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Workpackage 1

State-of-the-Art on the Knowledge-Based Economy

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1. Introduction

The last decade has seen an explosive growth in the number of articles and reports arguing that there is something unique about the global economy today and an equivalent growth in the number of indicator scoreboards that attempt to provide meaningful measures of modern economies. The terms for this brave new world have included the 'information society', the 'digital era', the 'network economy', the 'learning economy', the 'intangible economy', the 'knowledge-based' economy, or most simply, the 'new economy'[1].

Not all of the theoretical perspectives on modern economies currently have the same status. Some have lost favour, such as the 'new economy', although the Progressive Policy Institute still favours this term. The main idea behind the new economy was the belief that modern technologies such as ICT and the internet had ended the business cycle allowing for long-term growth 'undisturbed by inflation and uninterrupted by recessions' (Lundvall, 2004). Following the slump in economic growth in the 2000-2003 period in many countries and the implosion of stock values, particularly for internet and ICT companies, the term is less frequently used today. Other terms, such as the 'information society' or the 'digital era' are focused on the role of ICT as the cause of a shift in the techno-economic paradigm, while the 'learning economy' focuses on the need for continual learning by individuals and organisations to adapt to the changes wrought by ICT – or in Lundvall's words, 'to transform [ICT] from being new to being old'.

A common feature of many of these perspectives is that innovation, science and technology, and information and communication technologies (ICT) are central features of modern economies and a cause of the rapid increase in economic growth and productivity in the US during the last half of the 1990s. One feature of the focus on innovation is a common emphasis on change, resulting in a reconfiguration of economic, social and political relationships (Room, 2004). A second common perspective was that the rapid diffusion of ICT was creating output and productivity growth without inflationary pressures. Empirical work found that the contribution of computers to output growth in the US more than doubled between the first and second half of the 1990s, and that multifactor productivity growth had increased by nearly a factor of four from the 1980s and a factor of five from the early 1990s (Sichel and Oliner, 2002). These analyses supported the view that ICT and the internet were having a significant economic impact in a range of countries including the US, Australia, Canada, Finland and Ireland (Colecchia and Schreyer, 2001). Nor were the economic benefits of ICT confined to countries with large ICT manufacturing sectors, such as the US and Finland. Australia also benefited from rapid growth, even though it had almost no ICT manufacturing capabilities whatsoever, with ICT investment predominantly limited to 'user' sectors. The fact that neither ICT manufacturing nor investment in ICT by user sectors had led to marked increases in productivity and growth in other countries, including many within the European Union, suggested that much more than ICT investment was required.

[1] See Room, 2004; Zysman, 2004; OECD, 2001a; Smith 2002; Godin, 2004; Houghton and Sheehan, 2000.

The different theories to explain the uniqueness of modern economies, such as the 'digital', 'information', 'network' or 'knowledge economy' tend to stress a similar set of factors, although the level of importance given to each differs and not all factors are deemed important from each perspective[2]. An overview of the factors at the heart of each perspective produces five main characteristics or drivers:

1. The influence of ICT production and diffusion on opening up new areas of investment and increasing productivity growth,
2. The crucial role of human resources, particularly the highly skilled,
3. Quantitative and qualitative change in knowledge production, including R&D and creativity,
4. Greater levels of entrepreneurship and creative destruction, partly in response to rapid technological change and opportunities for innovation,
5. Far-reaching structural change, due to organisational innovation and the impact of the internationalisation of production and knowledge generation.

The theory of the 'digital economy' focuses on ICT and has little to say about human resources or knowledge production in general, while the 'network economy' perspective focuses on inter-organisational linkages and transaction technologies. In contrast, theories of the 'knowledge economy' or the 'knowledge-based economy' include most of the above factors, with a focus on the first four. Consequently, these perspectives provide a more complete coverage of the large changes that could be occurring in modern economies. Both capture a broad vision of modern economies and place generic concepts of knowledge as the core driver, although many studies of the 'knowledge economy' also focus on ICT and its role in creating new opportunities for efficiency improvements and new goods and services in a wide range of sectors.

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.

The fifth factor — far-reaching structural change — is attracting increasing attention. This is due in part to a growing recognition that theories to explain modern economic trends have been overly focused on the production of new technology, in particular ICT, and its diffusion at the national level. In contrast, many of the features of modern economies cannot be fully explained without an evaluation of structural and socio-political change, in part driven by the ability of ICT to minimize the economic costs of disappear and consequently create a global economy. For instance, the assumption that ICT alone was responsible for rapid, noninflationary economic growth in the late 1990s is probably naïve. A second important factor has been the effect of shifting manufacturing production to low cost countries that has driven down costs and prices. Similarly, the belief in the increasing importance of 'intangible' versus tangible investment is partly due to a myopic focus on events in developed countries. Tangible investment is still required to produce goods, but some of this investment has moved offshore and consequently out of reach of national statistical systems. A global perspective on a knowledge-based economy (KBE) is required to fully capture and understand the policy significance of these developments.

This report reviews the state-of-the-art of research on a KBE. Section 2 summarizes some of the main perspectives on a KBE, while Section 3 evaluates four examples of in-depth research on the issue. Section 4 provides an overview of current understanding for five main characteristics or drivers, including ICT, human resources, knowledge production, entrepreneurship, and structural change. Section 5 reviews performance indicators, including economic growth and productivity, social impacts, and environmental impacts. National, regional and sectoral variations in the effects of a knowledge economy are discussed in Section 6. Section 7 provides conclusions.

[2] The NESIS report provides a useful overview of each of these perspectives on modern economies.

2. Perspectives on a Knowledge Based Economy

There is extensive social and economic literature of relevance to the concept of a KBE ranging from book length analyses that develop an overview of all aspects of knowledge economies, to specialised research that evaluates specific features of the 'uniqueness' of modern developed economies or societies. The variety of approaches and viewpoints in the literature can be grouped into five main perspectives on the relationship between the ideal of a 'knowledge economy' and the reality of where we are today. Three of the perspectives are economic, one is social, and one is largely critical and derived in part from the sociology of science and knowledge. Despite this variance, similar themes run through the five perspectives.

1. We live in a new economy, a knowledge economy

A common perspective is that "we are living in a knowledge economy". The widespread use of ICT, the growing share of employment in what Richard Florida terms the 'creative' occupations, and the decline of manual workers is used as evidence for such a statement. Further evidence is provided through the OECD's growth project, which established a link between investment in ICT and growth in GDP and productivity since 1995. Knowledge is believed to become even more important in the future. This is the OECD view, espoused in a number of publications and a view shared by most OECD countries. Great importance is attached to high-technology sectors, not just by developed countries, but also by newly industrializing countries such as Taiwan and more recently by China and India. An extension of this view emphasizes that **knowledge is the key to all value-added in all sectors**, particularly in 'creative occupations' such as knowledge-intensive services, media, and architecture (Kok, 2004).

2. We are moving towards a knowledge economy

A variant of this perspective talks about an *emerging* KBE that is global rather than limited to the developed OECD countries. The internationalisation of knowledge and production is thought to strongly influence the form of the emerging knowledge economy. Both Zysman (2004) and Lundvall (2004) focus on the dynamic features of a shift from one techno-economic paradigm to another, requiring adaptation and learning on the part of governments, firms and individuals. This is the view expressed in the third European Report on Science & Technology indicators (EC, 2003b). **Knowledge is viewed as *the key resource* for competition in a globalizing world**, with knowledge creation and diffusion both deemed key factors in the ability of Europe to face increasing competition from low-wage countries. This means that the knowledge economy is considered also a *goal* for public policy and something to be encouraged by public policy. The EU has expressed the ambition to become the most dynamic, competitive, knowledge-based economy in the world at the Lisbon council in March 2000, while simultaneously preserving social cohesion and environmental sustainability.

3. All economies are based on knowledge

A more critical perspective holds that knowledge has always been a vital constituent of economies since time immemorial. An example is the shift in the techno-economic paradigm between 1880 and 1930 due to the development and application of electricity, with many of the productivity enhancing benefits requiring twenty-five years of learning and experimentation (David, 1991). **The role of ICT in the knowledge economy is not confined to that of a 'leading' technology but is based on the interaction between ICT and other factors such as knowledge and learning**. The goal of this perspective is to identify factors that differentiate current economies from their predecessors – which changes represent radical shifts, and which are only new variations on an old theme? This is the view of one variant of modern innovation theory, as described in Smith (2002).

From this perspective of innovation theory, the crucial feature of different periods of rapid technological change and economic adaptation concerns the nature of knowledge itself. The current economic transformation is partly based on the codification or digitization of knowledge (Houghton and Sheehan, 2000) which in turn leads to many secondary effects, such as distributed knowledge bases (Smith, 2002) or 'distributed networked production systems' (Zysman, 2004), including networks for the production of knowledge itself. Another important distinction is between knowledge embodied in machinery and equipment, and knowledge contained in journals, books, curricula, practices, and the minds of workers (including managers), procedures and beliefs. The latter type of knowledge is called *disembodied* knowledge. There is an ongoing debate over the role of disembodied (or codified) knowledge and tacit knowledge in innovation (Senker, 1995; Cowan et al, 2000; Breschi and Lissoni, 2001). A key characteristic of this innovation theory is that it does not focus on high technology sectors, but sees knowledge and the diffusion of knowledge (sometimes embodied in capital goods) as playing an increasing role in all sectors of the economy, including public services and low-technology manufacturing (Archibugi and Coco, 2005).

A variant of this perspective is from the Milken Institute in the US that believes fundamental change in modern economies is not due to entirely new developments, but to a shift in the relative importance of tangible and intangible economic assets. The importance of the former is believed to be declining while the economic value of intangible assets for different types of knowledge is increasing. These intangible assets include patents, copyright, trademarks, brands, customer relationships, organisational structures, and investments in developing new products and processes (DeVol et al, 2004). The Milken Institute notes that the relative value of intangible and tangible assets is shifting in all economic sectors, partly due to the impact of ICT.

4. We are moving towards a knowledge society

A fourth perspective is that the **fundamental changes taking place at the level of the economy will have wide-ranging impacts throughout society that could result in major changes to how people live and work**. A report by the Australian Bureau of Statistics (ABS) includes economic and social impacts of a KBE, although the report notes that there are few available indicators or social change (ABS, 2002). Another option is to focus on the wider issues of knowledge: knowledge for public policy (evidence-based knowledge and knowledge obtained through participatory processes), knowledge for social understanding (contributing to social cohesion), knowledge for its own sake and contributing to wisdom (helping individuals to become a better person) or being wanted out of sheer curiosity. The ABS study notes that knowledge includes not only technical know-how, but also cultural, social and managerial knowledge.

5. The knowledge economy is not all good news and requires surveillance and control

A fifth perspective focuses on the **negative aspects of a KBE**. These include the digital divide, associated annoyances such as spam and new criminal opportunities such as phishing[3] and destructive viruses, stress, greater income inequality, and unemployment induced by technical change. There is also the issue of *whose knowledge* counts. Expert, reductionist knowledge can ignore controversies that lead to social conflict, as in the case of nuclear power and agricultural biotechnology. There are policy options to mitigate or avoid some of these problems, such as greater income inequality or unemployment.

The first three perspectives focus on knowledge for economic use: knowledge for production and knowledge for the use of goods and services. The last two perspectives take a broader view.

The five different perspectives are summarized in Table 1.

[3] Phishing, is a variation on "fishing," the idea being that bait is thrown out with the hopes that while most will ignore the bait, some will be tempted into biting.

Table 1. Different Perspectives on Knowledge and the Knowledge Based Economy

	View on knowledge	Characteristic statements	Sources
1. *We are living in a new economy that is knowledge-based.*	Knowledge is used in an undefined manner. The focus is on ICT as a knowledge component. ICT is the key feature of the knowledge economy.	KBE are economies that are directly based on the production, distribution and use of knowledge and information (OECD, 1996b).	OECD, 1996b; 2001a.
2. *We are moving towards a knowledge economy*	Knowledge is more than information, which is merely one specific kind of knowledge, namely codified knowledge that exists independently from individuals. Knowledge in a broader sense, however, also includes the capability to treat and understand data and information and it includes cultural, social and managerial knowledge.	The internet is changing the world we live in, and the challenge for Europe is to embrace the digital age and become a truly knowledge-based economy. The way in which the European Union manages this transition will help determine our quality of life, our working conditions and the overall competitiveness of our industries and services (EC, 2002).	EC, 2003b EC, 2002 EC, 2003a, p. 4
3. *All economies are based on knowledge: k*nowledge always has been important in production. All industries are knowledge-intensive including those that do little R&D such as the food sector.	There are different types of knowledge: besides all kinds of technological knowledge we have knowledge about markets and marketing knowledge that is important. An important distinction is between embodied and disembodied knowledge.	Knowledge is distributed across agents, institutions and knowledge fields. Many of the relevant knowledge fields lie in sciences. These sciences inputs are supported by little-explored, indirect links with universities, research institutes and supplier companies.	Smith, 2002, p. 27 DeVol et al, 2004
4. *We are moving towards a knowledge society: k*nowledge is important not only for production but also for public decision-making and for social cohesion.	Knowledge is a key component not just of economy but also of society. Knowledge is important in its own right. There is a belief that more and better knowledge will improve social cohesion and public decision-making.	European governments want to ensure that these benefits are available to all, not just to a privileged minority. The new knowledge-based society must be an **inclusive** society. Here too, the internet offers tremendous possibilities: anyone who can use a computer can participate in society at the click of a mouse. eEurope and its component programmes (eLearning, eHealth, eGovernment and eBusiness) focus on fully exploiting this potential for social inclusion (EC, 2002, p.4) The UK government has committed itself to evidence-based policy.	EC, 2002 ABS, 2002
5. *The knowledge economy is not all good news and requires surveillance and control*: it leads to greater inequality. There are also risks and undesirable effects.	The knowledge society also has its own specific problems: digital divide and problems related to computer use: RSI, spam, privacy violation, computer fraud, etc.	ICTs [are not] an end in themselves, but a means towards reaching broader policy objectives, like improving the everyday lives of millions of people, fighting poverty and contributing towards the Millennium Development Goals. There is a real danger that new technologies will strengthen power elites and isolate vulnerable people further, from the elderly to the disabled. Avoiding the development of a two-speed society is a major challenge for all governments, even in advanced countries.	Kummer, in OECD Observer of Dec 2003

2.1 Hype and reality and indicator needs

Research on the knowledge economy has been conducted by the European Commission, national government ministries such as the Department of Trade and Industry (UK), statistical agencies such as the ABS, organisations such as the OECD, private think tanks such as the Progressive Policy Institute and the Milken Institute in the US, and by many individual researchers or unaffiliated research consortiums, such as NESIS. Much of the analyses of the KBE, particularly from a business perspective, accentuate the differences between the 'old' economy and the 'new' economy, with multiple examples of complete flips from one state to another. This could be called a general principle – everything about the KBE is the opposite of the old economy. An example is given in Table 2 that compares the 'new knowledge economy' with the "old industrial economy".

Everything is said to be different in the new economy. Human capital is the new scarce resource compared to financial capital in the old economy. Innovation is continuous and systemic instead of linear. Many of the characteristics of the KBE are clearly better and more humanistic: management-employee relations are deemed to be cooperative instead of confrontational, employees are seen as an investment rather than an expense, and undesirable gender biases in employment disappear.

Many elements of Table 2 can also be found in the report on the new economy by the Progressive Policy Institute. It states that the characteristics of the new economy include an increase in knowledge-based jobs, higher levels of entrepreneurial dynamism and competition, reduced delays between design and production, faster times to market, increased product and service diversity, constant technological innovation, the advent of the internet and the information technology revolution, globalization, the replacement of hierarchical organizational structures with networked learning organizations, and relentless economic churning (Atkinson and Court, 1998).

The belief in a complete reversal of many established patterns of business has also spread to the developing countries. According to Lim Boon Heng, the Chairman of Asian Productivity Organisation:

> "In the old Industrial Economy, where the environment is stable, the emphasis was on perfecting the known, that is, doing more with the same amount. Thus the focus was on efficiency of resources by cutting down on costs. In the new economy of discontinuous change, countries, companies and individuals must imperfectly seize the unknown. They must constantly learn and innovate, and venture beyond the comfort zone to seize opportunities ahead of others … we should not be constrained by scarcity of resources but leverage on the abundance of knowledge. Instead of diminishing returns, there is now the potential of increasing returns[4]…"

[4] see http://www.apo-tokyo.org/anniversary/4keynote.htm

Table 2. Differences between the old industrial and new knowledge economy

	Old Industrial Economy	New Knowledge Economy
	Markets	
Economic development	Steady and linear, predictable	Volatile and chaotic
Market changes	Slow and linear	Fast and unpredictable
Economy	Supplier-driven	Customer-driven
Product lifecycles	Long	Short
Key economy drivers	Large industrial firms	Innovative entrepreneurial knowledge-based firms
Scope of competition	Local	Global hyper-competition
Competition basis	Size: The big eats the small	Speed: The fast eats the slow
Marketing	Mass marketing	Differentiation
	Enterprise	
Pace of business	Slow	Fast with ever-rising customer expectations
Emphasis on	Stability	Change management
Business development approach	Strategy pyramid: vision, mission, goals, action plans	Opportunity-driven, dynamic strategy
Success measure	Profit	Market capitalization
Organization of production	Mass production	Flexible and lean production
Key drivers to growth	Capital	Resources: people, knowledge, capabilities
Key sources of innovation	Research	Research, systemic innovation, knowledge management, integration, new business creation, venture strategies
Key technology drivers	Automation and mechanization	ICT, e-business, computerized design and manufacturing
Main sources of competitive advantage	Access to raw materials, cheap labor, cost reduction through economies of scale	Distinctive capabilities: institutional excellence, moving with speed; human resources, customer partnership; differentiation strategies; competitive strategies
Scarce resource	Financial capital	Human capital
Decision making	Vertical	Distributed
Innovation processes	Periodic, linear	Continuous, systemic
Production focus	Internal processes	Entire value chain
Strategic alliances	Rare, "go alone" mindset	Teaming up to add complementary resources
Organizational structures	Hierarchical, bureaucratic, functional, pyramid structure	Interconnected subsystems, flexible, devolved, employee empowerment, flat or networked structure
Business model	Traditional: command & control	New: refocused on people, knowledge, and coherence
	Workforce	
Leadership	Vertical	Shared: employee empowerment & self-leadership
Work force characteristics	Mainly male, high proportion of semi-skilled or unskilled	No gender bias; high proportion of graduates
Skills	Mono-skilled, standardized	Multi-skilled, flexible
Education requirements	A skill or a degree	Continuous learning
Employee relations	Confrontation	Cooperation, teamwork
Employment	Stable	Affected by market opportunity & risk factors
Employees	Seen as expense	Seen as investment

Source: Vadim Kotelnikov, Founder, Ten3 BUSINESS e-COACH, 1000ventures.com

The apparent principle that the knowledge economy marks a 180° flip from conditions in the 'old' economy also applies to specific sectors and even as far as the factory floor, as shown by a report by Brynjolfsson *et al* (1997) and summarized in Table 3. The example refers to the differences between an old factory and a new one that has applied ICT-based technology.

Table 3. Old and new characteristics of the factory

Features of the "old" factory	Features of the "new" factory
• Designated equipment	• Flexible computer-based equipment
• Large inventories	• Low inventories
• Pay tied to amount produced	• All operators paid same flat rate
• Keep line running no matter what	• Stop line if not running at speed
• Thorough final inspection by quality assurance	• Operators responsible for quality
• Raw materials made in-house	• All materials outsourced
• Narrow job functions	• Flexible job descriptions
• Areas separated by machine type	• Areas organized in work cells
• Salaried employees make decisions	• All employees contribute ideas
• Hourly workers carry them out	• Supervisors can fill in on line
• Functional groups work independently	• Concurrent engineering
• Vertical information flow	• Line rationalization
• Several management layers	• Few management layers

Source: Brynjolfsson *et al* (1997)

There is a lot of anecdotal evidence that business strategies have changed due to the adoption of new technologies and the effect of structural change and that there are marked changes in modern factories compared to factories from the Fordist regimes of the 1960s. It is widely believed, for example, that a higher percentage of workers forty years ago performed specialized tasks within the framework of standardized production processes, while today a higher percentage of workers are probably given responsibilities in different domains, for which multiple skills and the ability to work in teams are required (OECD, 2002). Yet, how far has this shift gone, and how much of it is possibly a temporary reaction to current conditions versus a permanent change in work, as implied by theories of the knowledge economy?

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). This is especially problematic among business studies and is similar to the claims during the late 1990s that the rapid rise in stock valuations was not due to a speculative bubble but to a fundamental change in the financial value of intangible versus tangible stock. Under these conditions, better data and indicators would help to evaluate which aspects of Tables 2 and 3 above have actually occurred and the extent to which they are true. Without good indicators, we won't know which features of the KBE are true and which are simply wishful thinking.

3. Approaches to Classifying Indicators for a KBE

A large number of studies have assembled or identified indicators of relevance to a knowledge economy. Some of these studies have looked at specific components of a knowledge economy such as the SIBIS report on the 'Information society' (DG INFSO, 2003). Others such as the European Innovation Scoreboard (DG Enterprise, 2004) do not mention the 'knowledge economy' except in passing, although they include many relevant indicators. Yet other studies explicitly attempt to identify indicators that encompass all aspects of a knowledge economy (Atkinson and Coduri, 2002; ABS, 2002; Naumanen, 2004). As there are hundreds of potentially relevant indicators, a number of identified studies on the knowledge economy have classified indicators into related themes. There are two categories indicators in widespread use:

1. the characteristics and drivers of a knowledge economy, and
2. output or performance indicators.

Several studies (e.g. NESIS (Room, 2004), World Bank, 2002) have adopted a 'pillar' approach rather than an approach based on drivers. In contrast to drivers, the concept of a pillar implies a foundation that underlies a knowledge economy. The World Bank 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.

3.1 Characteristics and drivers

As noted in the introduction, the characteristics and drivers can be grouped into five classes:

1) ICT investment and use,
2) human resources,
3) knowledge production,
4) entrepreneurship, and
5) structural and organisational change. Although few studies on indicators use precisely this set of five classes, most use similar categories or their indicators can be readily assigned to one of these classes.

Table 4 presents eight studies of relevant indicators. It maps the indicators from the studies to the five classes of characteristics and drivers. Of note, the mapping does not always reflect the classification system used by each study, as discussed below. The first column of Table 4 describes the classification system used by each study. In almost all cases, the proposed indicators in these eight studies can be readily assigned to one of the five classes. In some cases, a study simply combined two of the five classes. For example, the ABS report combines 'innovation' or knowledge production with 'entrepreneurship'. In other cases, the indicators within a class are quite similar, but the class has been given a different name. For example, the indicators within the 'technological innovation capacity' class of the PPI study are relevant to the 'knowledge production' category. These results show that there is a general consensus on the main characteristics and drivers for a KBE.

Table 4. Mapping the five main characteristics or drivers of a Knowledge-Based Economy against other key studies					
Study	**KBE characteristics**				
	Production & diffusion of ICT	**Skilled human resources**	**Knowledge production: R&D & creativity**	**Entrepreneurship & creative destruction**	**Structural & organisational change**
1. De Vol 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.	*No separate class*, but ICT relevant indicators in other areas: R&D in math and computing sciences; workforce share of computer and related scientists	Education achievement measures Government investment in education Households with internet access Workforce share of skilled scientists and engineers, by field	R&D investment indicators, including in specific fields SBIR awards (subsidies to SMEs for research)	Venture capital & business incubator supply IPO proceeds New firms; net formation of high tech firms; share of fastest growing firms	*None*
2. ABS: Measuring a Knowledge-based Economy and Society (2002) Three classes of indicators for drivers: innovation and entrepreneurship, human capital, ICT	ICT infrastructure and access Household use of ICT Business use of ICT ICT skill base	Stocks and flows of skilled people Investment in education Life-long learning	R&D in new fields, knowledge with commercial potential, knowledge networks & flows	Venture capital Creation of new, fast growing firms	*None*
3. PPI (1999, 2002): The State New Economy Index Five classes of indicators: knowledge jobs, globalization, economic dynamism and competition, digital economy, technological innovation capacity. *Globalization indicators (export orientation and FDI do not map onto the five options, although FDI could be classified under structural and organisational change)*	Household use of ICT Use of ICT in schools Government use of ICT to deliver services Broadband use internet and computer use by farmers and manufacturers Employment of IT professionals	Education achievement measures Workforce share of skilled jobs; number of scientists and engineers	Industry investment in R&D Patents issued Jobs in high tech sectors	Venture capital Number of jobs in fast growing firms Economic churn rate (new entrants and exits) IPO proceeds	*None*
4. Room (2004), NESIS Four classes of indicators: microeconomic, innovation, digital economy, public investments	Adoption of ICT Government use of ICT Household use of ICT	Education achievement measures	R&D investments Patents	*None*	Knowledge management Networks Human resource management

Table 4. Mapping the five main characteristics or drivers of a Knowledge-Based Economy against other key studies					
Study	**KBE characteristics**				
	Production & diffusion of ICT	**Skilled human resources**	**Knowledge production: R&D & creativity**	**Entrepreneurship & creative destruction**	**Structural & organisational change**
5. OECD (2001a): The New Economy – Beyond the Hype Four classes of indicators: ICT, Innovation and technology diffusion, human capital, firm creation and entrepreneurship	ICT prices Telecom competition Internet costs E commerce Home & school internet access	Education achievement measures Knowledge intensive employment Life long learning	Patents Business R&D Spin offs from public research	Start-up activity Venture capital New equity markets Barriers to entrepreneurship	New work practices
6. EC (2005a): Towards a European Research Area: Key Figures 2003-2004 Two classes of indicators: investment in a KBE and performance of a KBE	E government	Education achievement measures Education expenditures Life long learning Researchers per capita	Public and business R&D Basic research investment Scientific publications Patents	Venture capital	*None*
7. OECD (2003a): Science, Technology and Industry Scoreboard Three classes of indicators: investment in knowledge, investment in ICT, and trends in trade and investment flows	Household use of ICT ICT use by firms Internet costs ICT investment	Education achievement measures International mobility of skilled people	Public and business R&D Basic research investments Patents Scientific publications	Entry and exit of firms	Cross-border mergers & acquisitions Internationalisation of manufacturing R&D International cooperation in science & technology
8. 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	Household use of ICT ICT investment	Education achievement measures Life long learning	Public and business R&D Patents Innovation cooperation	Venture capital	Non-technical innovation

A common feature is that the classification of specific indicators varies across the studies. For instance, several studies assign indicators of human resources for ICT to an ICT category, while others assign these indicators to a human resources or human capital category. Some studies list venture capital under a category that captures knowledge production while others link it to entrepreneurship. Table 4 assigns all similar indicators to the same category, based on a subjective judgement of where indicators belong. Differences in the assignment of indicators to a specific class will influence the value of composite indicators that are constructed for each class.

Table 4 highlights a general weakness of many of the studies of a KBE: poor coverage of structural and organisational change, although the importance of both are frequently emphasised in theoretical research as a major factor that produces a qualitative break between the KBE and the preceding economy. Without a meaningful qualitative change, the KBE could be nothing more than a simple evolution of the economic structures in place during the 1970s. The lack of coverage of structural and organisational change is probably due to two factors. The first is a comparative lack of reliable and relevant indicators, in contrast to widely available indicators on educational attainment, patenting, and R&D. Many indicators for organisational innovation, for example, are one-offs that were obtained at a single point in time, whereas there are frequently time series for other indicators in these studies. The second factor is that many of the possibly relevant indicators for structural and organisational change are not found among economic or science and technology indicators, which is the source of most of the indicators in these studies.

Another weakness is in the treatment of globalisation indicators. Very few are included in the eight 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.

Some of the studies refer to 'contextual' or background macroeconomic conditions that provide a good environment for the development of a KBE (OECD, 2001a; ABS, 2002). These include the business environment, functioning labour, finance and product markets, legal and regulatory frameworks, political institutions and transparency, and sound macroeconomic policies. These contextual factors are not included here because they apply equally to all economies – there is nothing that sets them apart as uniquely important for a KBE.

3.2 Output and performance indicators

Table 5 lists the output or performance indicators that included in the eight studies given in Table 4. They are divided into three main classes: economic impacts, social impacts, and environmental impacts. Table 5 shows that very few studies include social and environmental output measures. The most common economic performance measures are GDP, labour productivity, and trade in high technology products.

Table 5. Mapping outcome and performance characteristics of a KBE			
Study	**KBE impacts**		
	Economic	**Social**	**Environmental**
1. De Vol et al (2004): State Technology and Science Index, Milken Institute	*None*	*None*	*None*
2. ABS (2002): Measuring a Knowledge-based Economy and Society Explicitly recognizes economic and social classes	GDP per capita Labour productivity Industry structure Trade of high tech products Exports of education and training	Relative earnings by educational level Relative unemployment rates by educational level Teleworking trends	
3. PPI (1999, 2002): The State New Economy Index *No relevant classes*	Export focus on manufacturing	*None*	*None*
4. Room (2004), NESIS All three classes mentioned, but social and environmental undeveloped	GDP Economic growth Productivity Trade and investment	Social inclusion (further details?)	Sustainability (further details?)
5. OECD (2001a): The New Economy – Beyond the Hype	Growth of GDP per capita Labour productivity	*None*	*None*
6. EC (2005a): Towards a European Research Area: Key Figures 2003-2004 *Outputs not explicitly developed*	GDP growth High tech exports Labour productivity	*None*	*None*
7. OECD (2003a): Science, Technology and Industry Scoreboard	Labour productivity growth GDP Trade	*None*	*None*
8. DG Enterprise (2004): European Innovation Scoreboard	High tech exports	*None*	*None*

4. Characteristics and Drivers

This section provides a more in-depth analysis of current thinking on the five main characteristics and drivers of a KBE. A typical view of the forces driving the KBE are 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, all of which produce the contradiction of hyper-competition along with increasing interdependency of businesses[5]. Although almost all observers will agree with these forces, this system of classifying the drivers raises two difficult issues. The first is to what extent are these forces the drivers of a KBE versus the result? Second, are there 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 often forces us to use less than ideal classification schemes. The main problem is a lack of data on globalisation that is a thread that runs throughout many of the drivers that influence a KBE. This makes it difficult to construct a separate group of indicators to measure it. Instead, indicators for globalisation will be included, where available, within the classification system used in this report.

4.1 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. In the future, other generic technologies such as biotechnology and nanotechnology could intensify techno-economic change through a shift towards a 'bio-based economy' where non-renewable energy and manufacturing inputs are replaced with renewable plant products and where chemical-based production processes are replaced with enzymatic production. The bio-based economy would also be intricately connected to ICT through its dependence on bioinformatics.

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. In this respect, the knowledge to develop ICT hardware is not the main type of knowledge underlying KBEs. The main impact of ICT is through its diffusion across modern economies and the opportunities that it creates for reorganising production processes more efficiently and for creating new types of goods and services. This requires software knowledge and, more importantly, the ability to use software. The latter gives firms in different sectors the ability to combine the potential benefits of ICT with their own sector-specific knowledge bases, consisting of various kinds of scientific and technological knowledge, knowledge on how to organize processes and skills,

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[5] See Vadim Kotelnikov, *op cit*, http://www.1000ventures.com/business_guide/crosscuttings/new_economy_transition.html.

and knowledge about markets. Each of the latter three types of knowledge is important and could be essential to the ability to realise the benefits from ICT.

As an example of the range of essential knowledge sources, Smith (2002) provided an overview of advanced scientific and technological knowledge and the suppliers of this knowledge for the Norwegian food processing industry. These include advanced knowledge and expertise for the selection and preparation of raw materials, processing, preservation and storage, packing, wrapping and coating; hygiene and safety, quality and nutrition, quality control and documentation, transport and distribution, and trading and marketing. These highlight the complexity of the knowledge base for this 'low' technology sector. The large number of sources also shows that the knowledge base is highly distributed. The ability of ICT to assist in the codification and diffusion of knowledge helps to make this knowledge base accessible and useable by firms.

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 lies behind much of the European support for ICT research through the Framework and ESPRIT programs. This view 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 ICT producing sectors alone, but substantially due to the ability of firms in ICT *using* sectors to efficiently adapt ICT to their own specific circumstances.

One example should suffice here. A recent study by Blanchard (2004) on the productivity growth gap between the EU and the US since 1995 found that the difference was largely due to lower EU growth rates in ICT using sectors, including retail and wholesale trade that account for about a quarter of GDP. In the US, productivity in these sectors grew by 5.4% between 1995-2000 compared to 1.4% in the EU. The productivity growth gap between the EU and the U.S. was even larger in the ICT producing sectors (23.7% in the US versus 13.8% in the EU), but Blanchard points out that this sector accounts for less than 3% of GDP, whereas retail, a major ICT using sector, accounts for 8.7% of total employment in the US and, for comparison, 6.8% of employment in France.

The next question is the cause of the differences in productivity growth in the retail and wholesale sectors. Blanchard points to research for France that finds similar levels of labour productivity in retail with that in the US The study also finds that investment in ICT is roughly similar in the two countries. Other research cited by Blanchard suggests that most of the productivity growth in this sector in the US was due to the replacement of less productive outlets by more productive ones. There are no data on this factor for France, but if true it suggests that differences in ICT investment between France and the US might not be the key factor. Instead, the problem could be regulation that limits sector specific 'creative destruction'- or the entry of new efficient outlets and the closure of less productive outlets. Gordon (2004) makes a similar argument.

This example illustrates the importance of obtaining ICT and other KBE indicators by sector. 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).

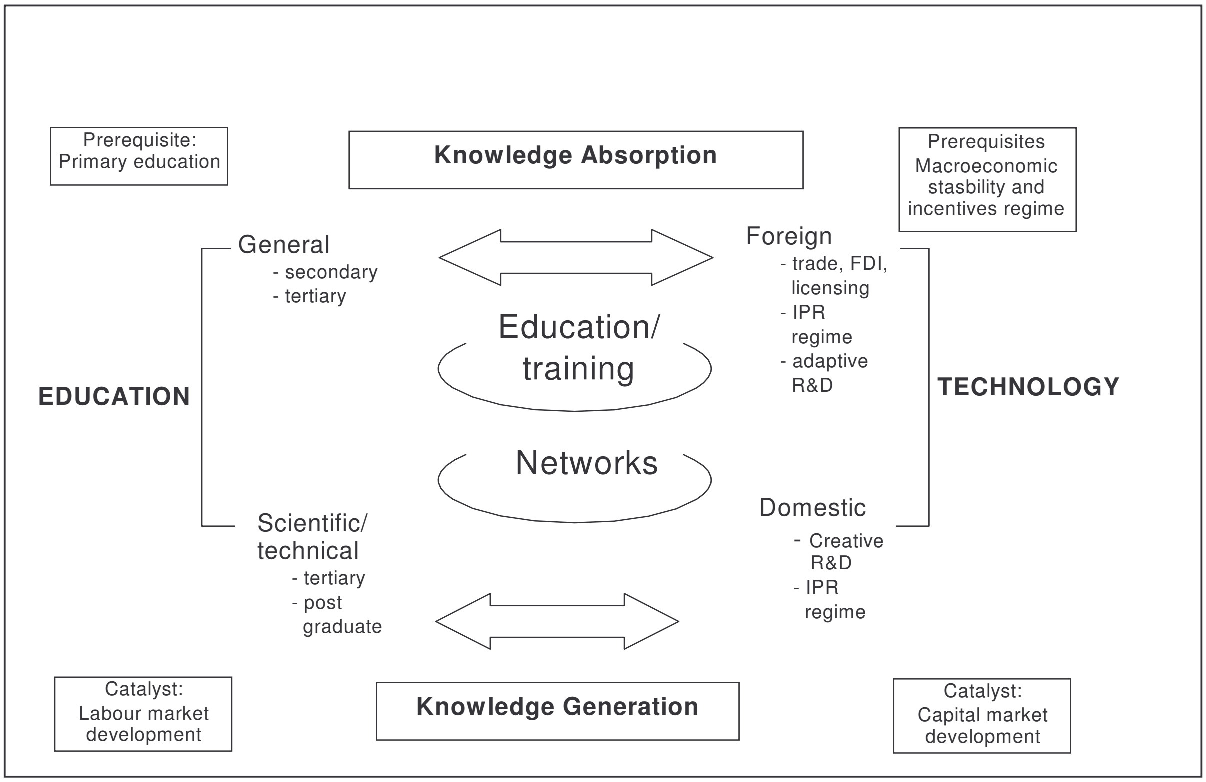
4.2 Human resources and skills

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 .

The most commonly used indicators of human resources typically consider data on the number of scientists, engineers (S&E) and S&E occupations, defined either according to skill level or sector of employment. An example of a well-used indicator is the number of R&D personnel per 1,000 employees. This has been adopted as an important indicator of a nation's scientific and technological efforts since the inception of S&T indicators in the 1960s (Hansen 1997). Other relevant indicators cover education, in a wider sense, and training, both of which were identified in the European Commission's 1993 White Paper on *Growth, Competitiveness and Employment, The Challenges and Ways Forward into the 21st Century* as important for reducing unemployment and boosting productivity through the development and application of new technologies. At the Detroit G7 Jobs Conference in 1994, the need for new measures to better understand jobs in a technology-driven KBE was tabled. The subsequent G7 conference in Lille (1996) determined that labour policy must be linked to structural policies, technology policies, and education and training policies. This brought additional pressure to bear on national statistical agencies to generate new indicators for human resources and skills that would be relevant to the KBE .

Figure 1 presents a simplified model of the role of human resources in the knowledge based economy. Gill (2002) argues that the major actors in both the educational system and in the technological process are students, highly-skilled workers and firms, insofar as they accumulate knowledge, use knowledge, and create knowledge for productivity and growth. He goes on to say that schools, universities and research centres are, although critically important, facilitators for the process of skills acquisition and technological developments and upgrading. Furthermore, employees in KBEs must bring not only task-specific skills as taught in school, but also more complex and experience based skills in decision-making and problem-solving.

Figure 1. The Knowledge economy simplified



Source: Gill (2002).

Employment markets are characterised by continuous and increasing demand for highly skilled workers. Highly skilled workers also have a comparative advantage in adjusting to changes in the labour force brought about by technology, due to a broader set of skills that better equip them to deal with economic fluctuations. Yet a focus on a highly-skilled group of elite ‘knowledge workers’ could be a mistake, as a much wider group of employees contribute to and are essential to the functioning of a KBE. To ignore the contributions of other groups of workers risks adding to existing polarisation of labour markets (Lowe, 2002) and distorting policy responses. As an example, skilled trades (e.g. glassblowers, fitters, welders, plumbers), plus moderately-skilled occupations in nursing care or bookkeeping, are generally poorly covered, or at worst entirely ignored, in policy discussions on human resources or of labour market skills for a KBE . They are frequently grouped into archaic categories of ‘blue collar’ or ‘white collar’ workers. Policy and planning are geared towards postsecondary education and high-level occupations in science, research and academia. This lack of interest for skilled trades and moderately skilled occupations in theories of a KBE could result in inadequate policies.

Economists tend to ignore the importance of skilled trades and vocations because of research showing higher rates of return from advanced levels of education, versus lower wages and higher unemployment rates for the skilled trades. From an institutional perspective, skilled trades tend to be considered as an afterthought for those who lack the academic aptitude to pursue the normal course from secondary school through to post-secondary school (e.g. in Canada) (CBC, 2002). Government policies often encourage as many youth as possible to pursue a university education, despite the fact that business surveys show that many positions for skilled trades persons go unfilled. The result is that several countries must meet the need for skilled trades and similar occupations through immigration.

Some studies suggest an increase in the number of highly-skilled workers could have a positive impact on demand for both skilled trades and for low skilled jobs because the presence of highly-skilled workers creates a demand for other skill levels. For example, research in chemistry requires custom glassware produced by skilled glass-blowers. In Europe, a shortage of highly-skilled occupations could limit demand for other types of jobs (EEAG, 2003).

4.2.1 Life-long learning

One of the limits of measures of human capital is the reliance upon 'formal' education indicators by level of skill and major field of specialisation. This fails to consider life-long learning as an additional investment in human capital in the work force (Gill et al., 2003). Firms that aggressively create, adopt, or adapt new technologies recruit employees with high skill levels, but they must also continually invest in training for their employees. The fact that workers, at all skill levels, need to acquire new skills and adapt old skills identifies the 'learning economy' (OECD, 1996b).

Traditional forms of learning are challenged in a KBE that requires the ability to create fresh and innovative approaches for active and continuous learning. For a firm, re-skilling and up-skilling of its work force is critical. Lifelong learning is crucial for workers so they can secure jobs in an environment that is changing rapidly to respond to market pressures and job changes driven by ICT and other new technology. Being a knowledge worker in a KBE is more than getting a degree or certificate. The degree or certificate is a foundation on which additional formal and informal learning can be built. We can look at the integration of work and learning brought about by ICTs and consider formal learning as the 'enabler' of this integration. A World Bank (2002) discussion paper on lifelong learning points out that developing and transition countries may be further marginalised because of the inability of their education and training systems to equip people with the skills they need to continuously learn. Table 6 shows how the traditional learning model contrasts with the life-long learning model in some important ways[6]. It demonstrates the challenge for developed economies and, more importantly, shows how the weaker educational foundation of workers in developing countries will affect their ability to engage in continuous learning.

[6] As in comparisons between the knowledge economy and the pre-existing economy, all features of the life-long learning model appear to be more progressive and better pedagogically than the 'traditional learning' model.

Table 6. Comparing the traditional learning model with the lifelong learning model

Traditional learning model	*Life-long learning model*
• The teacher is the source of knowledge.	• Educators are guides to sources of knowledge.
• Learners receive knowledge from the teacher.	• People learn by doing.
• Learners work by themselves.	• People learn in groups and from each other.
• Tests are given to prevent progress until students have mastered a set of skills and to ration access to further learning.	• Assessment is used to guide learning strategies and identify pathways for future learning.
• All learners do the same thing.	• Educators develop individualised learning plans.
• Teachers perceive initial training plus ad-hoc in-service training.	• Educators are lifelong learners themselves.
• 'Good' learners are identified and permitted to continue their education.	• People have access to learning opportunities over a lifetime.

Source: *World Bank, Lifelong Learning in the Global KBE.*

Measuring different modes of learning when even the terms like 'life-long learning' or 'organisational learning' lack clear definitions is difficult. Even if comparable classifications were available, measurement implies a framework that encompasses formal learning, non-formal learning such as the acquisition of on-the-job skills, and informal learning, such as learned in the community or with friends.

4.2.2 Flows of skilled human resources

An important aspect of a knowledge economy is the trend towards greater mobility of the highly-skilled work force (Gera, 2004). The exports of products, technology transfers, and R&D investment worldwide has been matched by the movement of key skilled personnel as well. In addition, an increase in international collaboration on innovation and on the fusion of different technologies means that scientists and engineers have been increasingly mobile across national boundaries and across disciplines. Consequently, traditional measures such as the stock of patents or current R&D expenditures within a specific country are increasingly inadequate for informing policy about innovation activities (Stephan, 1999). The OECD (1996b) argues that there is a need for both indicators of the stocks of human resources and indicators for the flows of human resources as part of the development and diffusion of knowledge and innovations.

The global economy brings other pressures to bear on the need for indicator development. In its 2004 Science and Engineering Indicators report, the National Science Foundation of the US points out that as the world is changing key indicators are going missing. The scenario for the US refers to the potential effects of foreign scientists' willingness to work and study in the US given the changes brought about under Homeland Security since the 2001 terrorist attacks.

How will government restrictions impact on foreign scientists' access to the US? And on the flip side, how will the US restrictions affect flows of scientists and engineers for European countries — might this have an effect on European moblity patterns? The report points to another important measure that needs attention, and in this Europe shares concerns with the US — the need for indicators of the international activities of firms, such as locating operations overseas to pursue new markets or well-trained talent and at lower costs (National Science Foundation, 2004a).

An essential research question in respect to mobility is why skilled workers migrate. Migration could occur in response to greater financial rewards for skills and talents, better funding of R&D, or opportunities for additional responsibilities or job functions. The World Bank (2002) suggests that the main motivation for moving is higher wages, but other evidence suggests, at least in the case of scientists and engineers, that higher wages are only one reason for mobility and not necessarily the deciding factor. A 2002 survey (Hansen, 2004) of internationally mobile scientists and engineers, developed for DG Research as part of a project on flows of scientists and engineers, reveals several factors in the decision to move abroad that are given a higher ranking than salaries: more R&D funding, the employer's reputation or prestige, career advancement opportunities, access to leading edge technologies and professional networking.

The KBE can put additional stress on the educational systems of developing countries as highly skilled scientists and engineers migrate to engage in international level research. Dickson (2003) says that despite offering attractive salaries to encourage highly-skilled persons to return home and other policies to stem the outflow from developing countries, the measures have had little impact and the flows continue. What can help developing countries gain something from their investment in education is access to the dispersed scientists and engineers through a network or 'scientific diaspora'. The case of South America, Africa, China or India comes to mind as an obvious example of domestic research efforts being enhanced and assisted by expatriate researchers. COLCIENGAS, a government-sponsored research institute in Columbia, created a network of expatriate Colombian researchers, university academics and engineers. Its core objective was to encourage the scientific, technical and socio-economic and cultural development of Colombia by drawing on expatriate resources. The result is CALDAS, a network that includes some 1,000 to 2,000 members of the Colombian scientific diaspora (Boffoof, 2004).

What are the costs and benefits of geographic mobility to the individual, the firm and the country? The global perspective is that it does not matter where the research is conducted as long as there is innovation and increased productivity — other countries can also source innovations from producer regions, as European countries source software and computers from the American firms that developed them. From this perspective, European countries could actually benefit from their best scientists and engineers emigrating to the US, particularly if their skills would have been under-exploited if they had remained in Europe. Saint-Paul (2004) estimates that between 40% and 80% of the 'star' European PhDs are in the

US. The thrust of European policy makes the opposite argument, which is that the ability of European firms to innovate, and hence for European economies to obtain the terms-of-trade benefits from European production of high technology products, has suffered from the emigration of highly-skilled scientists.

There is little empirical evidence for either the costs or the benefits of human capital mobility. In fact, it would appear that many of the recent policy decisions in the EU to encourage mobility are not based on impact assessments of human capital mobility but on the assumption that the circulation of knowledge and the creators of knowledge is always beneficial and leads to higher levels of innovation outputs. The timing of the mobility may be an important factor (is the scientist going abroad fresh from graduation or later in his/her career) and is typically completely overlooked. There is a need to develop indicators to understand the benefits and risks of international mobility at different stages in a scientific career.

Measuring mobility based on the characteristics of the persons who move (Salt 1997) requires the ability to distinguish between transfers within companies, temporary assignments, professionals, project experts, academics and so on. Todicso (2003) suggests classifying the mobile highly skilled person according to their area of employment such as scientist, researcher or academic, international expert, multinational manager and so on (Avveduto and Brandi 2003).

Multinational enterprises (MNEs) have the ability to export and import skilled workers internally and on a global scale. MNEs can move skilled workers about the globe and generally under the radar of even the strictest foreign worker (immigration/visa) policies. The growth of MNEs could increase the number of highly-skilled moving about on intercompany transfers. At the same time, the growth of MNEs has an impact on the employment of highly-skilled workers in their home country. Boyle et al (1994) examined the relationship between foreign investment and the transfer of experience (small French companies operating in Britain) and found that the relationship between investment and the transfer of experience to domestic workers depends on local availability of skilled workers in the first place. A study by Inzelt et al (2003) showed that the foreign owners of firms in Hungary sent foreign employees to Hungary for the intitial years of FDI to establish smooth collaboration or to train locals for the tasks. The resultant transfer of knowledge and organizational and work methods changed the employment environment to support upskilling and mutual learning.

The US collects data that are of relevance to many of the above issues, as shown in Table 7 that provides 2004 data on immigrants by region and type of visa. Those who enter the US on the H-1B visa are highly-skilled and permitted entry to meet the immediate and short term needs of American universities and firms.

Table 7. Temporary workers admitted to the US in fiscal year 2004.

	Total		All other visas	H1-B	Exchange visitors	Intracompany transfers*
	Number			Percent of total		
All countries	1,320,840	100.0	22.5	29.3	24.4	23.8
Europe – total	488,182	100.0	9.8	23.0	38.6	28.6
EU-25	**410,361**	**100.0**	**9.4**	**24.0**	**34.3**	**32.3**
Austria	5,776	100.0	13.0	24.2	32.9	29.8
Belgium	7,181	100.0	7.7	29.3	21.0	42.0
Cyprus	842	100.0	6.1	30.5	60.0	3.4
Czech	6,032	100.0	13.0	11.4	70.7	4.9
Denmark	7,374	100.0	8.2	23.5	29.9	38.3
Estonia	1,202	100.0	12.1	15.4	69.4	3.1
Finland	5,372	100.0	7.3	14.7	25.1	52.9
France	51,487	100.0	6.8	30.0	28.9	34.3
Germany	64,607	100.0	5.1	22.1	40.6	32.2
Greece	3,502	100.0	14.6	41.9	31.6	11.9
Hungary	3,585	100.0	11.7	25.6	50.8	11.9
Ireland	18,223	100.0	13.2	21.2	38.2	27.4
Italy	20,029	100.0	2.4	9.5	84.7	3.4
Latvia	1,044	100.0	7.0	13.9	75.5	3.6
Lithuania	2,851	100.0	6.6	9.4	82.4	1.6
Luxembourg	228	100.0	3.1	41.7	25.0	30.3
Malta	155	100.0	20.0	23.9	14.2	41.9
Netherlands	16532	100.0	7.9	24.0	21.8	46.3
Poland	27,153	100.0	6.1	5.7	85.1	3.2
Portugal	2,524	100.0	8.4	31.0	36.0	34.6
Slovakia	8,226	100.0	5.0	7.9	85.5	1.7
Slovenia	459	100.0	13.3	27.5	53.4	5.9
Spain	21,162	100.0	9.2	28.8	37.3	24.7
Sweden	11,875	100.0	10.0	27.2	27.6	35.3
UK	122,940	100.0	13.1	26.1	17.3	43.4
Asia	313,408	100.0	6.8	48.7	20.1	24.4
Africa	28,464	100.0	22.7	27.0	34.5	15.8
North America	312,357	100.0	63.7	16.4	6.2	13.6
South America	134,338	100.0	11.3	38.4	21.3	29.0
All other	44,091	100.0	17.6	25.2	28.3	28.9

Includes family members.

Source: US Department of Home Security, Yearbook of Immigration Statistics, 2004, Table 25.

The results in Table 7 show that contribution of foreign highly-skilled workers would be underestimated if the indicators excluded intra-company transfers, many of which are skilled workers. At the same time, the data reveals that the choice of mobility mechanism varies for different supplying regions and across countries within the EU. Overall 29.3% of the temporary workers enter the US on an H1-B visa. For the EU-25, the largest share enter the US as exchange visitors followed by intracompany transfers. Within the EU, the EU-25. For countries of Belgium, Finland, Malta, the Netherlands, and the UK, intracompany transfers were the preferred mode of entry for temporary workers — at least two in five (in fact, more than half of those from Finland entered the US on intracompany visas). For all other EU countries but for France and Greece, most entered the US as exchange visitors; for France and Greece, most entered the US on H1-B visas.

A study by the OECD (2003b) estimates that such transfers account for 5%-10% of the flows of skilled workers from Canada to the US.

Foreign direct investment (FDI) can substitute for international mobility when MNEs locate facilities abroad both for access to markets and to labour (Gera, 2004). Table 8 shows the increase in industrial employment in US foreign affiliates by host country between 1994 and 1999. NSF data tells us that in 2001, the affiliates of foreign-owned companies employed 141,700 R&D workers in the US, or about 15% of the total 1.05 million R&D workers in the business sector in the US. In turn, US multinationals employed a global R&D work force of 123,500 (or about 11% of total R&D employees in US firms were located overseas). The data on multinational R&D work forces, as developed in the US, can be used to develop indicators of employment and R&D across industries and occupations. These types of indicators are important for international comparability and potentially can be linked to R&D outputs such as patents and citations.

Table 8. Industrial employment, R&D employment and R&D expenditures in majority-owned US-foreign affiliates by selected host countries, 1994 and 1999.

	Employment (000s)				R&D expenditures (current US$ millions)	
	Total		R&D			
	1994	1999	1994	1999	1994	1999
All countries	5,707.1	7,765.8	102.0	123.5	11,877	18,144
Canada	810.2	1,004.2	7.3	7.9	836	1,681
Europe	2,582.7	3,530.5	73.1	83.1	8,676	12,217
France	364.6	530.4	11.3	10.8	1,372	1,452
Germany	548.9	640.6	24.4	25.3	2,849	3,377
Italy	164.1	188.2	4.4	3.8	365	504
Netherlands	136.5	165.5	4.2	3.8	415	374
UK	787.9	1,059.6	18.9	27.7	2,158	4,000
Asia/Pacific	1,073.6	1,516.7	13.0	20.8	1,775	3,226

Source: National Science Foundation.

Intersector and international relationships can also be explored through citation analysis. In the US, a few studies have explored linking patents with human resources (Stephan, 1999). One could go further and link the funding sources and educational origins of the authors of highly-cited patents. This can provide rich insights into the economic and social returns of public investment in education. In Europe, there is work underway to link education and economic activity. The task is to develop a concordance between industry field of science through patents and education by field of study in order to measure the science base of specific sectors.

Traditional indicators of R&D and the traditional unit of analysis, such as the firm, are less and less relevant in a global economy for knowledge, technology, and innovation. Stephan (1999) has produced examples of how human resources data and composite indicators can be developed to illuminate patterns of innovation, and more importantly the evolutionary paths from collaborative ventures to knowledge flows between sectors and between regions in the world. Lowell and Martin (1999) find that legislative and administrative action on immigration is greater than at any time in the past, yet policies are debated without reference to basic facts. Without reliable information, policy debates will remain out of synch with economic and social trends.

4.3 Knowledge production: R&D and creativity

Knowledge production and its effective use are the core features of a KBE and are pre-requisites to all types of innovation, including product, process, organisational, and marketing innovation. Knowledge production alone is an essential requirement, but by itself changes nothing, as shown by the long-standing debate over the 'European paradox', where Europe is believed to out-perform the US in the production of new knowledge, as measured through scientific publications, but lags behind the US in the commercial exploitation or use of this knowledge base[7]. Instead, firms must have different types of knowledge that allow them to effectively exploit their knowledge of basic technical principles, production methods, etc. This illustrates that the 'use' of knowledge is not so simple – in fact, it requires several different types of knowledge.

Lundvall and Johnson (1994), building on an extensive body of previous research, identify four types of knowledge:

- Know *why*: knowledge about principles and laws
- Know *what*: knowledge about facts
- Know *how*: the ability to do something
- Know *who*: knowledge about who knows what

Both knowledge production and the effective application of knowledge require competencies in all four types of knowledge, although knowledge production possibly requires greater emphasis in know *why* whereas knowledge application requires greater capabilities in know *how*. The difference is only relative, since the production of basic knowledge requires experimental expertise, such as how to test a hypothesis. R&D data, the most widely used

[7] This is a highly popular thesis in European policy circles, even though the empirical evidence over the past decade shows that Europe's apparent scientific lead over the US is in disciplines with fewer practical applications, whereas the US leads in areas such as bio-engineering and computing. For a recent review of the data, see Dosi et al, 2005.

source of indicators for knowledge production, does not distinguish between the different types of knowledge, with the exception of data on investment in basic research (know *why*), which is not collected in many countries. Other indicators can help to provide more information on the different types of knowledge. For example, indicators for scientific publications provide a proxy for know *why*, indicators of collaboration on science or innovation, such as co-publications or cooperative innovation projects, can provide a proxy for know *who*, and know *what* can be proxied by educational achievement. Unfortunately, the key to innovation is arguably know *how*, where the proxies are increasingly distant from the underlying phenomena. As an example, patent indicators can provide one measure of know *how*, but many of the intermediate outcomes of know *how* are not patented.

Other methods of classifying knowledge are also relevant to the development of indicators for a knowledge-based economy. These include the difference between *intangible* and *tangible* knowledge, *codified* and *tacit* knowledge (Cowan, et al, 2000; Lundvall and Johnson, 1994), *generic* and *specific* knowledge (Nelson, 1989), and *individual* (or personal) knowledge and *collective* knowledge (Lundvall and Johnson, 1994). [8]

Tangible knowledge refers to embodied knowledge contained in capital equipment and other investment goods. Intangible knowledge includes patents, organisational routines, R&D, tacit knowledge held by employees, customer lists, etc. A general view is that the relative importance of tangible knowledge (proxied through investment in physical capital) has been declining over time, while investment in intangible knowledge has been increasing. This is partly due to a shift to a service economy. According to Abramovitch and David (1996) (quoted in Third European Report on Science and Technology Indicators, EC, 2003b), in the second half of the 19th century, growth of physical capital accounted for two-thirds of labour productivity growth, while at the end of the 20th century it represented one one-fifth of it.

The importance of the difference between codified and tacit knowledge is that the former can be stored and transferred as information, using ICT (Lundvall and Johnson, 1994). An example is a computer programme, a database, or a manual of instructions. The rise of the KBE is partly due to the reduction in the cost of producing codified knowledge and partly due to the enormous reduction in the cost of accessing and moving such knowledge around the world. Paradoxically, the reduction in the costs of codifying knowledge could have simultaneously increased the value of tacit knowledge that is rooted in practice and experience and which has not yet been articulated or communicated in codified form.

The explanation for this paradox is due to the nature of tacit knowledge, which is wholly within the minds of individuals and can only be transmitted through apprenticeship, education, or personal contacts (Fleck, 1997 and Lam, (1998: 4), although 'personal' could

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[8] There are other classification systems for knowledge, but they are of too complex for indicator development. For example, Fleck (1997) distinguishes between *formal* knowledge embodied in codified theories, *instrumentalities* embodied in tool use, *informal* knowledge embodied in verbal interaction, *contingent* knowledge embodied in the specific context, *tacit* knowledge embodied in people and *meta*-knowledge embodied in organizations.

include contact by email or telephone.[9] It becomes increasingly valuable economically in a world where codified knowledge is instantly available, at minimal cost, to everyone. Under these conditions, firms can extract lead-time advantages over their competitors by being the first to learn about useful discoveries, for example through networks that include university scientists. Regrettably, although there are many possible indicators for codified knowledge, the slippery nature of tacit knowledge makes it extremely difficult to measure and hence develop indicators for it. The state of our understanding of tacit knowledge can largely be summed up as 'we can recognize it when we see it'. Only one study has attempted to quantify tacit knowledge, with only limited success (Arundel and Geuna, 2004).

Generic knowledge has widespread technological applications, in contrast to specialized knowledge. ICT is possibly the most generic technology ever discovered, with wider applications than previous generic technologies such as electricity and the internal combustion engine. It is this generic feature of ICT, combined with the fundamental role of information for all human activities, which drives much of the interest in a KBE[10].

Both generic and specific knowledge may be codified or tacit, and individual or collective, as noted above. Lam (1998, 2004) develops a classification system for knowledge that combines these two characteristics, as shown in Table 9.

Table 9. Types of knowledge

	Individual	***Collective***
Codified	Embrained knowledge	Encoded knowledge
Tacit	Embodied knowledge	Embedded knowledge

Source: Lam (1998)

Embrained knowledge depends on the conceptual skills and cognitive abilities of the individual. It is formal, abstract or theoretical knowledge that is primarily obtained through formal education and training, in other words, 'learning-by-studying' of codified materials. In contrast, embodied knowledge is tacit-individual knowledge, coming from experience. It is context specific, based on hands-on-experience and 'learning-by-doing'.

Encoded knowledge is codified and stored in blueprints, recipes, written rules and procedures. It is explicitly collective because it is potentially available to everyone. Embedded knowledge is the collective form of tacit knowledge residing in organisational routines, practices, values,

[9] According to Cowan *et al* (2000) codification is a matter of effort; most knowledge (for example how to ride a bike) can in principle be codified, given adequate resources.
[10] The technical application of electricity depended on the ability to produce reliable electrical current, which derived from the discoveries by Maxwell and Faraday of the connection between electricity and magnetism. Although ICT appears today to have wider economic applications than electricity, it is sobering to reflect that ICT would be impossible without it. Fundamentally, we still live in the electrical economy that developed at the end of the 19th century, even though we now take reliable electrical generation and supply for granted. Perhaps the future will see a new technology that depends on both ICT and electricity but which will similarly supplant ICT in the popular imagination.

norms and shared beliefs.[11] It includes the unwritten 'rules of the game'. This type of knowledge plays an important co-ordinating role but it is often hard to pin down. Embedded knowledge is relation-specific and situated.

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 can be proxied through investment in new machinery and equipment.

4.3.1 The socio-cultural foundations of knowledge

Indicators for the different characteristics of knowledge are a measure of a secondary outcome, since the 'knowledge' measured by indicators comes from the minds of inquisitive people with the skills to make discoveries. Without these people and appropriate institutional structures to support their work, there would be very little new knowledge or the application of existing knowledge in new ways. What conditions lead to inquisitive, curious people? Or, to ask the question in different terms, why is the area around Cambridge an incubator for biotechnology innovation and the area around Helsinki a global leader in mobile communications, while 'innovation' is rarely associated with other European cities such as Palermo, Athens, Rome, Bordeaux, Lisbon, Liverpool or Amsterdam? Part of the answer is due to the educational infrastructure (see Section 4.2 above) and to other institutions that shape the 'the system of industrial relations, the financial system, the state structure, the forms of competition, and the modes of inter-firm relationships' (Coriat and Weinstein, 2002). In addition, there are 'softer' indicators of 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. 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[12].

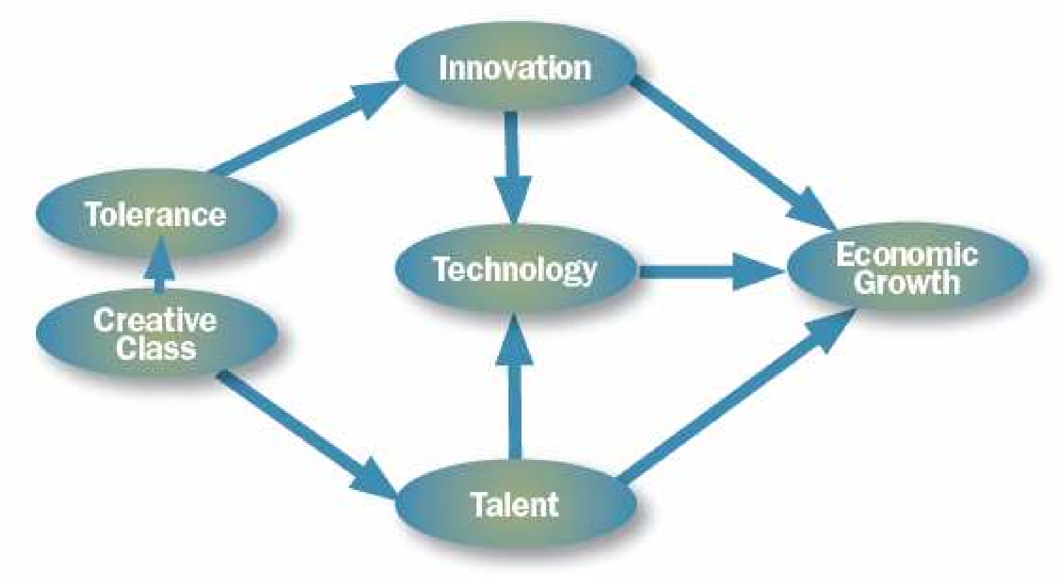
According to Richard Florida, it is not knowledge *per se* but the creativity of people that is the key to future economic growth. He argues in his book, *The Rise of the Creative Class* (2002), that the 'rise of human creativity' is 'the defining feature of economic life, because 'new technologies, new industries and new wealth and all other good economic things flow from it'

[11] The descriptions are taken from Lam (1998), published in Lam (2000).
[12] These 'soft' factors are often ignored in neoclassical economics, but the difference between success and failure in innovation is probably due to many 'soft' indicators such as values, politics and institutions (Mokyr, 2002).

(p 21). He further notes that "the economic leaders of the future … will be the nations and regions within nations that can best mobilise the creative capacities of their people and attract creative talent from around the world" (Florida and Tignali, 2004, p. 12). Florida's main thesis is that creative individuals are nurtured by social conditions that permit social diversity and openness to new ideas to thrive. These individuals, in turn, drive the innovative economy. The assumption is that socially creative societies that are more 'open' to new ideas will both be more willing to adopt new technologies developed elsewhere and also be more likely to develop new ideas internally.

In his book and in joint work with Tignali, Florida argues that economic growth and development depends upon the three 'T's: technology, talent and tolerance. Tolerance does not directly lead to economic growth, but is an indicator of an underlying culture that is open and conducive to creativity, thereby assisting in the formation of a functioning creative class. Florida reports a strong relationship at the metropolitan level between tolerance, as proxied by acceptance of homosexuals, bohemians and immigrants, and the ability of regions to innovate, generate high-technology industry, and secure high value-added economic growth. For example, one-third of all high-technology businesses created in Silicon Valley during the 1990s were founded by recent immigrants. Figure 2 shows the links between tolerance, creativity and economic growth.

Figure 2. Tolerance, creativity and economic growth.



Source: Florida and Tignali (2004, p. 12)

Florida and colleagues developed indices for talent, technology and tolerance at the national level (see Figure 3) for fourteen European countries plus the US. The results are combined into a creativity index. Instead of using the percentage of city populations that are homosexual as a proxy for tolerance (this indicator will not work at the national level), they use the results of several surveys to calculate a tolerance index. The US leads in technology and talent but Europe leads in tolerance (or did in the late 1990s).

The Trend Chart (2003) indicators for ‘receptiveness to new ideas’ cover similar territory, using indicators for the percentage of tertiary students that are foreign students, the percentage of the adult population that can speak a second language, regard for scientific professions, an indicator for urbanity, on the assumption that urban life attracts creative individuals, and an indicator for the percentage of the working population in creative occupations. The latter is similar to one of Florida’s indicators.

A problem with both Florida’s work on creativity and the Trend Chart research on the socio-cultural foundations of national innovation capabilities is that it is not possible to conclude that tolerance or receptiveness to new ideas is the initial *cause* of innovative success, since most of the analyses are based on simple correlations. It is also plausible that innovative regions draw in more creative people, resulting in positive feedbacks.

This section has shown that there are many potential indicators for knowledge production, including socio-cultural indicators for the factors that encourage the development of ‘creative’ individuals. Many of the indicators for both the type of knowledge available and the socio-cultural factors that possibly underpin knowledge production have not been used in scoreboards of the knowledge-based economy. This is unfortunate, since these factors provide crucial support to innovative capabilities and are consequently an essential pre-condition for a KBE.

4.4 Entrepreneurship and creative destruction

Innovation is inherently risky. A widespread acceptance throughout society of risk taking (or an entrepreneurial attitude) should increase the number of attempts at developing innovative products and services and firms to deliver them. 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.

Surprisingly, 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. This is partly because the vast majority of new firms are small family businesses in non-innovative service sectors. Consequently, the few innovative new firms are difficult to find, although some innovative start-ups grow into highly successful large firms and become visible. Economic models also indicate that is possible to have far too many entrepreneurial projects (Parker, 2005).

Figure 3. Florida's talent, technology and tolerance indices.

Euro-Creativity Index		TALENT INDEX			TECHNOLOGY INDEX			TOLERANCE INDEX		
Rank	Score	Creative Class Index	Human Capital Index	Scientific Talent Index	Innov. Index	High Tech Innov. Index	R&D Index	Attitudes Index	Values Index	Self-Express Index
1. Sweden	0.81	8	7	2	2	3	1	2	1	1
2. USA	0.73	1	1	3	1	1	3	n.a.	13	4
3. Finland	0.72	4	6	1	4	2	2	3	5	10
4. Netherlands	0.67	3	2	10	6	4	8	5	4	2
5. Denmark	0.58	9	15	4	5	5	6	7	3	3
6. Germany	0.57	11	4	7	3	6	4	12	2	9
7. Belgium	0.53	2	8	6	7	9	7	13	8	8
8. UK*	0.52	5	3	8	9	6	9	8	9	6
9. France	0.46	n.a.	11	5	10	8	5	11	7	11
10. Austria	0.42	12	14	11	8	10	10	9	10	5
11. Ireland	0.37	6	10	9	11	12	11	5	15	7
11. Spain	0.37	10	4	12	13	13	13	1	12	14
13. Italy	0.34	13	12	13	12	11	12	4	11	12
14. Greece	0.31	7	9	15	14	14	15	14	6	13
15. Portugal	0.19	14	13	14	15	15	14	9	14	15

Note: The numbers in column 3-11 indicate the relative position of the specific country with respect to the dimension reported in the column header (i.e. number 1 on the Human Capital column indicates that the country ranks first on human capital dimension). In bold, tied results.
** The scores on the Values Index and Self Expression Index refer to Britain (excluding Northern Ireland), for all other indexes scores refer to United Kingdom (Britain and Northern Ireland)*

Source: Florida and Tignali (2004, p. 32)

One approach for determining the link between entrepreneurship and innovations is to measure the innovative capacity of small firms (presumably entrepreneurial) and large established firms. A review of this issue by Acs and Audretsch (2005) finds some evidence to show that small firms produce more innovations per employee than large firms and more patents, but it is impossible in this research to assess the economic value of each 'innovation' or 'patent'.

We are left with the basic assumption that 'entrepreneurship is a good thing', based on the evidence of a few start-ups evolving into large innovative firms. Policy assumes that the number of these "successes" is positively correlated with the number of entrepreneurial attempts to establish a new firm. Consequently, an economy that creates 100,000 new start-ups per year will generate more successes than an economy that creates only 10,000 new start-ups per year. As noted by Parker (2005), this is a very crude approach to economic growth and one that risks socially inefficient overinvestment in new projects that are doomed to fail. The same problems apply 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 of investment. In both cases, there is a need for more research on the factors that improve the probability of success and indicators to track these factors.

There are three main methods for measuring entrepreneurship and creative destruction. The first is based on opinion surveys of attitudes towards risk or towards owning a firm. For example, several Eurobarometer polls (EC, 2001a, Eurobarometer, 2002) have asked a random sample of European adults (over age 15) on their preferences to being an employee versus being self-employed. This measures the personal attitude towards entrepreneurship. However, there are serious limitations to this indicator. We have no information on the form of self-employment envisaged by the respondent. The respondent could be thinking of establishing an innovative start-up, or simply establishing a café, restaurant, store, or small hotel. An alternative measure is the percentage of adults that disagreed with the statement "one should not start a business if there is a risk it might fail".

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. Data on the cost of establishing a business are available for both the time required and the cost of registering a new business (World Bank, 2004). Within Europe, these are not particularly informative indicators, since there is little variation in some of these factors across the EU.

An indicator for churn is used to measure 'economic dynamism and competition' in the 1999 'The State New Economy Index' from the Progressive Policy Institute. A second indicator is the number of fast-growing firms with sales growth of over 20% for four consecutive years. This indicator was more closely correlated with total employment growth than any other of the New Economy indicators (PPI, 1999). Regulatory limits to churn, in particular blocking the exit of inefficient firms and their replacement by more inefficient firms, is one possible cause of the lower productivity growth since the mid 1990s in Europe compared to the US (Blanchard, 2004).

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. Venture capital is only one of many different sources of capital to firms, but it can be essential to early stage establishment and growth.

4.5 Organisational change

Organisational change has long been the poor cousin of innovation research, which has traditionally focused on science-driven product and process innovation, due to its origins in R&D statistics. However, there has been a renaissance of interest in organisational change, in large part driven by research showing a link between organisational change and the adoption of ICT (Table 10), and secondly by research showing that the economic benefits of investment in ICT were much greater when firms adopted new organisational structures to take advantage of the capabilities of ICT, compared to firms that tried to fit ICT into their existing organisation (OECD, 2001a; Murphy, 2002; Gu and Gera, 2004). Brynjolfsson and Hitt (2000) find a positive relationship between the decentralization of the firm's organisational structure, investment in computer equipment, and the market value of the firm.

Survey research, however, shows that the main driver for organisational innovation was not ICT or other new technologies, but market forces, particularly competition.

Table 10. Work reorganisation and ICT: a close relationship

	Proportion of firms using ICT	
	Among firms which reorganise work	**Among firms which *do not* reorganise work**
Australia	24	14
Finland	62	52
European Union (except Finland)	49	34
US	58	49

Note: Due to methodological differences in the relevant questionnaires, the results cannot be compared between countries
Source: OECD (2001a).

There are two ways of interpreting Table 10: ICT requires work re-organisation (first interpretation) and companies who reorganize work are more likely to adopt ICT (second interpretation). It could very well be that the two sustain each other.

Lam (2004) has recently argued that rather than being an afterthought, 'organisational and technological innovations are intertwined' (p 115). There are two types of organisational innovation of relevance to innovation in general and to a knowledge-based economy. 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, as has been empirically established for the use of ICT. Changes to the structure of value-added chains could be essential for the development and growth of firms, including their ability to successfully commercialise new goods and services, or implement new processes.

Current thinking identifies three main types of organisational change[13].

— The first concerns the structure of work, or how responsibilities and decision-making are distributed within the workforce, the division of work within and between production and other activities, and the managerial structure. Examples include the establishment of formal or informal work teams with more flexible job responsibilities for individual workers, a move to greater decentralisation where the firm's employees are given greater autonomy in decision-making and employees are encouraged to contribute with their own ideas, or a move to greater centralisation where decision-making is consolidated within management. Changes to the structure of work include the integration of different business activities, such as build-to-order production systems

[13] The next few paragraphs on the different types of organisational innovation draws extensively from the 2005 revisions to the Oslo Manual.

(integrating sales and production) or greater integration of engineering and development with production.

- The second concerns business practices, or the routines and procedures concerning the conduct of work. These include the implementation of new practices to improve learning and knowledge sharing within the firm, plus many other changes to improve the ability of the firm to innovate. An example is the implementation of knowledge management systems, such as new practices for codifying knowledge, so that the firm's expertise is accessible to employees across the firm. Other examples of business practices include implementing new practices for employee development or to improve worker retention, such as education and training systems.
- The third type of organisational innovation involves how the firm connects to the rest of the world, or its external relations. These include formal and informal networks or linkages between a firm and other firms, plus other organisations such as universities or research institutes. Many firms are currently involved in developing international supply chains, which connect the firm to suppliers of services and goods in different locations. These changes encompass closer relations with suppliers, outsourcing and subcontracting, and collaboration on research and innovation.

Of course, some organisational innovations can involve simultaneous changes to each of the above three components: workplace organisation, business practices, and external relations. For instance, the implementation of supply-chain management systems, business re-engineering, lean production, and some quality-control systems can require extensive changes throughout the firm.

Organisational innovation also includes new business forms, such as start-ups supported by patient venture capital. Start-ups have played a remarkable role in producing and disseminating new technologies. The much-cited innovative cluster of Silicon Valley is the most visible expression of strong innovation dynamics that can emerge from the geographical interaction [economies of agglomeration] of young firms, an outward-oriented university system and favourable framework conditions for the financing and growth of start-ups. Even though the survival probability of start-ups in the new economy may not be high, some of the most widely-quoted successful new economy firms were fast growing, young enterprises. However, evidence of the role of young and growing firms has remained anecdotal. Systematic and timely indicators for entry, exit, growth and firm survival would be of use.

Indicators are needed for each of these three main forms of organisational innovation: 1) work structures (just in time, quality management, team working, flatter organisations, etc), 2) business practices (knowledge management, etc), and 3) external relations (outsourcing, networking). A particular challenge is to obtain measures of the prevalence and depth of organisational forms that integrate management and logistics throughout the entire value-added chain from the end consumer to suppliers. These chains can be particularly complex because they can span multiple firms or divisions of MNEs and cover the globe. For this reason, indicators for organisational innovation may need to be linked to indicators of globalization.

4.5.1 Socio-cultural factors behind organisational change

As with the development of knowledge (see Section 4.3.1 above), the types of organisational forms that are feasible depend on socio-cultural factors. A dominant factor is social trust that can reduce transaction costs and facilitate teamwork in organisations (ABS, 2002). A second factor is social capital, defined by the OECD as 'networks together with shared norms, values and understanding that facilitate cooperation within or among groups' (OECD, 2001b: 41). The link between social capital and innovation derives from the evolution in the concept of innovation over the last decades. Whereas in the 1950s the innovation process was an activity carried out in isolation, nowadays it is seen as a process involving different actors that have to interact socially. As a consequence, innovation can no longer be solely explained by the combination of tangible forms of capital, but also requires the combination of intangible forms of capital, with social capital among them (Landry et al., 2000).

Social capital could contribute to innovation by reducing transaction costs between firms, as well as information, and enforcement costs (Barney and Hansen, 1994). Although social capital can take different forms (trust, norms and networks), most of studies that include a measure of social capital use trust in people (Knack and Keefer, 1997; Whitely, 1997). According to Knack and Keefer (1997, p. 1252): "Low trust can also discourage innovation. If entrepreneurs must devote more time to monitoring possible malfeasance by partners, employees and suppliers, they have less time to devote to innovation in new products or processes."

Using survey data at the firm level, Landry et al. (2000) fail to find a positive effect of the level of trust on the firm's decision to innovate, but other measures of social capital used in their study, such as network assets and relational assets, are shown to increase the firm's likelihood to innovate. An important limitation of the study, however, is that it cannot link trust to innovation strategies among firms that already innovate. At the national level, Knack and Keefer (1997) find a positive and significant correlation between the level of trust in people and rates of economic growth, although its robustness has shown to be limited by Beugelsdijk et al. (2002). At the regional level, Putnam et al. (1993) find a relationship between social capital and the economic performance of Italian regions [14]. De Clercq and Dakhli (2003) find weak evidence for a positive relationship between several measures of innovation and two measures of social capital, trust and participation in networks. However, much of the relationship is lost after controlling for social equity.

[14] Contrary to Knack and Keffer (1997), Putnam et al. (1993) and other empirical studies that have used data on interpersonal trust and other general measures of social capital, Landry et al (2000) use indicators that specifically refer to the business environment. As such, they are better in assessing the level of social capital that is more likely to have an impact on innovation.

What we would like to measure is the level of social capital existing in the business community, since this is likely to have a more direct impact on the innovation process. Unfortunately, data on social capital for the EU is limited to national population data on interpersonal trust. We have no other EU-wide indicators for aspects of social capital such as networks.

5. Performance Outcomes

Almost everything of a positive nature has been linked to the KBE by someone, as shown in Section 2.1. These include expected beneficial effects on economic growth and productivity, incomes, environmental sustainability, social cohesion, and gender equality. These positive benefits are often linked to the diffusion of ICT to the '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.

5.1 Economic growth and productivity

The economic growth rate and the productivity growth rate are among the key output measures for the KBE. The effect of KBE factors on these two output measures is difficult to measure because there are many different drivers of growth and productivity as well as barriers that can reduce growth rates. An additional problem is that almost anything – or at least anything beneficial - can be said to be part of the KBE.

Some of the main drivers of economic growth have been recognized for centuries, such as population growth or access to natural resources. In the 18th century, based on the work of Adam Smith and David Ricardo, trade and the efficient division of labour were added to these two factors. Historians of the 19th century considered industrialization (essentially process innovations) and infrastructures such as railways and canals as important sources of growth. Industry-led growth became a growth strategy, which is still followed by the new industrializing countries.

Today, innovation in the broadest sense (including non-technological innovation) is viewed as the major source of economic growth and productivity. Population growth *per se* has diminished in importance because of a partial shift to measures based on per capita economic growth or labour productivity. Aggregate economic growth can be driven by simple population growth, the number of hours worked per employed person, or the workforce participation rate (Baldwin et al, 2005).

Many of the factors that can drive economic growth & productivity are linked to innovation:

- Competition by driving down costs and encouraging companies to innovate[15]
- Co-operation between companies (customers, suppliers and competitors)
- Human capital
- Entrepreneurship and start-ups
- Risk taking
- Generic technology such as the steam engine, electric motors, ICT etc.
- Social capital and trust
- Links between science and technology
- Institutions for learning and technology transfer (e.g., through cooperative arrangements)
- Property rights and political stability
- Good financial systems and an adequate supply of venture capital
- Consumer confidence and business optimism (whereas this is generally viewed as deriving from growth it also contributes to growth).

Conversely, several factors that are thought to suppress growth can also suppress innovation, at least under some conditions:

- Social regulation, labour protection, and environmental legislation
- Bureaucracy in companies
- Barriers to market entry or exit
- Government subsidies
- Social security benefits (although there is a vigorous debate over this one).

The effect of regulations on innovation is more complex, however, because regulations can also guide private investments in innovation towards socially constructive directions. An example is environmental legislation that can encourage firms to invest in developing innovative ways of managing or eliminating waste or reducing energy use.

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

- ICT
- Human capital
- Sound macro-economic management
- Venture capital

It is very difficult to establish the influence of different factors on economic growth and productivity. The four main methods are as follows:

[15] Aghion et al. (2002) find an inverted U-relationship between competition and innovation due to the mediating effect of other factors such as capability and market power.

1. Comparative analysis across countries or regions: growth & productivity differentials are plotted (or regressed) against several factors of relevance to growth and productivity.
2. Macro growth accounting
3. Micro-based studies of productivity on the basis of data from firms, correcting for sector and other structural effects.
4. Studies that measure the cost gains of a key technology or infrastructure.

The OECD relies on the first two methods (OECD, 2001a). The disadvantage of comparative analysis is that the observed correlations may be spurious or due to confounding by other, unobserved factors.

Macro growth accounting is based on a production function where y is the growth rate of output, m is the growth in multifactor productivity (MFP), h is the growth rate of labour inputs, and k is the growth rate of capital.

$$y = m + bh + (1 - b)k,$$

Output growth is thus the sum of productivity growth and of the separate contributions of labour and capital output weighted by the elasticity of output growth to each input.

$$y - h = m + (1 - b)(k - h).$$

Growth in output per hour (y - h) is equal to growth in multifactor productivity m plus the contribution of capital deepening. From this equation m is calculated. The growth in MFP (m) cannot be measured directly but only through the other variables, of which capital is very difficult to measure, due to differences in quality.

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 growth using at least one of the above four methods. As an example, OECD data show a positive relationship between increased R&D (a component of knowledge production) and MFP growth in the 1980s and 1990s. The relationship is not always positive, however, with increased expenditure on R&D and *negative* MFP growth for Belgium, Spain, France and Japan, indicating that other factors that are not included in this simple correlation also matter. Recent work by Meister and Verspagen (2005) suggest that one important factor in the relationship between R&D and productivity is where R&D investments occur. Using simulation techniques that adjust for knowledge spillovers, they predict that European productivity relative to the US would improve much faster through R&D investment in low technology than in high technology sectors – a conclusion that contradicts the thrust of current European R&D policy.

Other factors that have been found to positively influence MFP growth include educational achievement (human resources), job mobility and low administrative barriers to start-ups (entrepreneurship and creative destruction), organisational change, and ICT, which is examined at greater length below.

Methods for examining the sources of productivity growth have clear limitations. Simple correlations can give spurious answers that are not due to a causal relationship between two factors. For example, the 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. The growth accounting studies suffer from measurement problems and are unable to establish the effects of specific aspects of a National Innovation System. In the micro studies into productivity changes, many factors can be considered, such as conditions within the firm, sector effects and sector-external factors, but the results of these studies are not always applicable to an entire sector or economy. Analyses of the cost benefits of technology adoption are not always able to isolate the gains from other sources of innovation and growth.

5.1.1 ICT and productivity

The contribution of ICT to productivity growth and firm performance was evaluated in several studies in the late 1990s. The OECD report "The New Economy: Beyond the Hype" (2001a) contains estimates on the contribution of ICT to productivity growth (from Colecchia and Schreyer, 2001) showing an increase in the contribution of ICT to the GDP growth of several countries (Table 11). The increase is said to stem from an improvement in the overall quality of the capital stock thanks to ICT and an increase in the trend of multifactor productivity growth (MFP), but the results also show that several countries actually experienced a *decrease* in the trend of MFP growth.

Table 11. ICT capital and GDP growth: Percentage points contribution to annual average GDP growth in the business sector.

		United States	Japan	Germany	France	Italy	Canada	Australia	Finland
IT and communications equipment	1990-95	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.2
	1995-99	0.6	0.3	0.2	0.2	0.2	0.4	0.4	0.4
Software	1990-95	0.1	0.1	0.1	0.0	0.0	n.a.	0.1	0.1
	1995-99	0.3	0.0	0.1	0.1	0.1	n.a.	0.2	0.2
Total ICT	1990-95	0.4	0.3	0.3	0.2	0.2	n.a.	0.5	0.2
	1995-99	0.9	0.3	0.3	0.4	0.3	n.a.	0.6	0.6

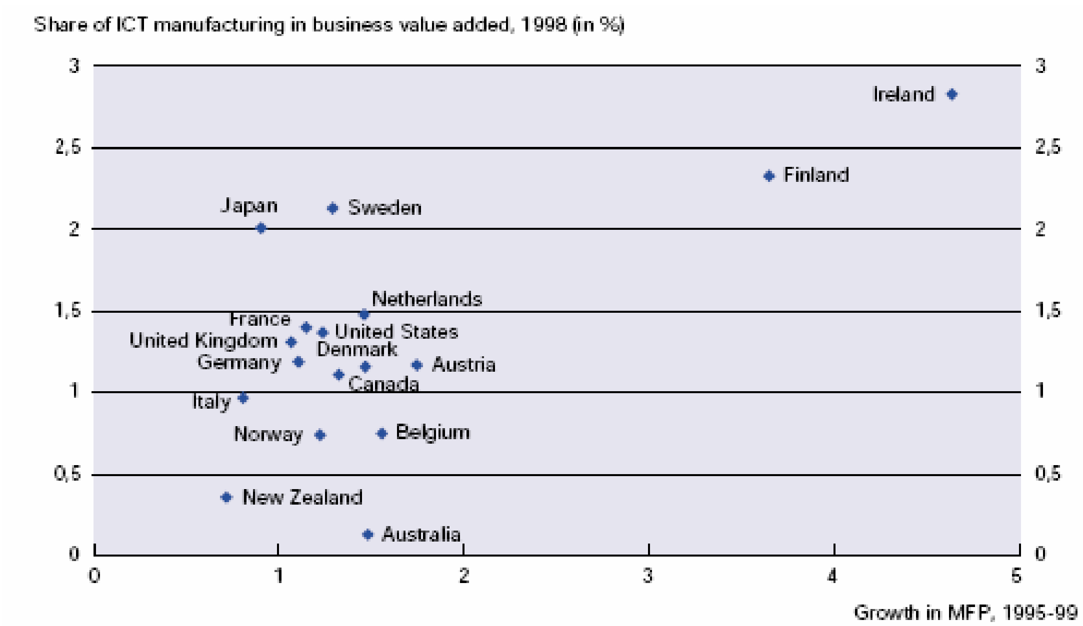
Note: *The table compares the contribution of ICT capital to GDP growth for eight countries, differentiating between the role of ICT hardware and software. It shows that ICT contributed 0.9 percentage point to US GDP growth between 1995 and 1999 (0.6 percent from IT and 0.3 from software), three times more than in Japan, Germany and Italy. Australia and Finland also received large contributions of ICT investment in GDP growth. The estimates are based on a harmonised deflator for ICT investment, adjusting for cross-country differences in methods. Methodological differences in measuring software investment may affect the results, however. The estimates are not adjusted for the business cycle.*

Source: Colecchia and Schreyer (2001) in OECD (2001a).

Not all of the results in the OECD report on the contribution of ICT to productivity are consistent. The estimates are based on growth accounting studies (macro data) rather than on micro data for productivity measures and ICT use by individual companies. Consequently, the growth accounting framework determines the effect of ICT on productivity from the residuals, which is less accurate than approaches based on micro-level firm data (Godin, 2004).

The OECD also reports a positive correlation between the percentage change in the number of personal computers (PCs) per 100 inhabitants and the change in MFP growth corrected for hours worked. Although the two are positively correlated, it is unclear if the relationship is causal or simply reflects confounding by other factors. Having more PCs could influence productivity by promoting computer literacy, but the contribution to growth and productivity from the use of PCs for recreational purposes could be very small.

Figure 4. ICT hardware manufacturing and MFP growth.



Source: OECD.

A large ICT sector doe not guarantee MFP growth and also does not appear necessary for productivity growth (Figure 4). Ireland and Finland, two countries with a large ICT manufacturing sector, experienced high MFP growth but Japan with a large ICT sector experienced slow growth (1%). Australia, with a very small ICT sector, also experienced strong MFP growth, suggesting that MFP growth doesn't depend on an ICT producing sector.

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 are quite revealing and show marked sectoral differences in the effect of ICT on productivity growth, a result that has been confirmed in more recent work. The 2000 papers contain evidence from macro studies and micro studies that ICT use leads to productivity growth. According to Oliner and Sichel (2000), the contribution from the use of computer hardware, software and communication equipment to growth of Real Non-farm Business Output increased from a level of 0.6% in 1994 to 1.3% in 1999. For the 1996-1999 period, MFP growth was 1.16%, almost 0.7% above the level for the 1991-1995 period. The acceleration in MFP growth is thus related to ICT. But this appears to occur primarily in durable manufacturing, not in the other part of the economy, where MFP growth decelerated.

According to Gordon, ICT-based productivity growth is limited to the 12% of the economy involved in manufacturing durable goods. In his words, "the new economy has meant little to the 88% of the economy outside of durable manufacturing; in that part of the economy, trend growth in multifactor productivity has actually decelerated, despite a massive investment boom in computers and related equipment" (Gordon, 2000, p. 72). Just 11.9% of computers are used in five computer-intensive industries within manufacturing, 76.6% of all computers are used in the industries of wholesale and retail trade, finance, insurance, real estate, and other services and the remaining 11.5% in the rest of the economy (Gordon, 2000). If this is true, the "Solow computer paradox" remains intact for most of the economy (Gordon, 2000).

It is unclear why ICT did not have a more positive impact on productivity in the service sectors. It could be due to measurement errors. A Canadian study (Harchaoui and Tarkhani, 2004) found that ICT use contributed to MFP growth both in the US and Canada, but some of the results confirm Gordon's (2000) findings. MFP growth in the US was largely due to the ICT producing sectors, with less MFP growth in the ICT using industries. Conversely, in Canada, MFP growth was much higher in the ICT using sectors.

5.1.2 Productivity, ICT and organisational change

A growing literature has evaluated the productivity effects of ICT investment combined with organisational change. The results indicate that to benefit from ICT, companies have to master some kind of transition, in which workers must be retrained to work with the machines in different ways and companies must develop new work arrangements (more decentralized structures with fewer management layers).

Brynjolfsson and Hitt (2000) provide both new results and a summary of other research on ICT, organization and productivity. They find a positive correlation between productivity and information technology stock.[16] They also present case study findings of the productivity effects of the introduction of ICT. The conclusion of these studies is that the productivity gains crucially depended on the organizational changes that were made: "Without proper organizational changes, ICT may even have a negative impact. Changing incrementally, either by making computer investments without organizational changes, can create significant productivity losses as any benefits of computerization are more than outweighed by negative interactions with existing organizational practices" (Brynjolfsson et al., 1997). An example is given of a well-intentioned employee who operated the machine very much in the old-time

[16] Reverse causality (large productive companies investing more than less-productive companies in ICT) is said not to be driving the results. Correction for this effect increases the estimated coefficients on IT even further.

manner of avoiding machine changeovers (creating work-in progress inventories) because he believed this was the key to productivity.

In addition to new organisational forms, investment in complementary intangible assets such as software and retraining play an important role in productivity growth. Brynjolfsson and Yang (1997) find that the $167 billion in computer capital investments recorded in the US national accounts in 1996 is the tip of the iceberg of $1.67 trillion of information technology-related complementary assets in the US. This goes some way in explaining why productivity gains in ICT-*using* sectors are low, at least for a while.

The non-current expenditures in intangibles should be viewed investments. This is only done recently for software but not for other intangibles. When all complementary assets are counted as investments, output and productivity growth become much higher than the official ones: at least 1% higher from 1980 on according to Yang (2000). We may have been using the wrong growth rates and the wrong data to estimate productivity growth.

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. If we accept this, it should no longer be a surprise as to why ICT investment did not show up in the productivity statistics until the 1990s. Until the early 1990s, computing equipment still represented a very small fraction of the total capital stock (Oliner and Sichel, 2000), and it simply takes time to learn how to use them efficiently. In the words of Oliner and Sichel (2000, p. 3 based on a study in 1994) “there was no puzzle—only unrealistic expectations”.

There is uncertainty about the exact size of the productivity gains from ICT. The initial benefits are small or perhaps negative. Benefits occur when companies move along a learning curve and implement appropriate forms of organisation. The long delays in reaping the productivity benefits of a new general purpose technology has also been reported from the economic history of other technologies, such as electricity (David, 1991, Greenwood, 1997). Whether ICT is the fuel of growth of the past ten years is doubtful. Gordon (2000) offers a discussion of why ICT could be far less important as a source of growth than the great inventions of the past: the steam engine, electric motor, chemicals and new materials. For understanding economic growth, we have to look beyond ICT.

5.2. Social impacts

Economic growth, beyond a level that can ensure adequate housing, education and health for all (approximately a per capita income of 15,000 USD in the late 1990s), is rarely the ultimate goal of either policy or of citizens (Layard, 2003). The social impacts of economic change, including those linked to a knowledge economy, are likely to be of greater importance. These include effects on income equality, happiness, life and job satisfaction, gender equality, and environmental sustainability.

An important issue that has been highlighted by recent analyses of the per capita GDP differences between the US and Europe is the work-leisure balance. A large percentage of the income difference is due to Europeans taking more time as leisure, while Americans work more, both in terms of hours worked per person and the workforce participation rate (Blanchard, 2004)[17]. Crucial question for policy are: is the KBE neutral in terms of the choice between leisure and work, or biased towards more work or more leisure, and, 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.

5.2.1 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. Table 12 provides an overview of wage dispersion in eighteen countries between the 1970s and the 1990s.

Table 12. Changes in difference in earnings between skilled and unskilled jobs in the 1970s, 1980s and 1990s.

Country	1970s	1980s	1990s	Expectations
Australia	-	+	..	Dispersion
Austria	-	+	..	
Belgium	..	+	..	
Canada	0	+	+	Compression
Denmark	..	0/+	..	
Finland	-	0	..	
France	-	-/+	+	Compression
Germany	0	-/0	+	Compression
Italy	-	0	..	
Japan	..	+	..	
Mexico	..	..	..	
Netherlands	0	-/+	0	Compression
Norway	..	0	..	
Portugal	..	+	..	
Spain	--/0	+	+	Dispersion
Sweden	0	0/+	..	
United Kingdom	-	++	+/-	Compression
US	+	++	+/-	Compression

++: strong increase in dispersion, +: increase in dispersion, 0: no clear change, -: decrease in dispersion, --: strong decrease in dispersion, +/-: increase followed by decrease, ..: no information available.
Note: The dispersion in earnings in this table is measured as the change in the $90^{th} - 10^{th}$ percentile of wages. distribution. See Juhn, Murphy and Pierce (1993) and OECD (1996c) for econometric details.
Source: Sanders and Ter Weel (2000).

Throughout the 1980s, the difference in relative wages for unskilled and skilled workers increased strongly in the United Kingdom and the US. Australia, Austria, Belgium, Canada,

[17] A related issue is if the European preference for leisure is the result of a free choice or due to structural problems such as high unemployment rates and low labour market flexibility.

Japan, Portugal and Spain also saw an increase in wage disparities. The pattern for the Netherlands, Denmark, France, Germany, Italy and Sweden was less pronounced, but the exclusion of the unemployed from the workforce in some countries strengthens the general conclusion that the job prospects for the unskilled have worsened dramatically. For the 1990s the little evidence that is available seems to suggest a levelling off of this trend.[18]

The employment opportunities for skilled and unskilled workers have also 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. However, in the US, the data show a bifurcation in labour demand, with an increase in low-skilled poorly paid occupations and in high skilled highly paid occupations, exacerbating income inequality (Atkinson, 2005)[19].

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 or offshoring reduces demand for routine and codifiable work, not only in industry but also increasingly in services. At the same time, ICT requires the development of complementary skills. Thus, the service desk employee is trained in capacities that the computer does not (as yet) possess: not so much technical skills, but social conversation skills, patience and friendliness.

5.2.2 Are we getting happier?

Are people getting happier? A striking finding from studies of ‘happiness’ in Europe, the US and Japan is that while per capita GDP has increased, happiness or life satisfaction has remained reasonably constant, although there is some evidence that happiness peaked in the mid 1950s in the US and declined until the 1980s, even as incomes rose substantially (Layard, 2003). Job satisfaction in the UK decreased in the early 1990s and slightly increased in 1996-1997, with job satisfaction higher in the public sector than in the private sector. The psychological stress reported by workers across Europe increased, according to a 1996 Eurobarometer survey. The UK study also gives some information on what people value most in work. For men, job security comes out as most important, while for women and people under the age of 30 the most important aspect is that the job gives them the responsibility to take initiative. The study did not probe deeply into the effect of ICT on work tasks and job satisfaction.

At the same time as average levels of happiness have not changed, there are marked differences by income, with more happiness in the top quartile than in the bottom quartile,

[18] A particular reference in this regard is Murphy and Welch (1999). They observe since 1994 a decline in wage inequality in the US, a trend that was not expected by many scholars in the field. However, this changed after 2000, with an increase in wage inequality (Atkinson, 2005).

[19] Machin and Van Reenen (1998) investigate seven OECD countries (Denmark, France, Germany, Japan, Sweden, the United Kingdom and the US) from 1973-1989 and Hollanders and Ter Weel (2002) include six

although job type does not have a large effect. A Eurobarometer report finds that life satisfaction varies by employment status, although the difference by job type is not very large. Managers reported the highest level of satisfaction (85% are satisfied) and self-employed workers the lowest (81% were satisfied).

A US Conference Board (2005) study of 5,000 households tells of falling job satisfaction and discontent in the workplace. In 1995, 60% of Americans surveyed were satisfied with their jobs compared with only 50% today. Only 14% surveyed today said they are very satisfied with their employment. The cause of falling job satisfaction is given to rapid technological changes in the workplace, rising (and constant) productivity demands and changing employee expectations. Job satisfaction has declined across all income brackets. Among workers earning more than $50,000 USD per year, 55% are satisfied with their jobs but only 14% reported they are very satisfied. At the other end of the pay scale, those with annual incomes below $15,000 USD, 45% of the workers reported satisfaction with their jobs and 17% expressed strong dissatisfaction. According to the Conference Board report, the largest decline in overall job satisfaction was among workers aged 35-44 and the second largest discontent registered among those aged 45-54. The report notes that younger workers today have significantly different attitudes about the role of work in their lives than their older co-workers and this presents a major challenge for employers and implications for policy as well. When asked to rate what caused dissatisfaction with their employment, company promotion policies and bonus plans were lowest on the satisfaction scale. Importantly, only 30% of employees were satisfied with their employers' offerings of education and job training programs.

What about workers in some of the key sectors in a knowledge economy? According to a survey of more than 1,400 IT workers (Computerworld), IT workers said they are generally happy with their compensation, job duties, relationships with management and understanding of their company's mission. That said, the respondents that indicated little job satisfaction were rather thankful for having a job (56% of the respondents indicated their companies had laid off workers or cut IT budgets). The majority indicated a desire for wider career options, higher pay and more training opportunities. One of the clearly identified problems was the 'double duty' asked of employees: increased work loads with few bonuses.

The overall conclusion is that the large structural changes in modern economies in the past few decades have had little effect on happiness one way or the other, nor has an increase in per capita income[20]. Nevertheless, the issue of happiness can be strongly influenced by several of the main characteristics of a KBE. An example is 'entrepreneurship and creative destruction'. The challenge of creating a new firm can increase the happiness of some individuals, but the destruction of other firms and a loss of employment or job stability will markedly decrease the happiness of others (Layard, 2003). The pressures of globalisation

countries (Finland, France, Germany, Japan, the United Kingdom and the US) in their analysis of the period 1975-1995.

(discussed below in Section 6) can also increase the pace of work, stress, and unemployment, all of which can decrease happiness. A second example concerns the role of social trust in knowledge production and organisational change. Trust has been decreasing over time in many European countries, which could reduce the effectiveness of networks and organisational forms that require higher trust levels. In so far as policy choices can influence these factors, policies to reduce the factors that cause unhappiness are preferable to policies that increase unhappiness.

5.2.3 Are there social cohesion benefits?

While technological change makes life more stimulating, cosmopolitan, and prosperous for some, it is making life more precarious and uncertain for many others (Ritzen, 2001). Europeans are aware of a number of potential threats from technology such as ICT to social cohesion: changing employment patterns and doubts about the sustainability of social security systems give many the feeling of uncertainty (Council of Europe, 2005). A number of groups are at risk of increasing vulnerability:

- Children
- Young people
- Families in precarious situations (e.g. single parents)
- Migrants and ethnic minorities
- People with disabilities and/or specific needs
- Elderly

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. Lack of employment early in one's working life is serious — it reduces income and blocks the development of skills through work experience and on-the-job training.

In 2003, the estimated unemployment rate for industrialized economies was 13.4% and an estimated 18.6% for transition economies, compared to a rate of 7.0% in East Asia. Youth unemployment rates are higher than overall unemployment rates in all regions examined. Under employment figures show that a disproportionately large number of youth work fewer hours than they would like. Brewer points to the lack of data on unemployment and employment for disadvantaged youths. This unemployment has many social costs, such as poorer health, breakdown of families, and increased crime. Youth unemployment threatens social cohesion as young people become dependent on welfare programmes and disenfranchised from mainstream society. Then there is 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

[20] One possibility 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.

in the economy — a KBE where investment in human resources is one of the most crucial areas of investment for future economic growth. The Council's strategy requires methods of measuring the impact of economic activity on social cohesion as well as legal and financial mechanisms for recognising and encouraging such contributions (e.g. tax advantages).

ICT and work access: Europe has significantly increased internet use and has the highest levels of use of digital telephony in the world (EC, 2001d). Employment prospects of 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. Teleworking and e-working could help. Teleworking can improve efficiency and productivity, work/life balance, and assist women to access the job market. Yet teleworking rates in 2000 were low in most European countries and the rates are consistently higher among men than among women, except in Ireland, Italy and Portugal (Table 13).

Table 13. European rates of teleworking by gender in 2000 (percent).

Country	Men	Women	Country	Men	Women
Belgium	5.0	4.1	Luxembourg	5.3	4.8
Denmark	20.9	12.8	Netherlands	12.1	5.6
Germany	4.4	2.8	Austria	4.0	3.9
Greece	4.6	1.3	Portugal	1.8	3.4
Spain	4.7	1.5	Finland	13.5	11.0
France	7.0	3.6	Sweden	11.4	5.5
Ireland	2.8	4.3	United Kingdom	10.6	10.2
Italy	2.6	4.2	EU (average)	6.2	4.8

Source: Eurobarometer, November 2000

The stereotypical teleworker that is based entirely at home is in fact one of the least popular forms of e-work (e-work meaning the use of new technologies to support multi-locational teleworking by employees, for example, and not limited to the typical definition of teleworking used to perform repetitive tasks off office premises). The survey found that one European employer in ten uses the new technologies to support multi-locational teleworking of employees, a form of working much less likely to be associated with social isolation.

An answer to whether or not the delocalisation effects of the KBE are favouring rural areas depends on our ability to measure the integration of non-urban, non-metro areas in the KBE. This requires indicators that are appropriate for the more isolated areas of the EU and for several of the new member states, who are at various levels of development in the diffusion of key ICT technology. ICTs enable the sharing of information and voicing of concerns about the social, economic and environmental policy issues that affect rural communities. Recent experience from Canada highlights some of the problems and issues, using several indicators that were developed to compare and contrast rural areas with urban centres. The UK government is encouraging the establishment of rural forums to engage the rural population in the development and delivery of policy (www.gosw.gov.uk).

Income disparities and the nature of work: According to Greenwood (1997), skilled workers have fared better than unskilled workers over the past decade, but this disparity could shrink over time for two reasons. First, as information technologies mature and become more user-friendly, the level of skill needed to work with them will decline. When this happens, the skill premium will decline, reducing income disparities. Second, young workers will tend to migrate away from low-paying unskilled jobs towards high-paying skilled ones. This tendency will increase the supply of skilled labour, easing pressure on the skill premium.

A predicted outcome of the KBE is a change in the nature of work and in working relationships, as described in Table 14. Some of the changes, such as an increase in computer and communication skills are related to ICT, while other changes are not. The trend towards the use of flexible contracts and job-hopping is not related to ICT. The shift towards greater autonomy, job rotation and flat organizational forms is weakly related to ICT. Job satisfaction might or might not be related to ICT, depending on how work is designed and organised (Ter Weel and Kemp, 2000). Of note, the predicted changes in Table 14 include a mix of both positive improvements, such as a greater workplace autonomy, and declines in the quality of life, such as a deterioration in the work-life balance.

ICT and skills: A 2003 ILO study suggests that labour markets are becoming increasingly ruthless in their treatment of unskilled workers. A reduction in welfare support combined with an increase in non-standard forms of work have made many workers more vulnerable. At the same time, ICTs can expand access to training by hitherto deprived population groups (women represent a large share of low-income and vulnerable workers in many countries). Improved skills and lifelong training are both key aspects of a KBE. In order to improve social cohesion, skills and training must be available to disadvantaged groups.

Table 14. Work in the future knowledge-based economy.

Labour contracts	Flexible contracts (offered by companies and asked by people) Return to performance-based pay? Less power of unions Job hopping
Skills and competencies	Computer and communicative (social) skills more important Competencies more important than skills Lifelong learning
Job content & work organisation	Bigger autonomy (discretion) of workers Workers become entrepreneurs, the exploitation and maintenance of human capital is partly a task for workers themselves Job rotation Flexible working hours Flat organisations
Job satisfaction & meaning	Work more important for people's identity Little reflection on meaning of work Work load increases (time saved through the use of computers is used for other tasks) Increase in stress and burn out Growing desire of people to work less and reduce work load
Relationship work & private life	Less strict division of work and private life: home is no longer a place for the family and for relaxation from work Social relationships are deteriorating and are increasingly work-related
Other aspects	Increase in communication through mobile telephones and intranet and internet

Source: Ter Weel and Kemp (2000) (based on Stichting Toekomstbeeld der Techniek, Toekomst@werk.nl. Reflecties op Economie, Technologie en Arbeid)

The Commission's Report on Economic and Social Cohesion (EC, 2004) says that people need to be able to access education and training in order to develop their capabilities wherever they live. Today, the individual is expected to organize his/her own learning and rather than being a passive recipient of information, persons must actively and interactively participate in learning. 'Learning-to-learn' is now a central skill (ILO, 2003). That said, the potential to harness ICT in education and training is huge (ILO, 2003). In Mexico there is a programme (Telesecundaria) that reaches some 100,000 to 700,000 small and remote communities that have few schools and teachers. But, this means resources need to be invested in new learner-based techniques of education and training and the ICT infrastructure will need strengthening — challenges for even the richest countries. The challenges to reap the benefits of ICTs are formidable in developing countries. The Commission's Report (EC, 2004) tells of the need to offer personalised services to job seekers in the form of guidance and training — developing preventative and active labour market policies is particularly important in the new Member States to promote economic restructuring.

Physically disabled people who cannot attend training programmes due to a lack of physical mobility, available transport, or prohibitive cost can (with the help of ICTs) access internet-based programmes at home. E-working enables professional employment of the disabled (EC, 2001d). In the UK, 4,000 Interwork[21] employees work in a wide range of public and private sector jobs.

The impact of IT on the lives of disabled and elderly persons has been the subject of policy speculation for a long time. In order to share in the benefits of ICTs, they need to have the skills and access. For disabled and elderly people, IT is something far more important than for many others. For many people whether at work or at home, IT enables them to do things better or faster and do things they couldn't do before (e.g. e-banking). But for disabled and handicapped persons, IT gives them independence and new opportunities. In Australia, although the ICT industry is one industry where disability should be less of a barrier to getting a job (compared with others), recent research reveals that the ICT industry is the least active sector in terms of proactively engaging mature aged people and could stand to improve its record by hiring more persons with disabilities (Dinham, 2004). Indicators need to be developed on employment afforded to special interest groups like the disabled and the elderly. Indicators are also needed on how developments in a KBE are granting (or not granting) more freedom and independence for the special interest groups.

The informal sector: The informal sector has figured significantly in the debate on employment issues and development policies over the past three decades. With the phenomenal expansion of the urban informal sector in recent years, national and international concern about its role and function has also increased (ILO, 2000). For example, to what extent can the informal sector absorb excess labour from rural areas and the formal sector? Does future economic growth and job creation rest with the informal sector in KBEs? Is the informal sector simply a haven for cheap labour? 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. The ILO tells of displaced workers from both the public and private sectors 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 identifies the need to measure the informal sector as a priorty (as well as the challenge of comparability at the international level).

5.2.4 Women and equality

A Status of Women in Canada report (Menzies, 1998) argues that the KBE will increase the overlap between the paid and non-market unpaid work that women do. There is concern over the lack of recognition of the linkages between the two, which could reduce the opportunities for women relative to men. The report recommends more research on the gender implications of a KBE. For instance, are these changes gender neutral? One possible outcome is that shifting patterns of ICT intensity and a demand for higher educational levels could increase opportunities for women.

[21] The Interwork scheme offers opportunities to disabled people within its national manufacturing network (www.remploy.co.uk).

An increase in the uptake of higher education in order to meet the increased need for skills in a KBE is likely to give women access to more interesting and better paid occupations and increase the opportunity costs of 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. More women are studying traditionally male specialisations such as mathematics, although they are still seriously under-represented. Table 15 shows that the share of women in professional occupations is almost equal to that of men, at 48%, but drops to 16% in the physical, mathematical and engineering occupations.

Table 15. Women's representation in occupations, 1998-2000, OECD averages.

	Percent jobs held by women
Legislators, senior officials and managers	30
Professionals	48
Physical, mathematical & engineering science professionals	16
Life science and health professionals	64
Teaching professionals	65
Technicians and associate professionals	54
Physical and engineering science associate professionals	21
Life science and health associate professionals	76
Clerks	69
Service workers and shop and market sales workers	69
Skilled agricultural and fishery workers	3
Craft and realted trades workers	12
Plant and machine operators and assemblers	19
Elementary occupations	52

Source: OECD Employment Outlook, 2002.

In Europe, there is an underused potential of women in scientific careers. For example, half of university graduates are women, but fewer than 10% of full professors are women (EC, 2001b). The boardrooms of most European companies continue to be male-dominated. There is still a significant gender gap in salaries and a visible lack of women in the top jobs. In the UK, there is a continuing and persistent trend for men to dominate academic positions (DTI 2004), research councils, and board memberships.

Faulkner et al's (2004) study of ICT and strategies for gender inclusion state that achieving a critical mass of women in or using ICTs is vital if ICT careers (or products) are to become 'gender authentic' options for girls and women. The most effective measures for increasing the recrutiment of women in ICT degree programmes and professions are those that increase the number of women in ICT (e.g. quotas, role models). The authors go on to speak of the 'leaky' pipe problem in core ICT sectors, where disproportionate numbers of women leave.

According to the National Science Foundation (2004b), women had the same plans as men in terms of staying in the US following graduation, but more women than men planned to work in academia (25.0% versus 20.5%) than in industry (15.5% versus 26.6%), which could result in women having less influence on the development and design of new technologies. Table 16 shows the postgraduate plans of men and women who earned their doctorate in 2001.

Table 16. Postgraduate plans of men and women graduates, US, 2001: percentage distributions.

Location and type of postgaduate activity	Both sexes	Women	Men
Total number of doctorate recipients	*11,601*	*4,684*	*6,917*
Plans are in the US	96.4	96.7	96.0
Acadmic employment	22.3	25.0	20.5
Postdoctoral study	39.3	42.6	37.1
Industry employment	22.1	15.5	26.6
All other employment (e.g. govt)	12.7	13.7	11.9
Plans to go abroad	3.3	2.8	3.6
Location unknown	0.3	0.3	0.3
	100%	100%	100%

Source: National Science Foundation, 2004b.

In many OECD countries, a higher percentage of women than men complete university, particularly in the social sciences. These are pivotal areas for skills in the knowledge economy. The participation rates for women in SMEs and innovation-intensive industries has also been increasing (OECD, 2002). At the same time, there is the risk that women will suffer through non-standard work patterns and fall behind in technology skills (e.g. if single parents, the majority of whom are women, cannot afford to keep up with computer technologies or cannot afford the time needed for continuous upskilling because of family responsibilities).

To what degree are the changes associated with a KBE driving economic and social disparities between men and women? Women are still overrepresented in clerical occupations, teaching, sales jobs and life-science/health jobs (OECD 2002; U.S. Census Bureau, 2004b.). A greater percentage of men are in 'knowledge occupations' compared with women (Drolet 2000). There are also marked differences between sectors. In the business sector, a higher share of men than women were in knowledge-based occupations, although the growth rates were higher for women than for men.

Data from the US Census Bureau shows that full-time full-year earnings of men continue to be considerably higher than that for women, although the difference varies by occupations and in the science and IT related occupations as well (Table 17). The smallest gap between men and women is for engineering managers: $80,000 versus $75,000, while women working as natural science managers report a median income $29,000 below that of their male colleagues.

Table 17. Occupations with the highest median earnings for men and women in the US (full-time, full-year workers), 1999.

Men		Women	
Occupations	**Median (USD)**	**Occupations**	**Median (USD)**
Physicians & surgeons	140,000	Physicians & surgeons	88,000
Dentists	110,000	Engineering managers	75,000
Chief executives	95,000	Dentists	68,000
Lawyers	90,000	Lawyers	66,000
Judges, magistrates	88,000	Optometrists	65,000
Natural sciences managers	84,000	Pharmacists	63,000
Optometrists	84,000	Chief executives	60,000
Actuaries	80,000	Economists	60,000
Engineering managers	80,000	Computer/info system managers	58,000
Economists	73,000	Sales engineers	57,000
Astronomers and physicists	71,000	Actuaries	56,000
Chemical engineers	70,000	Air traffic controllers	56,000
Computer/ info systems managers	70,000	Chemical engineers	56,000
Financial analysts	70,000	Computer software engineers	55,000
Marketing and sales managers	70,000	Natural sciences managers	55,000
Pharmacists	70,000	Aerospace engineers	54,000
Veterinarians	70,000	Electrical/electronics engineers	54,000
Personal financial advisors	69,000	Astronomers/physicists	51,000
Air traffic controllers	67,000	Engineers, all other	51,000
Management analysts	67,000	Computer programmers	50,000

Source: U.S. Census Bureau, 2004a.

Higher pay differentials occur between science, engineering and technical (SET) occupations and non-SET occupations. In the UK, the gender pay gap is smaller in SET occupations, particularly those for engineers and technologists (women earn 86% that of men) and computer analysts (women earn 90% that of men) (DTI, 2004).

Women may face especially difficult obstacles to achieving equal participation in the labour force. The OECD (2002) identifies two obstacles for women: level of education and presence of children. 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 (e.g. employers tend to train better educated workers more) (OECD 2002). Consequently, training can exacerbate wage differentials between women and men, given that training has a positive impact on future earnings and productivity.

Benefits of a KBE for gender equality: Menzies (1998) suggests that some features of the developing KBE will benefit women. The shift in technological and organizational change from the 'substitution phase' to the 'innovation phase' is simultaneously moving outward from the economy's core toward the periphery, where improvisational skills are required to apply ICTs and where women are ideally suited to contribute. Women are well represented in sectors where ICT intensity has not yet peaked (e.g. education and 'low tech' occupations) and in occupations with some of the fastest growth rates (social sciences and knowledge work occupations).

Twenty-five years ago a study identified several key barriers to women's advancement:

- Women do not behave in an authoritarian way,
- Women feel responsible,
- Women are available: their door is always open,
- Women get personally involved, relationships are important,
- Women share their success with others.

These very 'barriers' to women's advancement in the old economy were pointed out as the qualities needed to transform organisations in the KBE (Conference Board of Europe, 2005).

Kofman (2003) suggests a feminisation of international migration in Europe is taking place. Women now participate in global movements including labour flows and foreign students. According to Kofman, changing labour market needs and immigration policies are reshaping female migratory flows. Labour shortages have become more pronounced across a variety of skilled and less skilled sectors and the gender balance differs considerably between sectors. Although migrant women tend to be identified with certain sectors (e.g. domestic labour, manufacturing, retailing), changing evaluations of skills and severe labour shortages will alter the gender balance, especially among skilled workers (Kofman, 2003).

Women and men ciruclate differently in this economy. During the IT bubble, it was not surprising to find that most of the work permits were given to men. In Germany in 2000 for example, only some one in ten of the Green card permits in Germany were for women (Kofman, 2003). Things are changing. According to Dobson *et al* (2001), the representation of women among the inflows to the UK of professionals and managerial workers is on the rise while some traditional areas have levelled off (Table 18).

Table 18. Representation of women in inflows of workers in the United Kingdom, 1980 to 1999.

	Managerial & professional workers		Manual & clerical workers	
	Total number (000)	**Percent women**	**Total number (000)**	**Percent women**
1980-1984	246.9	27.5	161.1	46.1
1985-1989	341.9	34.8	217.1	51.5
1990-1994	380.4	37.3	250.1	53.0
1995-1999	516.2	39.2	298.7	50.9

Source: Dobson et al, 2001; pages 92 and 94

There are social, cultural and practical obstacles to transnational mobility (EC, 2001c) Women still typically responsible for the family unit, including the education children and the care of elderly parents and other obligations in the home country. All of these responsibilities can create obstacles for women to engage in transnational mobility. The report of the High Level Experts Group (EC, 2001c) tells us that only a few Member States take into account family and moving costs when funds are granted for research or teaching periods abroad. Age limits applied in some mobility schemes may also limit possibilities for mobility for women, especially for women researchers who have taken time off for maternity (or family) leave (EC, 2001c). The report says more information is needed on the impact of maternity on the attraction of fellowships for researchers who are, or will be parents.

5.3 Is the KBE a green economy?

Does ICT bring benefits for the environment? More 'knowledge' embedded in machinery and other goods could increase the "intelligence" with which they use energy and resources. A classic example is integrated pest management (IPM) where knowledge on pest life cycles combined with field data on pest infestation levels can lead to more intelligent and vastly lower levels of pesticide use (Cowan and Gunby, 1996). There is clearly a large potential for ICT to improve existing trajectories of development both directly and indirectly through public policy, but ICT can also be employed in ways that produce environmental harm. One myth is that the importance of intangible or 'weightless' knowledge reduces the use of tangible materials and energy. Although partially true, the focus on knowledge hides from view the material aspects of KBEs, including material goods themselves and the production systems for producing goods and services.

5.3.1 ICT

The primary technology for 'intelligent' machinery and consumer goods is ICT. The extension of ICT to ever more sections of the economy could have beneficial effects on sustainable development. ICT is often viewed as 'green' because it is not polluting, can facilitate recycling and cleaner production, and improve public decision-making and public policy for the environment. For example, real-time sensors linked to computer systems allow companies to immediately identify leakages and optimise production processes for resource efficiency. Theoretically, ICT could allow for less use of paper, and even a paperless office.

This view of ICT as being inherently green and greatly contributing to environmental sustainability is, regrettably, far too optimistic. We did not get a paperless office (in fact paper use has increased); ICT facilitates long-range air travel, and ICT-based manufacturing methods lead to shorter product life cycles (Sonntag, 2003) that can increase product turnover and hence consumer waste. Table 19 summarizes the positive and negative impacts of ICT on the environment via its direct, indirect and structural and behavioural effects.

Table 19. ICT impacts on the environment

	Positive impacts	Negative impacts
Direct effects	Environmental monitoring, e.g. *remote sensing*	Environmental impacts of production, use and disposal of ICTs, e.g. *electronic waste*
Indirect effects	Improved efficiency, dematerialisation and virtualisation, e.g. *intelligent logistics, electronic directories*	Proliferation of electronic devices, partial substitution, such as both shopping trips and e-shopping with frequent deliveries
Structural and behavioural effects	Structural and life style transitions e.g. *growth of light industries, green consumerism*	Stimulating growth and re-materialisation, e.g. *growth of long-distance travel*

Source: Hertin and Berkhout (2003).

The full potential of ICT for environmental sustainability is not utilized. ICT offers methods for improving public transport and for reducing car-based transport, but until now it is mainly used in cars, in the form of driver assistance systems (GPS) and mobile phones. ICT makes possible more intensive use of urban space, for example with semi-automatic parking systems. ICT can improve public transport by making public transport à la carte possible, such as dial-a-ride and self-serviced electric vehicles. ICT can also be used to regulate driver's behaviour: control of traffic flows, flexible tariffs on certain road sections, and traffic deviation with the use of information boards. Through the emergence of electronic reservation systems and vehicle detection systems, traffic in cities can be organised more efficiently.

A disadvantage is that ICT facilitates air travel and contributes to travel overall. The number of teleworkers has stabilized. The policy implication of this is clear: one should be aware of possible rebound effects and encourage those forms of ICT (and other general purpose technologies) that offer true societal benefits.

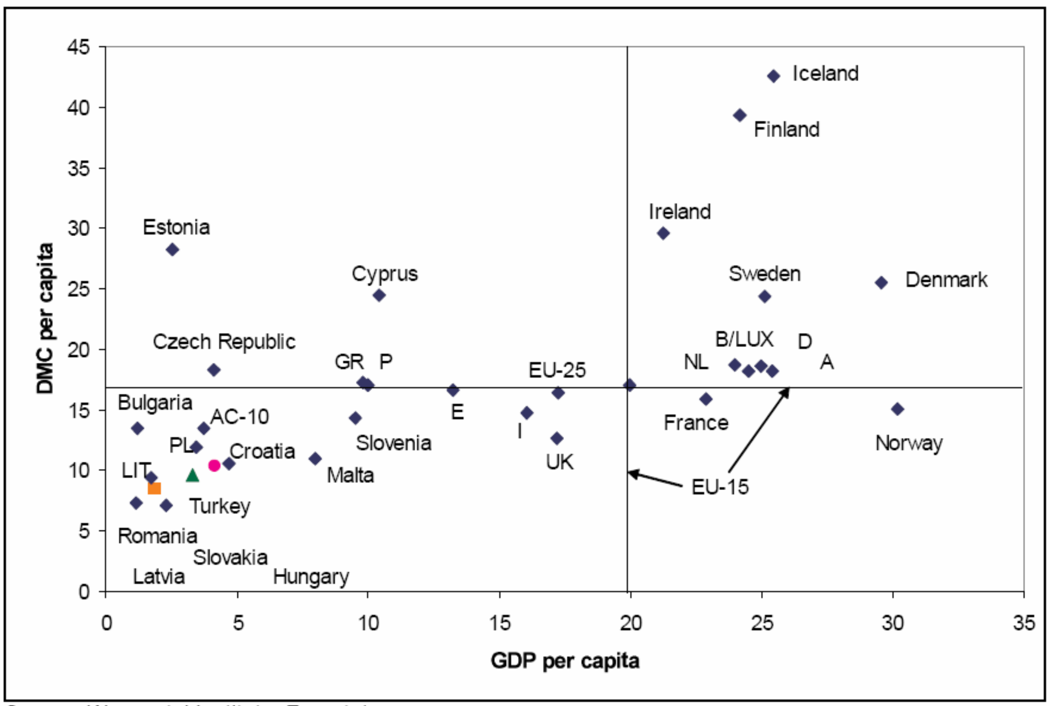
Better information at lower costs thanks to ICT might lead to better environmental policy. It allows nations to move towards a more responsive environmentalism that better internalises externalities, reduces costs, improves efficiency, promotes compensation for infringements of environmental property rights, and advances personal choice (Esty, 2004).

5.3.2 The weightless economy

In almost all economies, direct material consumption (DMC) per capita has increased, at the same time that economies have become more knowledge intensive. Countries that are viewed as knowledge-intensive such as Finland and Sweden use very high levels of material inputs, as shown in Figure 5[22].

Only a relative de-coupling between DMC and economic growth has been achieved, through improved efficiencies of material use. This is also apparent in Figure 5 that shows that Estonia, with a low GDP per capita, requires more material inputs than Demark or Sweden, with substantially higher GDP per capita. In Europe, resource productivity, measured as Gross Domestic Product derived from one kilogram of direct material consumed, varies from Euro 0.09/kg (Bulgaria, Estonia) to Euro 1.44/kg in France and Euro 2.01/kg in Norway. The average for the EU 25 is Euro 1.05/kg (ETCWM, 2005). These results show that we continue to live in a material world, even when the world is knowledge-based. Nevertheless, there are large opportunities for improving the efficiency with which resources are used.

Figure 5. Direct Material Consumption and GDP per capita in European countries.



Source: Wuppertal Institute, Eurostat

5.3.3 A note on the knowledge requirements for eco-innovation

Several types of knowledge are used in eco-innovation. Environmental innovation requires not only engineering knowledge about problems and solutions, but also organisational and managerial knowledge and knowledge about markets (about what customers want and how they can be persuaded into buying). Beliefs (which are also a form of knowledge) are also

[22] Direct Material Consumption (DMC) = domestic extraction + imports – exports.

important. For example, the belief that the “environment is a burden” will lead companies to avoid exploring innovative solutions.

It is hard to compare knowledge for eco-innovation with knowledge for normal innovation. For certain eco-innovations the technical knowledge requirements are quite large, much larger than that of less environmentally benign counterparts. From an engineering viewpoint, a hybrid electric vehicle with two forms of propulsion (one electric and the other based on combustion cycles) is far more complex than a vehicle with only an internal combustion engine, which is one of the reasons why car manufacturers were reluctant to invest in it. A bicycle, on the other hand, is simpler than any car.

6. Variations in Knowledge-Based Economi*es*

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), regions within specific countries (OECD, 2005; Florida, 2005), and among economic sectors. These include differences in investment in ICT, the supply of skilled human resources such as tertiary education levels or the educational attainment of 15 year olds; the production of new knowledge, as measured by investment in R&D, entrepreneurship, and the rate of adoption of new organisational forms. As an example, Figure 6 gives the 2005 results of the Summary Innovation Index (SII) from European Innovation Scoreboard, which includes several indicators of relevance to a KBE. Within Europe, national innovative performance ranges from a low of 0.18 in Slovakia (SK) to a high of 0.70 in Finland (FI) and Switzerland (CH).

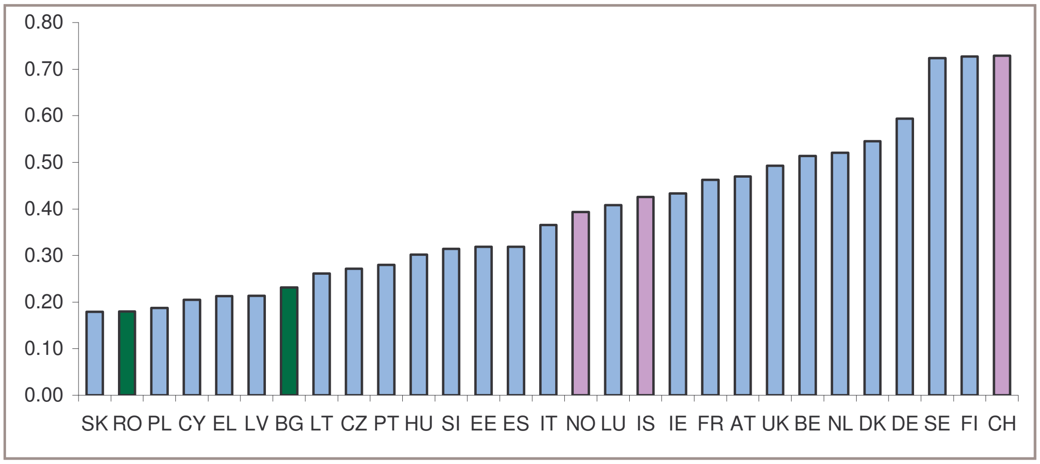
This section evaluates key issues in the characteristics of a KBE by geography, particularly across countries, and by sector. In addition, the public and non-profit sectors can play a vital role in the development of a KBE. The final sections discuss the limited evidence, to date, on KBE characteristics within these two sectors.

6.1 The geography of the KBE

The variation in many characteristics of a KBE across countries has been extensively studied for the last decade. One of the main issues is the effect of national institutions, including different national systems of innovation, on knowledge production, versus sectoral effects. For instance, many of indicators for knowledge production, such as patents, R&D and total innovation investments, and collaboration between firms vary both across countries and across sectors. A main research question is what fraction of these differences in knowledge production is due to country or sector effects? Research to date, although limited, indicates that sector affects account for a large percentage of national differences in business R&D investments (Evangelista et al, 1997) or in innovation outcomes (Calvert et al, 1996). This is not surprising. One would expect a country that specializes in pharmaceuticals and aerospace to have much higher R&D investments than a country that specializes in food products and textiles. These industry structure effects are the main reason why Finland has an R&D

intensity that is 94% above the EU average while Portugal has an R&D intensity 78% below the EU average.

Figure 6. The 2005 Summary Innovation Index (SII).



Notes: 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).

Other characteristics of a knowledge economy, such as total investment in ICT as a percentage of GDP, show far less variation across countries. For instance, the range in ICT investment across Europe ranges from only 18% below the EU average in Italy to a high of 39% above the EU average in Sweden. This is because ICT investment is relevant to all sectors, and consequently industrial distribution has less of an effect than it does for R&D expenditures.

6.1.1 Globalisation

Globalisation occurs when economically productive inputs are sourced in more than one country. A major challenge for the development of indicators is how to adjust for the effects of increasing globalisation on many of the main characteristics of a KBE, including the effect of the internet on consumption patterns, the sourcing of skilled human resources, knowledge production, and the organisation of production. The effects of globalisation are taken up in greater detail in WP 1.2.

A key example of globalisation concerns the location of R&D. As shown in Table 20, American MNEs spent 12.6% of their total R&D budget within foreign affiliates outside the US in 1999, an increase from 11.5% in 1994. Most of the foreign R&D by American MNEs was spent in Europe, but the European share has been declining, from 73% of the total in 1994 to 67% in 1999. Conversely, the share of Asia-Pacific countries has increased from 14.9% in 1994 to 17.8% in 1999.

Table 20. Global R&D employment & R&D expenditures by US MNEs, 1994 and 1999.

		Within US	Abroad	Total
R&D employees (thousands)	1994	624.8	102.0	726.8
		86.0%	*14.0%*	*100%*
	1999	646.8	123.5	770.3
		84.0%	*16.0%*	*100%*
R&D expenditures (million USD)	1994	91,574	11,877	103, 451
		88.5%	*11.5%*	*100%*
	1999	126,291	18,144	144,435
		87.4%	*12.6%*	*100%*

Source : National Science Foundation

6.2 Sectors

Studies on the KBE address the role of sectors in different ways. For example, Gera and Mang (1997) classify industries as belonging or not belonging to a 'knowledge' economy in order to analyse the economic transformations brought about by the KBE. Conversely, research by Lavoie and Roy (1998) and Baldwin and Gellatly (1998) do not restrict analyses of the KBE to a handful of industries, but argue that change is more pervasive and involves a series of changes in the nature of work and production. Baldwin and Beckstead (2003) find that high-technology firms are found across all sectors.

Beckstead and Gellatly (2004) identify 40 occupations as knowledge-based, falling under general classifications of professional workers, management workers and technical workers. Using these occupations, Beckstead and Gellatly focus on knowledge workers to identify 'high knowledge' sectors. They define 'knowledge leader' sectors as those that exhibit proportionately large concentrations of knowledge workers (e.g. workers employed in knowledge occupations). High knowledge sectors can be compared with traditional classification systems that classify sectors into high, medium and low technology industries. The results tell of dynamic growth in many sectors that are not classified as high technology (e.g. financial and business sectors). Financial services are a good example of a sector not previously classified as science or technology based. A second finding is that high levels of urbanization, often linked to emergent technology industries, are not unique to technology-based environments. A third finding is that using the high-knowledge classifications to examine the characteristics of the work force shows that the high-knowledge sectors place more emphasis on university education than do technology-based industries. Furthermore, many of the high-knowledge sectors have large concentrations of women in knowledge occupations. Beckstead and Gellatly's results show that the KBE is multidimensional rather than defined by sectors producing advanced technologies. Instead, the KBE includes all sectors that place a premium on knowledge creation.

All sectors are important players in a KBE, but the characteristics of the development and use of knowledge clearly varies by sector. It is well known, for example, that investment in R&D varies substantially by sector, as shown in Table 21. In the EU, the average R&D intensity in three low technology sectors (food, textiles, and wood products) was 0.2% in the latter half of the 1990s, versus 11.0% in aerospace (55 times greater). 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.

Table 21. Average sector R&D intensity in the US and EU between 1992-1995 & 1996-1999.

	US			EU-9[1]		
	Average 92-95	Average 96-99	% Change	Average 92-95	Average 96-99	% Change
TOTAL MANUFACTURING	3.0	3.2	**6.8**	1.9	1.8	-3.9
Food products, beverages and tobacco	0.3	0.4	**16.7**	0.2	0.2	0.0
Textiles, textile products, leather and footwear	0.2	0.3	**37.5**	0.2	0.2	**14.3**
Wood, paper, printing, publishing	0.5	0.6	**27.8**	0.1	0.2	**40.0**
Chemical, rubber, plastics and fuel products	3.5	3.3	-3.6	2.8	2.8	**0.9**
Coke, refined petroleum products & nuclear fuel	1.4	0.9	-33.9	0.8	0.6	-16.7
Chemicals and chemical products	5.3	5.2	-1.4	4.3	4.3	0.0
Chemicals excluding Pharmaceuticals	3.1	2.9	-6.4	2.6	2.3	-11.4
Pharmaceuticals	12.8	12.1	-5.3	9.2	9.9	**7.7**
Rubber and plastics products	1.1	1.0	-4.7	0.8	0.9	**12.5**
Other non-metallic mineral products	0.8	0.7	-12.9	0.5	0.5	0.0
Basic metals and fabricated metal products	0.5	0.6	**20.0**	0.5	0.4	-11.1
Machinery and equipment	5.9	6.6	**12.3**	3.7	3.2	-12.3
Machinery and equipment, n.e.c.	1.7	2.1	**20.6**	1.9	1.8	-6.6
Electrical and optical equipment	8.1	9.0	**10.8**	5.2	4.4	-15.4
Office, accounting and computing machinery	13.2	12.5	-5.7	4.7	2.5	-45.7
Electrical machinery and apparatus, nec	3.7	4.5	**23.3**	2.6	1.7	-32.4
Radio, television and communication equip.	8.0	8.7	**7.8**	9.8	8.8	-10.5
Medical, precision and optical instruments	7.9	9.7	**22.8**	6.0	5.1	-14.7
Transport equipment	6.8	6.1	-10.3	4.8	4.2	-13.5
Motor vehicles, trailers and semi-trailers	4.4	4.4	-0.6	3.6	3.3	-7.6
Other transport equipment	11.8	10.2	-13.8	8.8	7.2	-17.4
Building and repairing of ships and boats				1.1	1.1	**7.1**
Aerospace	14.8	12.9	-12.5	14.6	11.0	-24.6
Railroad equipment & transport equip. n.e.c.				2.6	3.2	**21.9**
Manufacturing nec				0.3	0.4	**16.7**
TOTAL SERVICES	0.35	0.38	**7.1**			
High-technology manufactures	10.6	10.7	**0.5**	8.7	7.7	-11.5
Medium-high technology manufactures	3.2	3.3	**3.1**	2.6	2.4	-8.6
Medium-low technology manufactures	0.8	0.7	-12.1	0.6	0.6	-4.3
Low technology manufactures				0.2	0.2	0.0

Source: OECD, STAN database. Increases in R&D intensity marked in **bold**.

A key characteristic of the KBE is sectoral change, or the shift from manufacturing towards services. In services, the percentage of knowledge workers is probably higher than in manufacturing. But does this mean that services are more knowledge intensive? They are more *labour*-intensive compared to manufacturing, but a direct comparison of the knowledge intensity of different sectors should include, in addition to the percentage of skilled labour, 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. Lacking a meaningful parameter for knowledge, we cannot say much on the changing knowledge intensity of the economy.

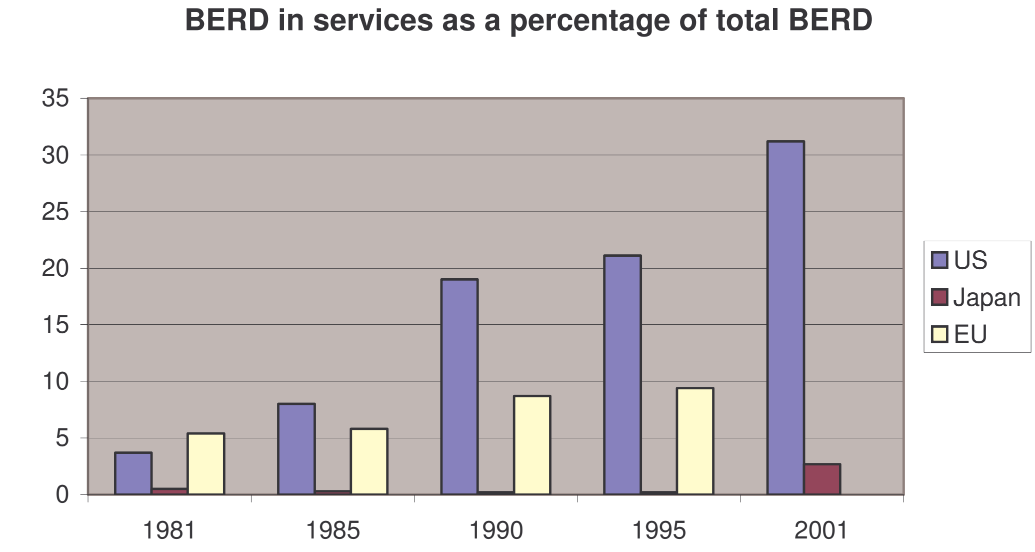
Other related aspects of sectoral change are discussed in OECD (1996a). All create problems for measurement. These include changes in the qualities and characteristics of existing products, the introduction of products with new, unspecified attributes or the development and expansion of new services that are notoriously difficult to measure, changes in the boundaries of firms, the sudden obsolescence of existing capital stock, and the entry and exit of firms.

There is increasing interaction between the manufacturing and services sector in today's economy (Wolf, 2005). According to Wolf's report on the service economy, this is happening for two reasons. First, the share of services that are necessary for or complementary to manufacturing goods production has increased (e.g. automobile production depends on marketing, technical research, development and design, human resources management, business consulting and sometimes financing provided by manufacturer).

Second, 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. In addition, 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. 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, as shown in Figure 7.

The discrepancy is partly due to how firms are classified to specific sectors. In the US, firms are classified by their principal activity, which is defined by the activities of the majority of their employees. In most EU countries, the classification is based on the types of products developed by the firm. For example, several major US firms that develop computer hardware are now classified as retail service firms, since there are more employees in sales than in manufacturing, due to production moving to Asia and Mexico. Consequently, R&D expenditures that used to be classified in office and computer equipment (a manufacturing sector) are now classified in retail services. In Europe, the R&D of this firm would continue to be assigned to manufacturing.

Figure 7



Source: OECD

Measures of the real impact of employment shifts brought about by the KBE are difficult. One example is the employment of engineers. Since outsourcing took off in the 1980s, data has shown declining employment of engineers in manufacturing industries and rising employment in services industries. Another example is the restructuring of the oil and gas sector. Originally, all activities were performed in-house, but after restructuring practically everything from civil engineering to soil testing was outsourced. Mobile Oil, for example, went from being a 'traditional' employer to an outsourcer of practically every activity from engineering to soil testing. For all intents and purposes the employment of scientists and engineers could have remained the same, but this S&T employment was now reported under the services sector and showed a drop in manufacturing industries.

Wolf recommends against considering services separately from manufacturing industries, given the complex interactions between them. Combining all services and all manufacturing would, however, be unrealistic, due to the large differences in conditions within specific 2-digit sectors. Nevertheless, Wolf's results underline the fact that there are serious measurement problems that can lead to biased measures of productivity growth and other conditions such as employment in both the manufacturing and services sector.

6.2.1 The public sector

The public sector can contribute to the knowledge economy through innovation in how it provides services to the public and through programmes to support the drivers of a KBE, such as educational programmes to supply skilled human capital. This report focuses on the first factor. WP 1.3 discusses policies for a KBE.

Technology adoption is important to the public sector. In Canada for 2002, the rate of technology adoption in the public sector was 82% and close to double the 42% of the private sector (Earl, 2004). Earl's work shows that the introduction of change, be it technological or organisational occurs more frequently in larger organisations and so this favours a public sector such as in Canada which is largely made up of organisation with more than 500 full-time employees. (Earl notes that although the private sector generally lagged the public sector in acquisition of significantly improved technologies, when firm size is comparable (e.g. a firm with at least 500 employees), there is minimal variation between the adoption rates).

A major innovation in the provision of public services is to provide internet portals for many government activities, including the filing of tax returns or information on 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 (e.g. education, government services) one must consider access. For e-learning and e-government to serve citizens, citizens must have access to the internet. Moreover, policy needs to consider variations in internet access according to variables such as gender, age, education, employment and qualifying factors for government programmes (e.g. disabled). Table 22 shows how internet access in Denmark varies by sex, age, education and employment status.

Table 22. Internet access in Denmark, 2004.

	Percent
Access to the internet – total	83
Total – for men	85
Total – for women	82
All persons aged 16-19 years	96
All persons aged 20-39 years	90
All persons aged 40-59 years	89
All persons aged 60-74 years	54
Persons with primary/lower secondary education	72
Persons with upper secondary education	85
Persons with university education	96
Students	96
Wage-earning employees	83
Salaried employees	96
Self employed	91

Source: StatBank Denmark (2005).

E-education: The OECD's *Education At A Glance* reveals considerable variance among students' access to new technologies (OECD, 2003b). For example, in Canada, Finland and New Zealand, 90% or more of students have access to a computer compared with 25% of students in Italy. A second useful indicator is internet use by students. On average, about half of the students in OECD countries use the internet, although the rates are higher in Canada and in the Scandinavian countries. This has implications for e-education policy.

We also need to consider the development of learning and up-skilling, both important features of a KBE and the need for life-long learning. How is education working to ensure citizens have the opportunities to engage in continuous learning and take advantage of the new technologies? What is the contribution of the government and private sector?

Post secondary institutes are busy building technologies into programme delivery. Leaving behind the discussion of a 'virtual university', research shows that a number of concrete activities are underway to improve access to skills development for citizens of all ages and abilities (e.g. disabled). For example, in Canada, universities, colleges and government have set up an internet portal that connects learners to more than 2,000 on-line credit courses as well as essential services such as skills assessment, skills development and other learning resources. The portal offers people one-window registration and student services, credit transfer and credit recognition, credit banking and prior learning assessment. The portal also services employers by providing workplace learning, information on areas of study, and customised training. Learners have instant access to a wide range of courses from work, at home and within the community. In 2002, government, industry and academia in Taiwan collaborated to develop systems and materials for online education in the Asia-Pacific region (Ministry of Economic Affairs for Taiwan, 2005).

E-learning means employers can upgrade the skills of their employees company-wide with a facilitated training process. At the same time, employees receive formal accreditation. Companies can deliver training in a consistent and timely matter and employees get a tangible return, from an accredited course to career advancement. E-education can change the way citizens and employers alike embrace lifelong learning.

Two groups of indicators would be useful for tracking these developments. First, we have to go beyond indicators of formal levels of education, such as the percentage of the population with a tertiary degree, and develop indicators for changes to the skills of workers and citizens that occur through other types of education and learning. Second, impact measures (e.g. composite indicators for learning and performance) are needed for policy and strategic planning. KMPG consulting provides an interesting example of an impact measurement for e-learning. Using a combination of classroom and e-learning, 8,000 employees completed a course on e-fundamentals in 12 weeks. KMPG estimated that to put these same employees through classroom training in its own facility (e.g. the 'old' traditional way) would have required three years (InternetWeek, November 2000).

E-government services: Government is not only a user of new technologies but also a key creator, keeper and distributor of strategic information to business and citizens. While many statistics to measure the KBE have been harmonized (e.g. ICT penetration and internet usage), definitions of the use of ICT and the internet by the public sector can vary across countries and even within countries (e.g. regional, municipal) (Lundø, 2001). Table 23 gives an example of the types of data collected in a Danish survey on the use of ICT in the public sector.

Table 23. Questionnaire modules on the use of ICT in the public sector, Denmark, 2001.

Web site/electronic services	• Home page • Information on home page • Communication via home page
Intranet	• Having Intranet • Organisational coverage • Contents
Other ICT systems	• Electronic filing system • EDI
ICT expenditure	• Previous year • Current year • Forecast
Strategy and co-operation	• Strategy • Coverage Co-operation with other governments (e.g. departments, municipalities)
Barriers to usage	• In general • Electronic services

Source: Statistics Denmark, 16th Meeting Voorburg Group on Services Statistics, (Lundø).

The forecast for total government ICT spending across Europe is that it will increase from EUR 87 billion in 2005 to EUR 94 billion in 2007 (IDABC, (Kable), 2005a). The UK public sector spends about 40% more on ICT than counterparts in Germany and or France. Sharp differences between spending in the UK and other European countries are continuing: 37% of total UK public sector ICT spending goes to external services such as consultancies and outsourcing while the European average is less than half of that at 16%. Denmark tops the per capita investment on public sector investment in ICT at EUR 384 per head compared with EUR 336 in the UK. Estonia leads on spending as a proportion of GDP at 1.15%. Overall growth rates are expected to reach 3.3% in 2006. In the Netherlands, the public sector is spending increasing monies on networking and connectivity. More and more public administrations are adopting virtual private networks (VPNs), permitting low-cost secure sharing of information among government employees and external contacts, when relevant. In the Netherlands, an estimated 21% of central government agencies and provinces and 16% of the municipalities were using VPNs in 2004 (IDABC, (MarketCap), 2005b).

Governments continue to expand services offered through electronic access. Table 24 presents data on the share of individuals and enterprises by country that interact with public authorities through the internet. Rather surprisingly, given the UK's lead in ICT expenditures, are the low percentages of citizens and enterprises in the UK that report the use of the internet for public authority exchanges. For instance, only 19% of individuals in the UK use the internet to obtain information about public services, compared to 43% of Danes and 27% of Slovenes.

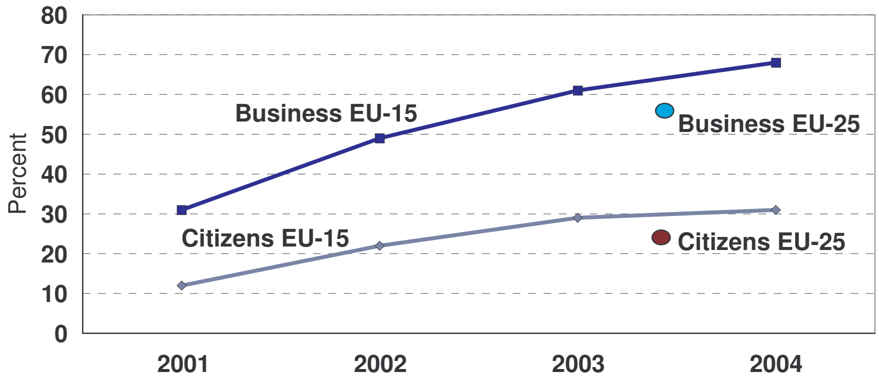
Table 24. Percent of individuals and enterprises using the internet to interact with public authorities. Data for 2003 (except where noted).

	Individuals			Enterprises		
Country	Obtaining information	Obtaining forms	Returning /filing forms	Obtaining information	Obtaining forms	Returning /filing forms
Austria	14	11	5	65	73	43
Belgium	--	--	--	59	40	24
Cyprus[1]	32	11	4	42	30	13
Czech	12	3	1	61	48	19
Denmark[1]	43	16	14	62	54	35
Finland	39	16	9	86	79	55
Germany	23	12	7	31	28	14
Greece	6	2	3	--	--	--
Ireland	10	7	5	56	45	25
Italy	--	--	--	68	53	35
Luxembourg	25	17	11	60	50	24
Netherlands	--	--	--	39	34	24
Poland	41	19	12	--	--	--
Portugal	10	5	5	46	40	44
Slovenia[1]	27	16	7	46	43	36
Spain	19	10	6	43	40	29
Sweden	41	23	12	85	83	41
UK	19	8	4	26	20	8

Source: IDABC, 2005b.
1: Data for 2004.
--: Not available

According to an on-line report on public services (EC, 2005b), the share of fully transactional on-line public services stands at around 40%. In the EU-15, 46% of the public services are fully transactional whereas the figure is lower for the EU-10 at 29%. The report goes on to say that online sophistication of public service provision is still more developed for businesses than for private citizens. This may not be surprising given the that the best performing cluster in public services was among income generating services followed by registrations, returns and then permits and licenses. Figure 8 shows the evolution of full on-line availability of services for business and citizens.

Figure 8. Public services fully on-line by target group, 2001 to 2004



Source: DG for Information and Media.

E-participation in governance: Web-based technologies can provide the opportunity for governments to increase the participation of citizens in the democratic process. Central government sees local government as critical for establishing local electronic policy to offer technology and service delivery at local councils that can in turn be used as centres for local area ICT-dissemination (Malta e-Government). Town hall meetings may well give way to on-line discussion forums. It would be difficult but useful to have indicators on the extent to which the internet and other ICT technologies have been drawing citizens into the democratic process. We know that e-mail has made it easier for citizens to contact their elected representatives — in the US in 2001, 85.5 million e-mails were sent to the US Congress. To what extent are citizens making use of the volumes of information available in the government domain? Is it possible to develop indicators for e-decision-making?

A United Nations (World Public Sector Report 2003, E-Government at the Crossroads) was carried out to develop an *e-participation* index to gauge differences in on-line strategies and approaches to citizens' involvement. Although the survey does not fully account for different types of political e-participation, it does look for government attempts to use ICTs to engage citizens, albeit in a consultative process as opposed to decision-making. Table 25 shows the 2004 e-participation index for the top 20 countries surveyed in which the UK leads with the US close behind. As the table shows, the score drops from 100 to half of its value over the top 15 countries. The results 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 (UN, 2003).

Table 25. E-participation index 2003.

Rank	Country	Index	Rank	Country	Index
1	United Kingdom	1.000	11	Mexico	0.603
2	US	0.966	12	Argentina	0.586
3	Canada	0.828	13	Ireland	0.586
4	Chile	0.828	14	Sweden	0.586
5	Estonia	0.759	15	Germany	0.534
6	New Zealand	0.690	16	Republic of Korea	0.483
7	Philippines	0.672	17	Italy	0.466
8	France	0638	18	Singapore	0.466
9	Netherlands	0.638	19	Switzerland	0.466
10	Australia	0.621	20	Denmark Finland Portugal	0.448

Source: UN, World Public Sector Report, 2003

Public science: The science system (essentially public research laboratories and institutes of higher education) carries out a key function in the KBE, including knowledge production, transmission and transfer. The problem facing the public science system is how to reconcile its traditional functions of producing new knowledge through basic research and educating new scientists and engineers with its newer role, one of collaboration with industry (OECD,1996c). Toonen (2004) recommends that public-private dynamics in higher education need to be understood in the context of a long-term, international, and institutional change in the role of the public sector, which suggests that it might be impossible to influence private-public interactions. This seems unlikely, since an unknown but significant proportion of business-public science interaction is directly supported by European policy, such as through direct subsidies for collaborative research. The concern is that 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. Some relevant indicators are available, such as on the percentage of firms that collaborate with universities and patenting by public science. However, 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.

6.2.2 The volunteer non-profit sector

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

From local soup kitchens to national charities for the homeless and international aid agencies, information is continuously gathered, processed and disseminated (Burt and Taylor, 1999).

A 1999 survey carried out in the UK confirmed that 84% of more than 400 volunteer organisations reported using some form of computer networking. Table 26 gives some of the survey results on the use of ICT by these organisations.

ICTs have the potential to transform internal governance in the volunteer non-profit sector, but the evidence from the UK (Burt and Taylor) suggests that the sector is not exploiting the opportunities available: only 7% provide electronic discussion forums (or similar electronic mechanisms to exchange information with stakeholders) and fewer than 3% enable stakeholders to participate in the internal policy process.

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. How are ICTs transforming internal governance? How do ICTs support strategic and operational activities? What about the geographic re-location of work? Have services improved (quality and speed) for citizens? How are ICTs supporting organisational requirements?

Table 26. Measures of technology uptake among volunteer organisations, UK, 1999.

Telephone	69% used mobile telephony; 6% use smart phones; 5% of organisations had call centres.
Basic computing	98% (in 1998) used desktop computing; 6% drop forecast in use of desktop computing; almost 65% used some form of portable computing (with 10% expecting to adopt it).
Electronic networking	Number of organisations using ISDN expected to rise to 51% within five years of survey; 69% use server technology; by 2000, 87% expect to use web sites compared with 50% already using it; Intranets used by about 25% of the organisations with 46% signalling their use within a few years; 2% use extranet technologies.

Source: Burt and Taylor (1999).

Government has a role in the reshaping of the volunteer non-profit sector brought about by ICTs, as they try to take advantage of ICTs to provide better client services through e-delivery. Non-profit organisations typically operate on shoestring budgets and ICTs can help stretch the funds — more can be achieved with the same funds. ICTs increase the capacity of volunteer organisations and improve programme effectiveness (IM/IT Canada, 2002). There are many opportunities for government to work with non-profits and businesses to provide technology solutions and hands-on technical experience (Voluntarygateway.ca, 2005).

7. Conclusions

The preceding literature review identifies an extensive economic and social debate on what the KBE has brought about and what it may bring about in the future. Regardless of the different theories to explain the uniqueness (or lack of uniqueness) of a KBE, there is a common core of factors that are important for a KBE. It is the stress or importance placed on each factor as a driver of economic growth that differentiates one theory of a KBE from another.

Theories may place different emphasis on the components of a KBE, but regardless of the debate, the literature signals the need for more and broader coverage of component indicators. For example, it could be a mistake to adopt a narrow definition of the "highly-skilled" and to focus data collection and analysis on one narrow segment of skilled workers, such as PhD holders. Instead, research to date suggests that we need indicators for different types of skill levels, defined not only by education levels but also through informal learning. An increase in the variety and number of indicators also suggests a role for composite indicators that can reduce complex data sets in a way that can help users to better understand the relationships among the factors in the KBE.

7.1 Indicators and composite indices for the KBE

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. Here we can think of commonly used indicators of business performance, R&D activities, patents and so on. The 1970s and 1980s saw increasing use of these indicators and analyses of their effect on GDP (ABS, 2003). A large array of indicators was assembled and evaluated to identify causal or leading relationships and to recognize the early signals that predict performance and growth.

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 (ABS, 2003). Taken together, a group of indicators can 'collectively' give early warning signals. 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. One problem is that composite indices, even more than individual indicators, suffer from the 'black boxing' problem, in which problems of comparability and accuracy with the original data become invisible (Godin, 2005, ch 9).[23]

[23] 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 2005.

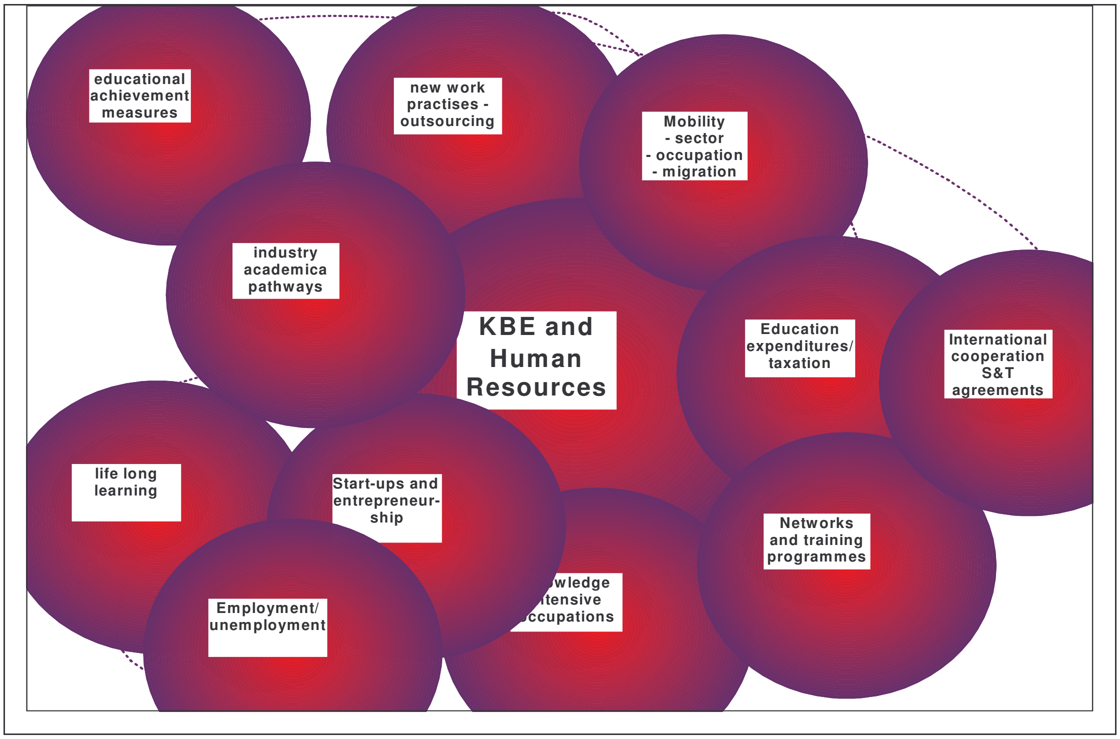
The review of KBE characteristics and drivers points to the need to revisit existing composite indicators as well as the need to develop new composite indices. If we go back to the notion of a ‘constellation’ of indicators, we can consider the “night sky” of a KBE (see Figure 9). Some ‘stars’ (indicators) 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 need indicators development.

The European Parliament, in its 7th Framework Programme, recognizes the increased role of knowledge in the economy and is looking to interpret research and innovation across all sectors within Europe and among major competitors, such as the US and Japan. At the same time, indicators for India and China are required to keep track of their advances, their adoption of new technologies, their adaptation to the requirements of a developing KBE, and what this might mean for European research and innovation. Policy priorities for the 7th Framework Programme include health, food, agriculture and biotechnology; information and communication technologies; nanosciences, nanotechnologies, materials and new production technologies; energy, environment, transport, socio-economic sciences and humanities; and, security and space. The diversity of research areas will increase the need for more sophistication with existing composite indices as well as increase the need to develop new indicators for use in new composite indices. What are the key segments of the economy in relation to overall economic activity? How much of the KBE is truly different or new and driven by technology’s power to make things for business and people better, vs. how much is it business as usual, but simply with new tools? This latter point came across quite clearly when government e-services were examined. There is rather intriguing evidence that suggests that governments developed e-services most rapidly for revenue generating activities, as compared with knowledge-sharing purposes. It appears that e-technology made few fundamental changes in government. Instead, e-technology 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).

Human resources are a priority in the KBE. Typically a form of ‘lip service’ has been given to addressing the human element of the KBE, but again, much of the data and indicator development rests with traditional approaches. Occupations are still classified as high skill or medium skill, despite the diversification of skills within occupations and across sectors. Occupations are composed of a range of skills (and specializations) and vary across sectors (and countries). The utility of comparing occupations on the basis of low, medium and high skill levels is limited, unless all countries use an identical set of classification criteria, which is not the case.

Revisiting indicators for measuring human beings in the KBE is necessary. Figure 10 shows some dimensions and indicator needs for human resource indicators. The figure suggests the linkages and needs for composite indicators that can inform horizontal policy requirements.

Figure 9. Some of the human capital dimensions in a KBE.

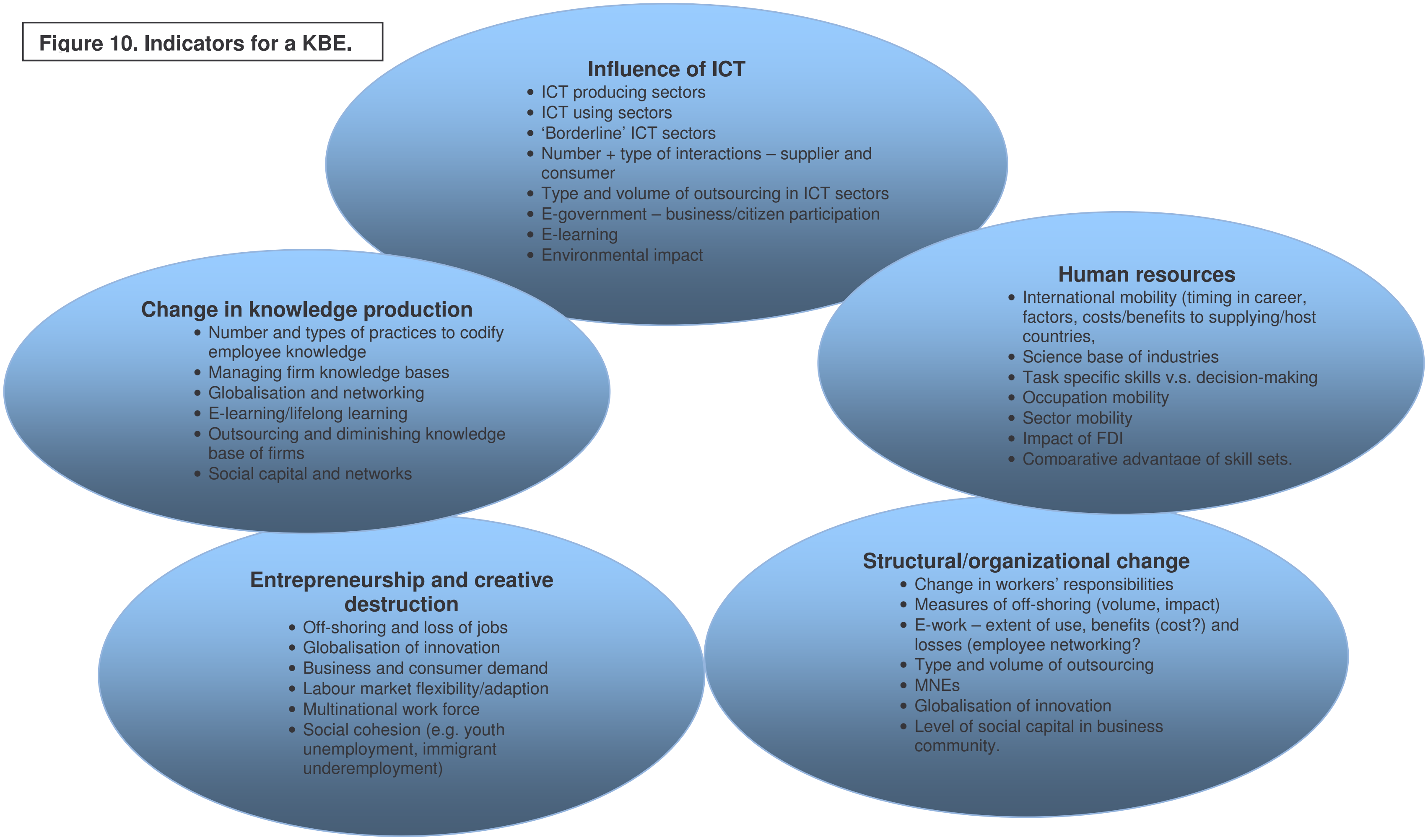


7.2 A Brief Summary of indicator requirements

The review of the 'state of the art' has identified 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. Research also shows that it is impossible to assign all indicators to only one category within a classification scheme. This is illustrated in Figure 10, which assigns many of the new indicators that still need to be developed to the five main characteristics of a KBE. For example, several of the needed indicators for work structure and organizational change are also measures of the influence of ICT production and diffusion, just as human resource indicators will respond to demand for indicators on ICT production and diffusion and changes in the work structure. 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. And the cross-connections go on and on.

The indicators presented in Figure 10 give some of the priorities identified in the research for indicator development. It also serves to show the overlaps in indicator requirements based on the five main characteristics of the KBE. A more detailed list of indicator requirements is presented in Annex A for additional reference.

Figure 10. Indicators for a KBE.



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Annex - A

KBE indicators 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 off-shoring 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 (graying of 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.