basis of innovation will depend on structural factors such as the educational level of the population, the level of interest in science and technology, the availability of capital, and incentives to start small innovative businesses The most appropriate policy mix will depend on the industrial structure as well as on other economic and political factors that influence innovation opportunities.

[65] Many of the new member states are in the process of developing policies of relevance to a KBE. Consequently, it may be too early to assess the relevance of policies in many of these countries.

6. Current and emerging policy needs and priorities

A total of 40 interviews were conducted in 2007 to assess policy and user needs for KBE indicators and to help identify new and improved indicators for emerging policy challenges. The interviews targeted policy analysts both inside and outside the EU. The analysts were involved with policy coordination, implementation or evaluation.

The results of the interviews indicated that, overall, current indicators related to innovation are not adequate, partly because of issues to do with timeliness, detail or international comparability, but partly also because of the changing needs for indicators for a KBE. The interviewees also recognised a certain lack of a 'bigger picture', i.e. indicators remain a 'bunch of unconnected dots on a drawing board'.

The greatest need for new indicators concerned:

- Innovation flow (e.g. indicators on innovation capabilities, adoption and diffusion of innovation),
- Economic impact of innovation (e.g. indicators on the impact of subsidies or tax exemptions),
- Innovation collaboration (e.g. indicators on linkages, networks and clustering),
- Human resources (e.g. better indicators on mobility, gender, life-long learning, financing of researchers, graduate job markets),
- Social impact of innovation,
- Security issues (e.g. how do tighter immigration policies affect international HR mobility?),
- Role of consumers in the innovation process,
- Venture capital,
- Organisational innovation,
- Changing nature of research: convergence of different scientific fields (e.g. how is this affecting the outputs from research?).

The economic sectors in need of better indicators (and better classification systems) were identified as:

- Services, including indicators on e-government and e-health, among others,
- Biotechnology and nanotechnology,
- Energy and environmental technology,
- ICT (more indicators on use and impact in firms and households).

Finally, the interviewees hoped for better indicators to measure the effectiveness and impact of innovation policies.

7. Conclusions

The design of successful policies to encourage a KBE requires data and indicators for new challenges, such as the impact of an ageing workforce, globalisation, rising imports and rising job insecurity. The rapid integration into the world trading system of China and India, with their huge pools of low-wage labour, and the recent enlargement of the European Union have fuelled fears of further job losses, as global competitive pressures increase.

There are many possible responses to competition, including developing new products, product differentiation, branding, improved design, and efficiency gains from technological and organisational change. All of these methods entail some degree of innovation (OECD, 2005b). The ability to innovate relies upon the health of the economic environment (availability of skilled labour, R&D funding, tools for commercialisation) that is nurtured and facilitated by the policy environment, which in turn is informed and guided by indicators.

Certain aspects of the KBE are already covered by a rich set of indicators from established surveys. These include indicators of business performance, R&D activities, and patents. These and other indicators are used to evaluate causal relationships between investment and economic performance and growth.

Other aspects of indicator development for a KBE are in their infancy, such as composite indicators based on summarizing several component indices. Composite indices can be used to generate a 'constellation' of events (ABS, 2003). A group of indicators can 'collectively' give early warning signals, while also reducing complex data sets in a way that can help users to better understand the relationships among the factors in the KBE. The review of KBE characteristics and drivers points to the need to revisit existing composite indicators as well as the need to develop new composite indices.[66] If we go back to the notion of a 'constellation' of indicators, we can consider the 'night sky' of a KBE. Some 'stars' (indicators) are constant in illuminating a picture, others flare up and gain more attention while yet others burn out and no longer play an important role. In the KBE, different segments of the economy grow or decline, different players gain or lose their importance, emerge or disappear. Ways of learning, producing and exchanging knowledge are different than in previous economies and continue to change. While the role of ICT in the KBE is undeniable, it is the reconfiguration of economic, social and political relationships that needs indicator development.

The interviews with policy analysts show that indicators are often seen more as a bunch of dots that remain unconnected on a drawing board – or to continue with our previous analogy, the actual constellation patterns in the night sky are not yet visible. The challenges include understanding the process and interactions of the system of innovation, and developing indicators and measures that can connect the individual dots or stars.

[66] Of note, the value of a composite index depends on the quality of the component indicators, which can suffer from the limits of data collection, in particular timeliness and consistency of scope and coverage. Composite indices can also suffer from the 'black boxing' problem, in which issues with comparability and accuracy with the original data become invisible (Godin, 2005). Another problem is that the name of a composite indicator can remain the same, even as the component indicators change over time. This can lead to inaccurate interpretation by unwary readers. As an example, almost half of the indicators in the European Innovation Scoreboard have changed between 2001 and 2007.

References

AEA (American Electronics Association). 2005. *Losing the comparative advantage? The challenge for science and technology in the US,* AEA, Washington DC.

Arundel, A. 2003. Biotechnology Indicators and Public Policy. *STI Working Paper 2003/5*, OECD.

Arundel, A., Colecchia, A., and Wyckoff, A. 2006. Rethinking science and technology indicators for innovation policy in the 21st century. In Earl L. and Gault F. *Innovation and Impacts: The Next Decade.* Edward Elgar, Cheltenham, pp. 167-198.

Atkinson, R. and Coduri, R. 2002. *The 2002 State New Economy Index: Benchmarking Economic Transformation in the States*. Progressive Policy Institute, Washington DC.

Australian Bureau of Statistics (ABS). 2002. Measuring a Knowledge-based Economy and Society: An Australian Framework. *Discussion Paper No. 1375.0,* Commonwealth of Australia, Canberra.

Australian Bureau of Statistics (ABS). 2003. *Australian Economic Indicators, 2003. Cessation of the Composite Leading Indicator*.

Beckstead, D. and Gellatly, G. 2004. *Are Knowledge Workers Found Only in High-technology Industries?*, The Canadian Economy in Transition Series, Statistics Canada.

Beckstead, D. and Vinodrai, T. 2003. *Dimensions of Occupational Changes in Canada's Knowledge Economy, 1971 -1996*, Statsistics Canada.

Beise, M. 2001. *Lead markets: country specific success factors of the global diffusion of innovations*, ZEW Economy Studies 14, Physical Verlag, Heidelberg.

Blanchard, O. 2004. The Economic Future of Europe, *NBER Working Paper 10310*, NBER, Cambridge Mass.

Brewer, Laura. 2004. *Youth at Risk: The Role of Skills Development in Facilitating Transition to Work*, InFocus Programme on Skills, Knowledge and Employability.

Brynjolfsson, E., and Hitt, L. M. 2000. Beyond Computation: Information Technology, Organizational Transformation and Business Performance. *Journal of Economic Perspectives,* 14(4): 23-48.

Brynjolfsson, E., Renshaw, A. and Alstyne, M. V. 1997. The Matrix of Change, *Sloan Management Review*, Winter.

Burt, E. and Taylor, J. 1999. *Information and Communication Technologies: Reshaping the Voluntary Sector in the Information Age?*, Centre for the Study of Telematics and Governance, Glasgow Caledonian University.

Calvert, J., Ibarra, C., Patel, P. and Pavitt, K. 1996. *Innovation Outputs in European Industry: Analysis from CIS. EIMS report 93/52,* European Commission.

Cap Gemini. 2005. *Online Availability of Public Services: How is Europe Progressing?* European Commission: DG Information Society and Media.

Coriat, B. and Weinstein, O. 2002. Organizations, firms and institutions in the generation of innovation. *Research Policy* 31:273-290.

Council of Europe. 2005. *Social Cohesion: A Priority for the Council of Europe*.

Cowan, R. and Jonard, N. 2004. Network structure and the diffusion of knowledge. *Journal of Economic Dynamics and Control*, vol 28(8), pp: 1557-1575.

Cowan, R., Paul, D. and Foray, D. 2000. The Explicit Economics of Knowledge Codification and Tacitness, *Industrial and Corporate Change*, vol 9(2), pp. 211-253.

DeVol, R., Koepp, R., and Ki, J. 2004. *State Technology and Science Index: Enduring Lessons for the Intangible Economy*. Milken Institute.

DG Enterprise. 2004. The European Innovation Scoreboard 2004, DG Enterprise, Brussels.

DG INFOS. 2003. *SIBIS: Statistical Indicators Benchmarking the Information Society*. Luxembourg.

Dobson, J., Koser, K., Mclaughlin, G. and Salt, J. 2001. *International Migration and the United Kingdom: Recent Patterns and Trends*.

Dosi, G., Llerena, P. and Labini, M. S. 2005. Science-Technology Industry Links and the European Paradox: Some Notes on the Dynamics of Scientific and Technological Research in Europe. *Working Paper, Santa Anna School of Advanced Studies*, Pisa, January.

Drolet, M. 2000. The Persistent Gap: New Evidence of the Canadian Gender Wage Gap. *Analytical Studies Research Paper Series*, 11F0019MIE2000157. Ottawa: Statistics Canada.

ECOFIN. 2005. Increasing Growth and Employment in Europe. *Cover note by the Council (ECOFIN) to the European Council on the 2005-2008 BEPGs*, June 7.

European Commission. 1995. White Paper on Education and Training – Towards the Learning Society, (COM(95) 590).

European Commission. 2000. *Innovation in a knowledge-driven economy*. Communication from the Commission (COM(2000) 567).

European Commission. 2001. IST, eWork 2002, *Status Report on New Ways To Work in the Knowledge Economy.*

European Commission. 2002a. *Key Figures 2002*. Brussels: DG Research.

European Commission. 2002b. *Towards a knowledge-based Europe. The European Union and the information society.*

European Commission. 2003a. *Choosing to grow*: *Knowledge, innovation and jobs in a cohesive society*, p. 4.

European Commission. 2003b. *Third European report on science and technology indicators 2003 – Towards a knowledge-based economy*. Brussels: DG Research.

European Commission. 2005. *Key Figures 2005 – Towards a European Research Area: Science, technology and innovation*. Brussels: DG Research.

Evangelista, R., Sandven, T., Sirilli, G. and Smith, K. 1997. Innovation Expenditures in European Industry. *STEP Report R-05*, STEP, Oslo.

Florida R. 2005. *The Flight of the Creative Class.* Harper Business, New York.

Godin B. 2004. The new economy: what the concept owes to the OECD. *Research Policy* 33:679-690.

Godin B. 2005. *Measurement and Statistics on Science and Technology*. Routledge, London.

Gordon, R. J. 2000. Does the "New Economy" Measure up to the Great Inventions of the Past?, *Journal of Economic Perspectives* 14(14): 49-71.

Greenwood, J. 1997. *The Third Industrial Revolution: Technology, Productivity and Income Inequality*, AEI Studies on Understanding Inequality, Washington, DC. The AEI Press. Also, printed in the *Economic Review*, 1999, Federal Reserve Bank of Cleveland. http://www.econ.rochester.edu/Faculty/GreenwoodPapers/third.pdf

Harfi, M. 2004. *International mobility of doctorate holders: Trends and issues at stake*. Report for an OECD workshop held on 27 September on user needs for indicators on careers of doctorate holders, DSTI/EAS/STP/NESTI/RD(2004)25. Paris: OECD.

Haupt, A. and Janeba, E. 2004. Education, Redistribution, and the Threat of Brain Drain. *NBER Working Papers 10618,* National Bureau of Economic Research.

Hollanders, H. and Ter Weel, B. 2002. Technology, Knowledge Spillovers and Changes in Employment Structure: Evidence from Six OECD Countries; *Labour Economics*, 9(5): 579-99.

ILO. 2000. *Employment and Social Protection in the Informal Sector*.

ILO. 2003. *Learning and Training for Work in the Knowledge Society*.

IM/IT Canada. 2002. *Strengthening Voluntary Sector Capacity Through Technology*. Report of the Joint Table on Information Management/Information Technology of the Voluntary Sector Initiative. Industry Canada.

Inno Metrics 2008. *European Innovation Scoreboard 2007. Comparative Analysis of Innovation Performance*, DG Enterprise, Brussels, February.

Keita, N. 2004. White Paper on International Trade 2004 – toward a new value creation economy, *Japan Spotlight*, pp 6-18.

Kofman, E. 2003. *Woman Migrants and Refugees in the European Union*, presented at EU-OECD conference, Brussels.

Kok, W. (chair) High Level Group. 2004. *Facing the Challenge: The Lisbon Strategy for Growth and Employment*, European communities, Luxembourg.

Krugman, P. 1979. A model of innovation, technology transfer, and the world distribution of income. *Journal of Political Economy* 87:253-266.

Lam, A. 1998. Tacit Knowledge, Organisational Learning and Innovation: A Societal Perspective. *DRUID Working Papers 98-22*, DRUID, Copenhagen Business School, Department of Industrial Economics and Strategy/Aalborg University, Department of Business Studies.

Landry, R., Amara, N. and Lamari, M. 2000. *'Does social capital determine innovation? To what extent?'*, mimeo, Departement de science et politique, Université de Laval, Quebec.

Layard, R. 2003. *Lionel Robbins Memorial Lectures*, London School of Economics, March 3-5.

Lundvall, B.-A., Johnson, B. 1994. The learning economy, *Journal of Industry Studies*, Vol. 1 No.2, pp.23-42.

Machin, S, and Van Reenen, J. 1998. Technology And Changes In Skill Structure: Evidence From Seven OECD Countries, *The Quarterly Journal of Economics*, 113(4): 1215-1244

Marwaha, S., Seth, P., and Tanner, D.W. 2005. What global executives think about technology and innovation," in *McKinsey on IT*, No. 5.

Menzies, C. H. 1998. *Discussion paper for the Women and the Knowledge-Based Economy and Society Workshop*, commissioned by the Policy Analysis and Development and External Relations Directorate, Status of Women Canada.

Millenium Ecosystem Assessment (MA). 2005. *Millenium Ecosystem Assessment Synthesis Report*, United Nations Environment Program, New York.

Naumanen, M. 2004. Comparing Technological and Scientific Development: The knowledge society development barometer. *Tijdschrift voor Arbeidsvraagstukken* 20:323-335.

Nelson, R. N. 1989. What Is Private and What Is Public about Technology? *Science, Technology, & Human Values,* Vol. 14 (3), pp. 229-241.

OECD. 1996. *The Knowledge-based Economy*, OECD/GD (96)102.

OECD. 2001a. *The New Economy: Beyond the Hype*, OECD, Paris.

OECD. 2001b. *The well-being of nations: the role of human and social capital*. OECD, Paris.

OECD, 2002. *OECD Employment Outlook*, OECD, Paris.

OECD. 2003a. *Education at a Glance*. Paris: OECD.

OECD. 2003b. *Science, Technology and Industry Scoreboard*. Paris: OECD.

OECD. 2004. *Internationalisation and trade in higher education: Opportunities and challenges.* Paris: OECD.

OECD. 2005a. *Cities and Regions in the New Learning Economy*. OECD, Paris.

OECD, 2005b. *Oslo Manual*: Third revision. OECD, Paris.

Parker, S. 2005. The economics of entrepreneurship: What we know and what we don't. *Discussion papers on Entrepreneurship, Growth and Public Policy*, Max Planck Institute, Jena.

Patel, P., Hopkins, M., Arundel, A. 2008. *Sectoral Innovation Systems in Europe: Monitoring, Analysing Trends and Identifying Challenges for Biotechnology*. Europe Innova, DG Enterprise, Brussels.

Pisano, G. 2006. *Science Business: the Promise, the Reality and the Future of Biotech*. Harvard Business School Press, Boston.

PPI (Progressive Policy Institute). 1999. *The State New Economy Index*. PPI, Washington DC.

PPI (Progressive Policy Institute). 2002. *The State New Economy Index*. PPI, Washington DC.

Puga, D. and Trefler, D. 2007. Wake Up and Smell the Ginseng: International Trade and the Rise of Incremental Innovation in Low-Wage Countries. *Centro Studi Luca d'Aglaino Development Studies Working Paper No. 222.* Social Science Research Network (http://ssrn.com/abstract=964158*).*

Ritzen, Jo, 2001. Social Cohesion, Public Policy, and Economic Growth: Implications for OECD Countries. In *The Contribution of Human and Social Capital to Sustained Economic Growth and Well-Being.* International Symposium Report (J. F. Helliwell and A. Bonikowska, eds.). OECD and Human Resources Development, Canada. (http://www.hrdc-drhc.gc.ca/arb)

Room, G. 2004. The scope of the new economy. *NESIS Final Report*, pp 220-227.

Sanders, M. and Ter Weel, B. 2000. *Skill-biased technical change: A theoretical framework and a survey of the evidence,* MERIT RM 2000-012.

Schaaper, M. 2004. An emerging knowledge-based economy in China? *Indicators from OECD databases. STI Working Paper 2004/4*, OECD, Paris, March.

Smith, K. 2002. *What is the Knowledge Economy? Knowledge Intensity and Distributed Knowledge Bases*, INTECH Discussion Paper Series 2002-6, INTECH, Maastricht.

Sonntag, V. 2003. *Speed, Scale and Sustainability. An Inquiry into Technological Momentum and the Strategic Use of Advanced Manufacturing Technologies*, PhD, Faculty of Economics and Business Administration, Maastricht University, Maastricht, the Netherlands.

Teichler, U. 2002. Graduate employment and work in Europe: Diverse situations and common perceptions. *Tertiary Education and Management*, 8, pp. 199-216.

Ter Weel, B., and Kemp, R. 2000. *The Dutch Labour Market and the New Economy*, paper for PATHWAY project, MERIT, Maastricht.

The Conference Board (Europe). 2005. *Changing Perceptions*.

TrendChart. 2003. NIS indicators and innovation: Are there European modes of Innovation? *Trend Chart Technical Report 5*.

TrendChart. 2004. *Innovation Policy in Europe 2004*. Brussels: European Commission, DG Enterprise and Industry.

TrendChart. 2005. Innovation Policy in Europe. *Innobarometer 2005*. http://trendchart.cordis.lu/scoreboard2005/innobarometer.cfm

United Nations, 2003. *E-government at the crossroads - World public sector report*. New York: UN.

US Census Bureau. 2004. *Evidence from Census 2000 About Earnings by Detailed Occupation for Men and Women*, CENSR-15.

van Welsum, D. and Vickery, G. 2004. *Potential off-shoring of ICT-intensive using occupations*, DSTI/ICCP/IE (2004)19, OECD, Paris.

Vinodrai, T., Gertler, M., Lambert, R. 2007. Capturing design: Lessons from the United Kingdom and Canada, In *Science, Technology and Innovation Indicators in a Changing World*, OECD, Paris, pp. 65-86.

von Hippel, E. 2005. *Democratizing Innovation.* Cambridge, Mass.: The MIT Press.

Wickramasekara, P. 2003. *Policy responses to skilled migration: Retention, return and circulation*. Geneva, ILO.

Wolf A. 2005. *The Service Economy in OECD Countries*, OECD.

World Bank. 2002. *Lifelong Learning in the Global Knowledge Economy: Challenges for Developing Countries*. World Bank.

Wyckoff, A. and Schaaper, M. 2005. *The Changing Dynamics of the Global Market for the Highly Skilled*. Paper prepared for Advancing Knowledge and the Knowledge-Economy Conference, held at the National Academy of Science, Washington DC, 10-11 January.

Zysman, J. 2004. *Creating value in a digital era: How do wealthy nations stay wealthy?* Mimeo.

Annex A - KBE indicator needs for future development

- Measuring ICT (e.g. for productivity and other measures)
  - Produce separate set of indicators for ICT producing sectors, ICT using sectors, and ‘borderline’ ICT users
- Innovation
  - Indicators for business and consumer demand for innovations
    - Measure of value for consumer — for consumer demand/consumer patterns
    - Number and type of interactions with consumer and supplier (e.g. use of new technologies and new practices)
  - Globalization of innovative activities — type, frequency
    - Work structure and organizational change
  - How are workers’ responsibilities actually being altered or added to — indicators on work activities.
  - To what extent is delocalisation of production taking place? What type of activities are moving off-shore — types of jobs and occupations — to develop indicators on employment such as:
    - unemployment that may be expected
    - types of skills being sought off-shore (low-skill or high-skill, field of expertise)
    - occupation
    - employment status (salaried employees or consulting firms)
    - salaries according to employment (occupation, responsibilities, gender)
  - E-work — extent of use; costs and benefits to business
  - Measuring workers’ task-specific skills and decision-making/problem-solving skills — what do companies use, what will they need?
  - Scientific base of industries (field of specialization of work force to field of science and research)
  - Type and volume of outsourcing (e.g. ICT and ICT-driven)
  - Level of social capital in the business community (e.g. trust and participation in networks)
- Knowledge management
  - Number and type of practices to codify employee knowledge
  - The extent to which companies are building useable knowledge base by codifying knowledge of workers
- E-government services — types of services; business and citizen participation
  - Percent of citizens using the internet to interact with public authorities
  - Types of services, frequency of use
  - Growth of public services on-line
- E-education and e-training — business and citizens
  - Indicator on changes to skills and knowledge of individuals (e.g. gained through on-the-job training and life-long learning)
  - Impact results of e-learning (for individual and business)
- The KBE and citizens
  - Lifelong learning — participation rate
  - E-government services — type and volume measures
  - E-transparency – changes between relationship of government and citizens

    - E-work and its impact on work and home life (disappearing boundaries – citizens better or worse off – time use)
    - ‘happiness’ measures/satisfaction scale
    - social cohesion measures
        - youth unemployment in the KBE
        - under-employment – waste of skills and segments of the population (e.g. immigrants with training under-employed)
- Foreign direct investment and MNEs
    - effect on researchers’ work force (e.g. increase in demand; expansion of local skills; access to international network);
    - is it being used to develop innovative capabilities or to adapt products to markets
    - multinational R&D work force (e.g. such as in the US)
- Scientific, technical and engineering personnel (STE personnel)
    - International mobility
        - Timing and its impact (e.g. at what stage in a researcher’s career is benefits of mobility optimal – beginning of career or mid-career?);
        - Factors that trigger outflows and inflows;
        - Costs and benefits to supply country (e.g. networking, diaspora, career opportunities, access to international research teams/networks);
        - Timely indicators of barriers to intra-Europe and international mobility
        - Mechanisms for international mobility
        - Characteristics of internationally mobile STE personnel (age, gender, country of origin and so on)
        - Return rate of mobile STE personnel
    - Occupation mobility of scientific, technical and engineering (STE) personnel
    - Sector mobility (e.g. university to private sector) of SE personnel
    - Knowledge base of sectors (e.g. as measured by composite indicators such as relating field of specialization to business activity)
    - Comparative advantage of skill sets (e.g. adaptability, mobility)
    - Globalization of science — global research teams
    - Indicators on technically skilled personnel (e.g. below university degree)
    - Women and research – impact of ICTs for mobility and family
- Environment and the KBE
    - Impact of ICTs
        - Tele-working – measures for reduction of use of energy
        - Printing and publishing – progress to paperless office.

Annex B – Indicators for measuring some KBE challenges

	Available indicators	Missing or inadequate indicators
A. Entrepreneurship		
		• Spin-offs and new subsidy creation abroad by domestic firms • Technology use rates by age cohorts: e.g. for internet • New firm establishment rates in developing fields
B. Environment (eco-innovation)		
	• Energy intensity of the economy - Gross inland consumption of energy divided by GDP • Environmental regulatory regime index (ERRI) or something similar on the stringency, clarity and stability of environmental regulations • Exports in EU eco-industry products to large developing economies, such as China and India (as share of total exports to these countries) • Intermediate material or energy inputs (IIM and IIE) at current purchasers' prices per GDP • Publications in specialized journals in 'environment /ecology' in the EU per capita • Patent counts in the EGSS or outside it • Relative world shares (RWS) – relative position of a nation in international trade in EGS (export orientation), or revealed comparative advantage (RCA) – EGS export-import ratio compared to the pattern of all traded goods • Resource productivity of the economy – GDP per direct material consumption (DMC) • Survey data on the effects from product or process innovation in terms of reduced materials and energy per produced unit, or highly improved environmental impact • Weighted emissions of acidifying pollutants per GDP • Weighted emissions of greenhouse gases per GDP	• Business environmental R&D, as a share of total business expenditure on R&D (BERD) • Foreign direct investment in EGSS (outside the EU) • Sales or profits from environmentally beneficial innovation across sectors • Venture capital for firms in the EGSS
C. Human resources		
	• Population with tertiary education per 100 (aged 24 to 65)	• Age distribution of HRST, S&Es and researchers

	Available indicators	Missing or inadequate indicators
	• Unemployment rates for HRST	• Availability of skilled workers in emerging fields
	• Average exit age from the labour force	• Educational background of researchers
	• EU nationals holding temporary H-1B visas in the US	• Employment effects of delocalisation of production by occupation type
	• Number of scientists and engineers graduating annually in the US, China and India	• Employment rates of immigrants by gender
	• Re-skilling/life long learning by age cohorts	• Further careers of EU graduates – e.g. in 1, 5 and 10 years after graduation
	• Numbers of new entrants into S&E fields of study by gender (at ISCED level 5a)	• Further careers and locations of non-EU graduates
	• Numbers of foreign students by nationality and gender	• Immigration and emigration of scientists and engineers, by age, gender, and educational background
	• Numbers of mature students by educational field/age and gender	• Relevance of educational background of immigrants to current employment
	• Numbers of foreign graduates by gender and field of study	• Transfer of embodied knowledge to Europe from Europeans working abroad
		• High school pupils studying S&E subjects by gender and by breakdown to ISCED levels 3a, b and c
		• Interest in science among young age cohorts by gender
		• Quality indicator for EU universities/S&E programs
		• Survival rates in education by field of study and gender
		• Numbers of foreign students by field of study
		• S&E students at the ISCED level 6 (PhD)
		• Numbers of foreign graduates by nationality
		• Numbers of mature students by educational field, *and* age and gender
D. Knowledge production: R&D & creativity		
	• Innovation collaboration outside the EU	• Capabilities of foreign R&D centres owned by MNES
	• Euro creativity index	• Educational attainment levels for innovation by sector
		• Measures of growth of emerging areas: patents, bibliometrics, etc.
		• Mobility between public science and industry
		• Prevalence of market differentiation strategies using industrial design and trademarks

	Available indicators	Missing or inadequate indicators
		• Expenditures on R&D abroad • Effectiveness of different methods of transmitting knowledge (PACE)
E. Markets & innovation demand		
	• Breadth of international markets • Degree of customer orientation • Extent market dominance • Intensity of local competition • Demanding regulatory standards • Government procurement for advanced technology products • Broadband penetration rate • Buyer sophistication • Fertility / birth rates • Gender empowerment measure • Youth share of the population	• Ability of firms to use foreign markets to replace limited domestic markets • Demand by sector • Demand by structure (monopsony, polypsony and oligopsony) • Impact of advertisement in creating demand. • Role of niche markets • Demand for innovative products by age cohorts
F. Structural and organizational change		
	• Employment participation rate by age and sex	• Percent of firms by sector that have moved some production off shore (directly or via contracting out) • Use of consumer-supplier integrated production chains • Technological opportunities in emerging fields