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The IPTS REPORT

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ABOUT THE IPTS REPORT

The IPTS Report is produced on a monthly basis - ten issues a year to be precise, since there are no issues in January and August - by the Institute for Prospective Technological Studies (IPTS) of the Joint Research Centre (JRC) of the European Commission. The IPTS formally collaborates in the production of the IPTS Report with a group of prestigious European institutions, forming with IPTS the European Science and Technology Observatory (ESTO). It also benefits from contributions from other colleagues in the JRC.

The Report is produced simultaneously in four languages (English, French, German and Spanish) by the IPTS. The fact that it is not only available in several languages, but also largely prepared and produced on the Internet's World Wide Web, makes it quite an uncommon undertaking.

The Report publishes articles in numerous areas, maintaining a rough balance between them, and exploiting interdisciplinarity as far as possible. Articles are deemed prospectively relevant if they attempt to explore issues not yet on the policymaker's agenda (but projected to be there sooner or later), or underappreciated aspects of issues already on the policymaker's agenda. The multi-stage drafting and redrafting process, based on a series of interactive consultations with outside experts guarantees quality control.

The first, and possibly most significant indicator, of success is that the Report is being read. The issue 00 (December 1995) had a print run of 2000 copies, in what seemed an optimistic projection at the time. Since then, readership of the paper and electronic versions has far exceeded the 10,000 mark. Feedback, requests for subscriptions, as well as contributions, have come from policymaking (but also academic and private sector) circles not only from various parts of Europe but also from the US, Japan, Australia, Latin America, N. Africa, etc.

We shall continue to endeavour to find the best way of fulfilling the expectations of our quite diverse readership, avoiding oversimplification, as well as encyclopaedic reviews and the inaccessibility of academic journals. The key is to remind ourselves, as well as the readers, that we cannot be all things to all people, that it is important to carve our niche and continue optimally exploring and exploiting it, hoping to illuminate topics under a new, revealing light for the benefit of the readers, in order to prepare them for managing the challenges ahead.

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ERRATUM

In issue 46, for reasons of space, the marginal note on page 17 referred to ICANN as the "US naming agency". This may have caused confusion. Strictly speaking, ICANN is the US-based international agency responsible for overseeing the administration of the domain name system and not a domain name registrar. Full details of its role, and a (long) list of registrars accredited by it, are available from its website at **www.icann.org**

EDITORIAL

Efficiency in health care: technical arguments and values

Dimitris Kyriakou, *IPTS*

Health care innovations and the way we pay for them involve extremely thorny questions, and provide critical tests for dearly held notions such as efficiency, equity and social welfare. The pressures to innovate in the health-care systems themselves have been growing in recent years for several reasons, including an ageing population (recall that more than 60% of an individual's health care expenditure is concentrated in the last year of his/her life) and evolving (costly) technology. Health-care costs already represent a conspicuously large part of GDP expenditures in many western countries (with the US routinely registering above 12% of GDP).

Given the fiscal pressures (often exacerbated by the need to reduce overall budget deficits, or to shift expenditures towards other categories), it is not surprising that there are increasingly calls to maximize the return for each euro spent on health care. This is often (and occasionally misleadingly) called "raising the system's efficiency".

Whereas in everyday terms raising efficiency implies reducing wastefulness, in this case the definition implied is both more "positive" (increasing something as opposed to reducing waste) and more subject to interpretation: increasing efficiency is reflected in rising "social welfare". But how is an increase in social welfare to be measured/represented in this context? Most commentators on this are not explicit about this, but what lurks in the back of their minds is often one of two ideas.

In the "easy" cases social welfare can be raised by improving at least one person's welfare without making anyone else worse off (reflecting the so-called Pareto criterion) – which however assumes away altruism, guilt, envy, etc. (i.e. all the well known very human feelings that make the welfare of others impinge on ours).

In more difficult cases where actions benefit some and hurt others, examining the impact on social welfare involves comparing the value different individuals attach to developments/events. To enable comparisons between the value placed on a given thing by different individuals the maximum amount of money each individual would be willing (and able) to pay for that thing is normally taken as the measure of its value to him or her. In the medical context, the value of a certain clinical procedure costing 10,000 euros to an individual eager (and able) to pay it, would be taken to be precisely 10,000 euros, even if all doctors clearly advise him/her that it is useless. As another example, the value (and corresponding increase in welfare) of a certain procedure that costs 50 euros to a family willing (and able) to pay 1000 euros for it, is higher than that experienced by a family unwilling (and/or unable) to pay no more than 100 euros for it. The net increase in their welfare would be 950 for the former family and 50 for the latter.

A very prominent view of what raising efficiency and social welfare implies, in the case of comparing valuations between people (the so-called Kaldor criterion), suggests that if those who benefit from a development/event value their benefits so that they could in principle compensate those who lose from it, then total social welfare would be raised through these developments, even if COMPENSATION IS NOT ACTUALLY GIVEN.

An example may make the argument clearer: If market liberalization pushes the price of the 50Euro treatment to 200 Euros and the family who valued it at 1000 Euros can have it whereas the family willing to pay up to 100Euros for it will not. This will reduce waiting-in-line as fewer people will be getting the treatment (i.e. those that value it at 1000Euros). The net benefit to the patient using it at 200 Euros (and valuing it at 1000) is so high, the argument goes, that he could compensate those who value it at 100 – give them the 100 Euros they do not receive in terms of the value they assign to the foregone treatment – and still be better off. So, even if there is no actual compensation, the argument goes, overall welfare goes up.

The outline of this version of the "raising efficiency" argument can be summarized as follows: raise social welfare by allocating scarce resources in health care services to where they are more highly valued. Note that in the "pure form" of the argument, even endowing low-income families (unable to pay the 50 euros in the example above) with a corresponding voucher will not help much, because prices will be bid up by those willing and able to pay 1000 euros for the same procedure.

In short, raising efficiency through bringing allocation of health services to reflect willingness and ability to pay will simply make the distribution of health services reflect ever more closely the distribution of income in society. Starting with the technical, objective-sounding premise of raising efficiency one may end up with a heavily value-laden justification of associating income/wealth and deservedness of medical treatment.

Such considerations are far from merely theoretical. The aforementioned approaches have propelled efficiency-enhancing liberalization (in the US since the late seventies), which have raised vastly the technical sophistication of health care and the amenities offered to well-insured patients. On the other hand however, and perhaps surprisingly, at least to their proponents, these reforms have also increased sharply the prices of health services and health insurance policies, while generating excess capacity all around! Part of the reason for this peculiar situation is the role of (and competition in) technology. When it comes to health decisions, consumers of medical services find it hard to engage in comparison-shopping to find a better price. Since they can often not identify with certainty equal quality levels (so that they can choose the cheaper alternative within the same quality class) they focus on signals such as technology, office looks and location, etc. which all are contributors to raising costs.

As a result, and by way of example, even at times in which the average occupancy ratio in US hospitals is not high, hospitals charge prices high enough to enjoy positive profit margins. Studies on screening mammography for instance in the early nineties showed that the US had four times as many mammography machines as needed, given the utilization rate. Since the average machine was highly underused, prices were twice as high as would be needed to amortize a fully used machine with decent profit margins. If preventive mammography is uninsured then one can arrive at the paradoxical situation in which low-income families have little access to such screening because there are too many mammography machines.

Patent Citation Analysis as a Policy Planning Tool

Martin Meyer, *SPRU*

Issue: Patent citation analysis is a relatively recent bibliometric approach to studying the science/technology interface. Currently, patent citation data is chiefly used to justify public funding of basic research. However, there are also a number of other potential applications that could be of use in programme and workshop planning.

Relevance: Actors in RTD policy refer increasingly to bibliometric evaluation tools. Not infrequently, the development of new metric tools generates a certain degree of insecurity and uncertainty regarding the interpretation of the data they generate. Applying problematic interpretations in a policy context could lead to misinformed decision-making.

Patent citation data is often applied in the context of the linear model, which assumes that spectacular breakthroughs by academic scientists are transformed almost instantly into innovations by industry

Patent citations and the linear model

The analysis of patent citations referring to the scientific literature is subject to debate. Patent citation data is often applied in the context of the linear model. The *"linear model of innovation"* assumes that spectacular breakthroughs by academic scientists are transformed almost instantly into innovations by industry through the transfer to industry of specific artefacts that arise from university research. A simplistic interpretation of this model suggests that increased funding of basic research would lead to a higher rate of innovation. For a long time, this "science-push" model has prevailed for the lack of alternatives. However, case studies by historians of technology have demonstrated that the linear model does not sufficiently explain technical change. Layton (1988) showed that, in the case of steam power, technology even led science. Other studies pointed to the manifold and complex reciprocal contributions of science and technology (e.g. Meyer 2000a, b). However, linear lines of thought can still be traced in work on so-called science-based technologies. One must be aware of a basically linear understanding of the innovation process in the context of patent citation analysis. Potentially suggestive terms, such as "science dependence" of technologies, should be avoided. Micro-level case studies of patents in science-related fields seem to indicate that in many instances where patent citations link patented technology to published scientific work it is very difficult to make judgements as to the direction of the knowledge flows. Rather than indicating just scientific contributions to technology, patent citations seem to link technological artefacts and scientific work that are the result of either unified knowledge generation or essentially reciprocal exchange processes.

In short, it would be a substantial mistake to use patent citations and their frequencies as an indicator of the science-dependence of a technology, without bearing in mind the contributions in the opposite direction. It is highly problematic (and perhaps prone to misinterpretations) to justify the public funding of basic research by relying on the number of patent citations to scientific research papers[1]. However, patent citations might find new applications as a policy-planning tool.

Novel applications

In this section, we shall explore potential new applications of patent citation analysis. In particular, we shall give examples of how patent citation analysis and related measures could be used to address the following tasks:

- Following the general orientation of fields over time;
- Measuring the intensity of the science-technology interaction;
- Tracking potential knowledge flows:
    - between scientific and technological or industrial fields and subfields;
    - between organizational entities within a scientific and technological area;
- Identifying potential key actors, i.e. the people that are capable of both academic research and technological development in an area.

We shall illustrate these potential applications using recent bibliometric data on nanotechnology-an emerging, science-based technology. We chose nanoscale sciences and technologies as an example for a variety of reasons. Braun et al. (1997) describe nanoscience and nanotechnology in their bibliometric study as a young and emerging area with hardly any publishing activity in the 1980s but exponential growth in the 1990s. In a later study, Olle Persson and I confirmed the Braun et al.'s findings and also detected some evidence for the science-related character of the field (Meyer and Persson, 1998). More than 60% of the nanoscience papers we found belonged to the category of natural sciences, whereas only around 20% of the papers belonged to an explicit engineering discipline. We were able to identify more than 2,600 patents using search terms based on our bibliometric study. The patent database comprises mainly patents in instrumentation, electronics and electrical engineering, and chemicals/pharmaceuticals, which are fairly close to the major scientific disciplines dealing with nano-scale phenomena. Therefore, one should expect an increased number of connections to occur between these subfields of science and technology. The following examples of applications are based on exploiting these databases, mostly by way of analysing the patent citations that connect them.

Following the general orientation of fields over time

Patent citations are the link that connects the publication and patent databases. If one understood patent citation analysis in a sufficiently broad manner, it could also include observations as to the development of the particular data sets it draws on, namely patents and publications. Again our example is taken from the area of nanoscience and technology. This application is fairly straightforward since it tracks over time both the development of publications in a scientific field and the evolution of the corresponding technological field. Fig. 1 illustrates our example.

If one looks at the development of nanotechnology patenting, one can find a slow and gradual increase of patenting activity starting in the early seventies and continuing up until the late eighties. Then, one can observe a much stronger growth pattern. Nanoscience publications began to

Case studies by historians of technology have demonstrated that the linear model does not sufficiently explain technical change, indeed, in some cases technology can even be ahead of science

In the studied example, patenting in the nanotechnology field grew slowly from the early seventies through to the late eighties. Much stronger growth then followed and by the early nineties several hundred papers had been published appear in the late eighties and by the early nineties several hundred nanoscience papers had been published. This take-off has not stopped yet. This leads on to ask questions such as: What is behind these developments? What has led to this growth? Is there a connection between publications and patenting in nanoscience & technology?

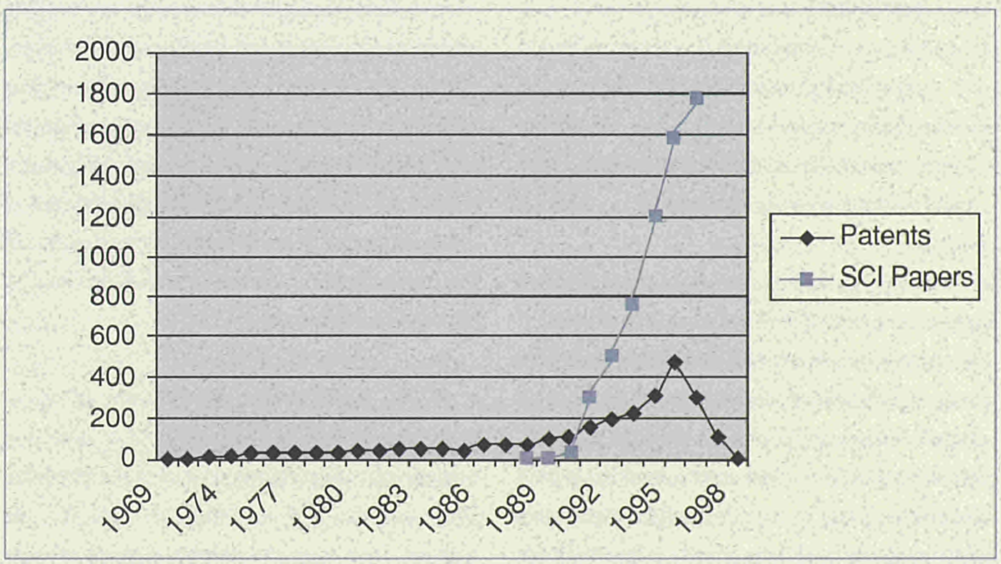
One can construct a plausible connection. One finding from the analysis of the patent data was the large share of instruments-related patents. These began to appear early on in the development of the field. Furthermore, the rapid increase in scientific publications appears to coincide with an upswing in patenting. This seems to suggest a "Rosenberg pattern", in which instrumentation developed in the early stages preceded and facilitated scientific exploration that, in turn, stimulated technological development. Tracing publications in relation to patenting in given subfields seems to be a useful instrument for identifying governance shifts in certain scientific-technological areas. More specifically in our example, the data appear to point to the transition from an instrument-driven field of science into a science-based field of technology. Recognizing such a shift is important since an instrument-driven field of science demands a different support and incentive structure than does a science-based field of technology. The following section will show how one can use patent citations to determine the extent to which these developments in publications and patenting are related to each other.

In the case of nanotechnology, the data appear to point to a transition from an instrument-driven field of science into a science-based field of technology in which instrumentation developed in the early stages preceded and facilitated scientific exploration that, in turn, stimulated technological development

Measuring the intensity of the science-technology interaction

The previous section compared patenting to publication activity. In this section we shall show how patent citations can be used to find the actual overlap between the two fields. One way of measuring the relevant "interaction" between science and technology is tracking the connection between scientific and technological output databases. This link can be established by way of patent citations. In our context, the number of patent citations are not taken as a measure of the science-dependence of a particular technology but as an indicator regarding the extent to which respective scientific

Figure 1. Nanoscience publications and patenting over time[2]



Source: Meyer (2000b)

and technological fields are interrelated. Given appropriately adjusted time periods and key word approaches, one should be able to track potentially relevant interactions between science and technology in this area.

To assess these interactions we connected both the databases described above. Our original hypothesis was that, as these sectors are science-related, one should expect a substantial overlap between nano-science and nano-technology. This would be indicated by a large number of relevant nano-research papers being cited by nano-patents. However, matching the 5,000 nano-papers with the 2,600 nano-patents resulted in only 275 matches. A control procedure with another database has led to similar results (see Fig. 2 for an illustration). A test matching procedure, with 22,000 papers related to the nano-scale found in the INSPEC database, also resulted in 371 matches. Based on the matching procedure, one can calculate a number of ratios. For instance, we know that approximately 3.4% of the nano-SCI papers cited in nano-patents per total nano-SCI-papers and the share of nano-INSPEC Patent Citations is around 1.6% of all nano-INSPEC-papers[3]. The share of nano-papers cited in relation to the total number of nano-patents is about 7%.

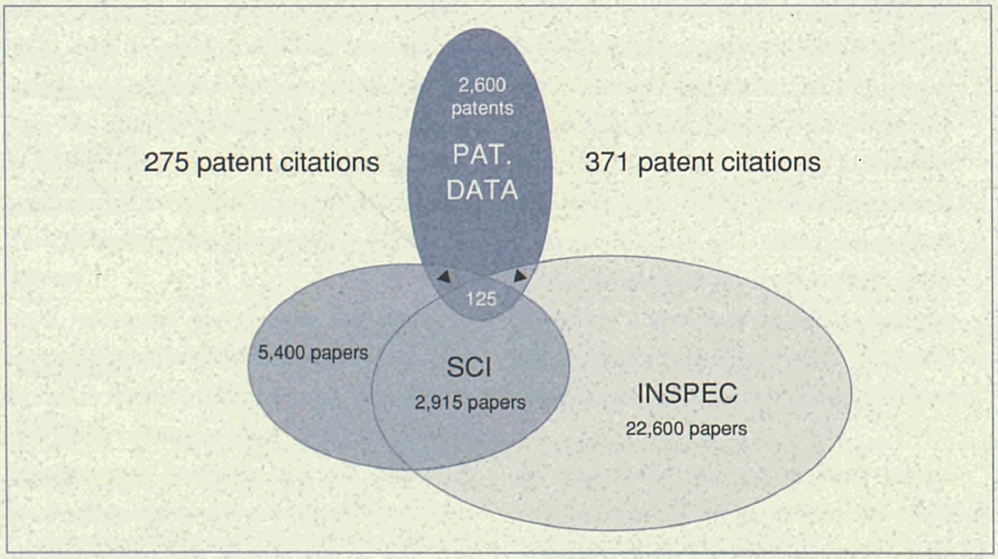
Given the size of the source databases, the relatively small number of corresponding citations can be taken as an indicator of a weak interaction between nano-science and technology, at least in absolute terms.

It would be possible to set up similar databases for other science-related technologies and track their patterns of interactions. This seems to be a particularly useful approach in emerging areas that can be tracked by way of a key-word approach. However, the real value of these databases can be derived if and when a number of databases of fields at the science/technology interface are established. Comparing these data sets should enable the policy-planner to pinpoint specific areas in which science-technology interaction could be promising but does not occur and thereby identify potential new areas for future activity.

One way of measuring the relevant "interaction" between science and technology is tracking the connection between scientific and technological output databases

Given the size of the source databases, the relatively small number of corresponding citations can be taken as an indicator of a weak interaction between nanoscience and technology

Figure 2. Patent citation links in nano-science and technology



Source: Meyer (2000b)

At this point, insufficient data is available to facilitate such comparisons. However, recent research at CHI allows us to relate our data to other results and get a feeling for what the data means and is useful for. Hicks and her colleagues compared the number of U.S. papers published 1993-95 cited in 1997 U.S. invented patents with the total number of U.S. papers published 1993-95 by field and research type. 2.4 % of the more applied physics papers are cited in patents; 2.3% basic biomedical research papers are cited; followed by 1.5% of the basic research clinical medicine papers. This would suggest two things: (a) in absolute numbers, science and technology do not seem to have a high level of interaction in terms of citations, (b) our nano-subfield of the science/technology interface seems to be one of the more "interactive" ones.

Tracking potential knowledge flows

- The previous section has illustrated how patent citation analysis can help determine the level of interaction between science and technology. By tracking patent citations at disciplinary and sectoral levels, one can identify potential knowledge flows between science and technology. Following up our example we can further track the manner in which particular subfields of science and technology exchange and "interact". Again, we will look at patent citations. For purposes of illustration, we shall use rather broad classifications (SPRU main fields and Technological units). One could also apply a similar methodology at a much lower level of aggregation. First we shall have a look at the "interplay" taking place between scientific and technological or industrial fields and subfields.

A policy-planner might be interested also in the organizational and institutional locations where the science-technology interactions take place

Table 1 illustrates the patent citations in our example by technological fields (rows) and scientific disciplines (columns). In the following sections, the study will present a typology of relations between specified technological areas and scientific disciplines. Most citations found connect instrumentation technology with natural sciences (especially physics and chemistry) and multidisciplinary sciences. Electrical machinery is related to scientific domains in a similar manner. Electronics is linked to natural, especially physical sciences more strongly, but there is also a link to multidisciplinary areas. Pharmaceutical and chemical classes of technology are connected to different underlying scientific fields. In pharmaceuticals, there is a stronger interplay with life sciences. Chemistry patents are related to multidisciplinary and materials-engineering publications, but also to physics.

The previous section has illustrated how patent citations can be used to track areas where scientific activities are relevant to technological work, and vice versa. Another application of patent citations is to locate knowledge flows between organizational entities within a scientific and technological area.

A policy-planner might also be interested in the organizational and institutional locations where the science-technology interactions take place. Citation links occur in different forms and one can establish connections between the citing patent and the cited article in a variety of ways. In the previous section we had a look at how technological sectors and scientific domains are interlinked by way of patent citations. In this section we will look at how patent citations link organizational domains in nanoscience and technology.

Patents not only contain information about technical fields but also details of the inventors and assignees. Similarly, scientific publications include bibliographic data, such as author names and affiliations. The data presented gives important clues regarding the location of knowledge-flows. Not only is the overall interaction between nanoscience and nano-technology relatively weak

Table 1. Patent citations after industrial sectors and SPRU main-classes

	Natural	Multi-disciplinary	Engineering & materials	Life	GRAND TOTAL
Instruments	30	13	3	3	49
Electr. Mach., ex. Electronics	26	13	1		40
Electronics	27	7		1	35
Pharmacy	4	12	2	11	29
Chemistry, ex. Pharmacy	6	11	4		21
Metal products, ex. Machines	14	2	3		19
Other industrial products	7	7	4		18
Other machinery	5	6	1	1	13
Non ferrous basic metals	6	2	2		10
Computers and office machines	5				7
Ferrous basic metals	1	3	3		7
Stone, clay and glass products	1	1	3		5
Paper, printing and publishing	4				4
Food, beverages, tobacco		1			1
No classification	2				2
Others*	7	7		1	16
GRAND TOTAL	**145**	**87**	**26**	**17**	**275**

* This category includes those patent citations that could not be related to a single industrial sector.

Source: Meyer (2000b)

(with 275 citations) but almost two fifths of the knowledge flows take place between papers written at universities or other public sector organizations (PSR) and patents held exclusively by such establishments. Less than 30% of the knowledge flows are located between a PSR "sender" (i.e. a cited paper authored by university-based researcher) and an industry "receiver" (i.e. a patent assigned to an industrial company).

One observation is that multinational companies "rely" to a lesser extent on PSR science than do small and medium-sized companies. Amongst the PSR organizations, universities appear to play the most important part in providing useful scientific contributions. Patents held by both multinational corporations (MNCs) and SMEs refer mostly to nano-publications authored by university-based researchers. The other PSR organizations appear to produce information that is mainly cited by nano-patents within the research sector, and here predominantly by university-held patents.

One observation is that multinational corporations "rely" to a lesser extent on public sector science than do small and medium-sized companies

MNCs are far more than mere receivers of knowledge. They have to be viewed as producers of relevant knowledge as well. In fact, 27% of the patent citations referred to in MNC-held patents are related to scientific publications authored by MNC-based scientists. If one adds those papers with combined MNC-university co-authorships to this, almost 35% of the nano-publications cited in MNC-assigned patents are based on research in which MNCs were actively involved. This does not mean at all that university research is not relevant

Almost 35% of the nano-publications cited in patents held by multinational corporations are based on research in which such corporations were actively involved

Table 2. Patent citations by organizational categories

PATENT ASSIGNATION Author affiliation	University	Multi-national corporation	Small and medium-sized enterprise	Industrial association	Other	TOTAL
University	68	34	23	5	8	138
Multinational corporation	8	21	8	4	6	47
Research establishment	13	5	9	5	5	37
Multinational corp. And university	4	6	3	1	3	17
University and research establishment	7	2	3		4	16
Small and medium-sized enterprise	1	2	2	2	0	7
Other	1	3	3	1	4	12
Unknown	0	1	0	0	0	1
TOTAL	**102**	**74**	**51**	**18**	**30**	**275**

Source: Based on Meyer (2000b)

to MNC nano-patenting. In fact 45% of the nano-patent citations identified in MNC-patents were authored in universities.

SME-held nano-patents have a different citation pattern. 45% of their citations refer to university-authored papers. Almost 18% of the citations are to papers written in non-university research organizations. Another 16% goes to MNC-authored nano-literature. Slightly less than 4% of the nano-references originated in the SME-sector.

This organizational analysis of the patent citations further corroborates our impression that little relevant interchange seems to occur across the industry-university divide. This illustrates how patent citation analysis can be used to identify "missing links" between the university sector and industry. In a further step, one could track those university-assigned patents that refer to university cited literature by disciplines and sectors and see if there are any particular connections.

So far we have illustrated at a fairly general level the various types of information patent citation can generate with respect to knowledge flows. In order to illustrate why patent citation analysis is a useful tool and what kind of policy implications can be derived from it, we shall look at our case again in more detail. Another possibility to apply this tool is to combine disciplinary/sectoral and organizational aspects. This variation of the analysis can contribute to a better understanding of knowledge flows in a heterogeneous field at the science/technology interface by specifying the assignation/affiliation pattern for a given subfield by organizational categories. It would go beyond the scope of this article to demonstrate this for all subfields in this technological area. However, for purposes of demonstration we shall have a closer look at activities related to the instruments, electronics, metal products, and other machinery categories (Table 3-6).

The case of nanoscale patent citation links in the field of other machinery (Table 3) indicates that university patents almost exclusively cite university or public sector-authored research papers. Patents assigned to multinational corporations seem to cite mostly MNC-authored papers, but also refer to PSR-originated work to a lesser extent. We seem to be looking here at a field that is characterized by knowledge generation in both spheres, public sector and industry, but with little interaction between them. The case of metal products (Table 4) points to the universities as the main producer of nano-scientific information relevant to nano-patents. However, it also reveals that the universities are the most frequently citing assignee organization in this area. This might raise questions as to how "industrial" academic patents really are. The case of electronics (Table 5) illustrates the importance of universities as science producers. However, university-held patents cite university-generated research much more frequently than others. Industry, in the form of multinational corporations, appears to be an important producer of scientific knowledge and also a major absorber. The case of nano-instruments (Table 6) indicates the importance of intermediary organizations in terms of knowledge diffusion. Industrial associations and similar organizations seem to be the second absorber of knowledge in the field. Again, it can be pointed out that university-papers are most frequently cited in university papers.

The examples given in Tables 3-6 illustrate insights that can be gained from the application of patent citation analysis at the combined sectoral/organizational levels. We were able to demonstrate that the nanoscale science and technology cluster is very heterogeneous and its different subfields show somewhat diverse patterns of knowledge diffusion and absorption. One overall result is that one should make a clear distinction between science and technology on the one hand and academia

There are ways in which patent citation analysis can be used to identify "missing links" between the university sector and industry where little relevant interchange seems to be taking place

Policy planners could use the results of patent citation analysis as a starting point to investigate further whether a programme directed at increasing collaborative efforts is appropriate

Table 3. Other machinery

PATENT ASSIGNATION Author affiliation	Multinational corporation	University	Industrial association	GRAND TOTAL
University	1	2	2	5
Multinational corporation	3			3
Research establishment	1	2		3
Multinational corporation and university	1			1
University and research establishment		1		1
GRAND TOTAL	**6**	**5**	**2**	**13**

Table 4. Metal products, excluding Machines

PATENT ASSIGNATION Author affiliation	University	Multinational corporation	Small and medium-sized enterprise	GRAND TOTAL
University	8	1	1	10
Multinational corporation	3	1		4
Research establishment	3	1		4
Small and medium-sized enterprise	1			1
GRAND TOTAL	**15**	**3**	**1**	**19**

Table 5. Electronics

PATENT ASSIGNATION Author affiliation	University	Multinational corporation	Small and medium-sized enterprise	Government agency	Research establish-ment	GRAND TOTAL
University	11	4	2	1		18
Multinational corporation		4	3			7
University and research establishment	2	1		1	2	6
Research establishment		1		1		2
Multinational corporation and govt				1		1
Small and medium-sized enterprise		1				1
GRAND TOTAL	**13**	**11**	**5**	**4**	**2**	**35**

Table 6. Instruments

PATENT ASSIGNATION Author affiliation	University	Industrial Association	Multinational Corporation	Small And Medium-Sized Enterprise	Research establishment	Government Agency	GRAND TOTAL
University	13	1	6	2			22
Multinational corporation	3	3	1			1	8
Research establishment	3	3					6
University and research establishment	5						5
Multinational corporation and university	1	1	1	1			4
Small and medium-sized enterprise		1		1			2
Hospital		1					1
Multinational corporation and research establishment					1		1
GRAND TOTAL	**25**	**10**	**8**	**4**	**1**	**1**	**49**

and industry on the other. The analysis has shown that increased patenting activity in a science-based field does not necessarily mean industry taking up developments coming from the academic sector. The more detailed analyses illustrate how patent citation analysis can pinpoint areas where considerable public and private research organizations are generating knowledge in isolation from one another. Here, the policy-planner could use results like these as a starting point to investigate further whether a programme directed at increasing collaborative efforts is appropriate. Similarly, patent citation analysis might be a useful ex-post evaluation tool to see if any of the collaborative activities of a research group have proven relevant in patenting efforts by industry.

Identifying potential key actors

The previous section illustrated potential applications at a more detailed level of analysis. This section goes a step further and illustrate how one can use data at the level of individual patent citations in a policy context. One important task of programme managers in research agencies is to plan effective workshops. When planning these workshops, it might be of value to be able to select those individuals who have a sufficient understanding of both the technology in question and the related science. One way to track people that are capable of both academic research and technological development in an area is to identify those actors who both patent and publish. Table 7 gives an illustration, which is solely based on one IPC sub-class (C01B - Non-Metallic Elements; Compounds Thereof). Each of the patent citations links a piece of science to a technological artefact, but more importantly it connects inventors and authors of relevant work to each other.

It might be of value when planning workshops to be able to select those individuals who have a sufficient understanding of both the technology in question and the related science

This way it is also possible, by tracking self-citations, to identify those individuals in a technological or scientific subfield that could possi-

Table 7. CO1B group of nano-patents and the nano-publication they cite

PAT-Inventors	PAT-Assignee	PAT-Title	PUB Authors	PUB Addresses	PUB Title
Dorfman Veniamin (8 norman Dr., Shoreham, NY 11786); Pypkin Boris (Moscow, RU)	Dorfman; Veniamin (Shoreham, NY)	Diamond-like metallic nanocomposites	Dorfman Vf	Suny Stony Brook, Moltech Corp, Chem Bldg/ Stony Brook/ /NY/11794	Diamond-Like Nanocomposites (Dln)
Hiura Hidefumi (Tokyo, JP); Ebbesen Thomas (Tokyo, JP)	NEC Corporation (Tokyo, JP)	Process for purifying, uncapping and chemically modifying carbon nanotubes	Tsang Sc; Chen Yk; Harris Pjf; Green Mlh	Univ Oxford/ Ctr Catalysis/ Inorgan Chem Lab/ Oxford Ox1 3qr/ /England	A Simple Chemical Method Of Opening And Filling Carbon Nanotubes
Ganguly Parthasarthy (Pune, IN); Pavaskar Neela Raghunath (Pune, IN); Vijayamohanan Kunjukrishna Pillai (Pune, IN); George Santhi (Kerala, IN); Singh Prabhat (Pune, IN)	Council of Scientific and Industrial Research (New Delhi, IN)	Process for the preparation of nanodimensional particles of oxides and sulphides of metals	Meldrum Fc; Wade Vj; Nimmo Dl; Heywood Br; Mann S	Univ Bath/Sch Chem/ Bath Ba2 7ay/Avon/ /England	Synthesis Of Inorganic Nanophase Materials In Supramolecular Protein Cages
Luo Ping (2843A Forest Ave., Berkeley, CA 94705)	Not Found	Methods of synthesizing hydroxyapatite powders and bulk materials	Liu Xd; Lu K; Ding Bz; Hu Zq; Zhu J; Jiang J	Acad Sinica/ Inst Met Res/State Key Lab Rsa/ Shenyang 110015/ /Peoples R China; Acad Sinica/Int Ctr Mat Phys/ Shenyang 110015/ /Peoples R China	The Lattice Structure Of Nanocrystalline Fe-Cu-Si-B Alloys
Goldstein Avery Nathan (Oak Park, MI)	Starfire Electronics Development & Marketing, Ltd. (Bloomfield Hills, MI)	Method for pho-tolytic liquid phase synthesis of silicon and germanium nanocrystalline materials	Castro Dt; Ying Jy	Mit,Dept Mat Sci & Engn/Cambridge/ /Ma/02139; Mit, Dept Chem Engn/ Cambridge//Ma/ 02139	Synthesis And Nitridation Of Nanocrystalline Silicon Produced Via A Tubular Forced Flow Reactor
Olk Charles Howard (Leonard, MI)	General Motors Corporation (Detroit, MI)	Method for making carbon nanotubes	Ebbesen Tw	Nec Corp Ltd/ Fundamental Res Labs/ 34 Miyukigaoka/ Tsukuba 305//Japan	Carbon Nanotubes
			Ebbesen Tw	Nec Corp Ltd/ Fundamental Res Lab/Tsukuba/ Ibaraki//Japan	Carbon Nanotubes
			Ebbesen Tw; Ajayan Pm	Nec Corp Ltd/ Fundamental Res Labs/34 Miyukigaoka/ Tsukuba 305//Japan	Large-Scale Synthesis Of Carbon Nanotubes
Yamamoto Kazunori (Naka-gun, JP); Funasaka Hideyuki (Hitachinaka, JP); Takahashi Takeshi (Hitachinaka, JP); Suzuki Toshiyasu (Tsukuba, JP); Maruyama Yusei (Tachikawa, JP); Kato Tatsuhisa (Okazaki, JP); Akasaka Takeshi (Tsukuba, JP)	Doryokuro Kakunenryo Kaihatsu Jigyodan (Tokyo, JP)	Metal-encapsulated fullerene derivative compound of and method for making the derivative	Bethune Ds; Kiang Ch; Devries Ms; Gorman G; Savoy R; Vazquez J; Beyers R	IBM Corp,Div Res, Almaden Res Ctr,650 Harry Rd/San Jose/ /Ca/95120; Caltech, Beckman Inst, Ctr Mat & Molec Simulat/Pasadena/ /Ca/91125	Cobalt-Catalyzed Growth Of Carbon Nanotubes With Single- Atomic-Layerwalls
			Funasaka H; Sugiyama K; Yamamoto K; Takahashi T	Power Reactor & Nucl Fuel Dev Corp/Tokai Works /Div Nucl Fuel Technol Dev/ Tokai/Ibaraki 31911//Japan	Synthesis of Lanthanum Compound Encapsulated Within Carbon Nanoparticles

Source: Based on data from Meyer/Persson (1999) bly perform a bridging function and know both "languages" of science and technology.

Discussion and Conclusions

Patent citation analysis is a tool that should be used with care. One can easily draw misleading conclusions from superficial approaches. Patent citation analysis cannot be used to justify the importance of basic science for technological development and industrial applications. However, citation indicators can be useful in other policy-relevant ways.

We have shown that relating developments of publications and patenting can indicate shifts in the emergence of a scientific and technological field. Patent citation analyses can not only trace the degree of "communication" between fields of science and technology, but also identify "communicating" subfields. The article has also demonstrated that by calculating citation intensities one can identify areas in which more contact between university and industry would be warranted but is not forthcoming. Policy-planners could use such results as a starting point to initiate design of appropriate policies to facilitate exchange between industry and science in the area in question. Designing appropriate policy measures necessitates a sufficient understanding of the respective field. Developments at the science/technology interface are often complex. As we have seen, novel fields in particular can be extremely heterogeneous. In this context, a combined organizational-sectoral analysis of patent citations can give important clues as to the location of the knowledge flows. As the examples in the text have shown, patent citation tables allow a concise overview of how relevant knowledge is linked to an organizational category. This allows policy-planners to get an overview as to how and where exchange processes take place. A final application of patent citation analysis is the preparation of workshops. Using patent citations at the individual level it is possible to identify key individuals in the field. For example, a policy-planner might want to organize an industry-university workshop in a particular field of technology and use patent citation analysis as preparatory method. By selecting authors of scientific publications who also patent in that area, one can ensure the participation of individuals who have at least a minimal knowledge of both the science and technology in that area. They could take on a kind of bridging function.

However, it is essential to bear the limitations of patent citations in mind. Patent citation analysis is very useful when it comes to generating relevant questions policy planners might want to discuss with actors in the field, such as: "Why is the rate of interchange so low between science and technology in the area?" "How come that there seem to be only knowledge transformation processes within the university sector?" "Why are there no knowledge transfer processes to be observed?" "Why do industry and universities appear to go different ways in that particular subsector?" And, "Why is this not the case in other areas?" However, answering these questions goes beyond the possibilities of novel citation metrics and requires the use of other methods, including qualitative ones.

Patent citation analysis cannot be used to justify the importance of basic science for technological development and industrial applications, although citation indicators can be useful in other policy-relevant ways

By calculating citation intensities one can identify areas in which more contact between university and industry would be warranted but is not forthcoming

Keywords
evaluation, bibliometrics, S&T indicators

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Notes

1. However, it should be pointed out that this paper does not question the idea of publicly funded basic research.
2. The decline in patenting after 1996 is due to a pipeline problem. The decrease in patenting reflects the time lag that is due to lengthy examination procedures rather than actual developments.
3. The percentage could be higher if one excluded older publications.

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The Impact of Convergence on the Competitiveness of the European Consumer Electronics Industry

Nicolas Hazewindus, *Merit,* J.C. Burgelman, *IPTS,* Marc Bogdanowicz, *IPTS*

Issue: Digital technologies that first affected the convergence of media, IT and telecommunications sectors are now triggering further convergence among a growing range of communicating consumer electronics devices. This has important consequences for the structure and the competitiveness of the European Consumer Electronics Industry.

Relevance: Convergence influences the competitiveness and hence the employment potential of the European Consumer Electronics (CE) industry in two ways. The spectrum of CE products is changing, rendering existing industrial knowledge and technologies irrelevant whilst requiring new ones. The global structure of the CE industry is also shifting as mergers, acquisitions and alliances occur on a global scale and as business parameters change.

Introduction

Consumer Electronics (CE) encompasses the whole spectrum of electronic hardware and software products and systems- fixed or mobile– intended for purchase by large numbers of private consumers. These products are typically used to access services, functions and content in a way that is controlled by users. As such, CE can be viewed as a series of products and services resulting from a consumer-oriented value chain as opposed to, or complementary to a business-oriented one.

The CE business is a global business and the European CE industry therefore mainly consists of global players. An "educated guess" puts the total CE market in Western Europe at about 50 billion euros, of which Europe produces 35 billion euros.[1]

In 1999, some 29 million people were employed full-time in the manufacturing sector in the EU. Of these, about 0.8 million were employed in radio, television and communication equipment and apparatus manufacturing industries, or about 2.8% of the total. There are considerable variations in the figures across the different countries (Finland with 7.1% is highest, Spain with 1.1 % is lowest).

CE is undergoing rapid change, induced by the convergence of technologies, products and markets. In Europe, these changes began some two decades ago when the home computer began to take hold among private consumers. At that time

Consumer Electronics (CE) encompasses a whole spectrum of electronic hardware and software products and systems used to access services, functions and content in flexible, user-centred ways

The consumer electronics sector is undergoing profound changes as digitization enables television, telephony and data processing to share similar technologies

All the existing CE products were designed, produced and marketed by some forty globally operating companies out of which roughly half could be considered to make up the core of the EU industrial CE base

the Single Market became a European reality, ending the national constraints of many industrial operations, whilst increasing competition. Globalization changed manufacturing strategies and the flow of CE products around the world.

Today, as the CE industry rapidly goes digital, it is in the midst of a new wave of change. The different worlds of television, telephone and data processing are beginning to share similar technologies and are starting to overlap in some areas. This technological "convergence" is spurring an array of other convergence moves in products, markets and businesses.

This leaves industrial, commercial and public policy-makers in Europe with three major questions. Firstly, how is the CE product spectrum changing, with regard to services and usage? Secondly, how is the global structure of the CE industry changing and what effect could this have on employment in the European Union? And thirdly which (public) policies could be important in this context and what underlying research is needed?

Consumer Electronics in Europe: the state of the art

Products and technologies

By the end of the nineties, a wide range of products was on offer on the CE market. These products could be grouped into a number of distinct "technology platforms", intended to satisfy all consumers' needs for entertainment (Video, Audio, Gameplayers), communication (Fixed and Mobile telecom devices) and information (Desk and Mobile computing partly shared with professional electronics). However, new kinds of products were progressively developed as well that did not readily fit into any of these platforms. Examples here are set top boxes, car systems, home networks, stand-alone devices like robotic pets or musical instruments, and new terminals like MP3 players, GPS watches, Web Pads or e-Books.

Most of the development of these new CE products has been driven by technological change resulting from the digitization of information, in particular digital signalling and picture processing, which allows low-cost transmission and storage of sound and video. But it has also been boosted by new integrated circuit technologies allowing dramatically increased complexity and speed of operation at lower cost. Finally standardization of products and transmissions as well as new telecommunication technologies have also played an important role.

The fall in product prices, benefiting of a learning curve effect, at a time when production volumes were increasing thanks to the growing popularity of CE devices and the conscious efforts of manufacturers, have resulted in ever-larger ranges of both key components and final products.

Industry structure

All these products were designed, produced and marketed by some forty globally operating companies out of which roughly half could be considered to form the core of the EU industrial CE base[2]. These include companies such as Alcatel, Bang and Olufsen, Blaupunkt, Bull, Ericsson AB, Grundig AG, Italtel, Loewe Opta, Nokia, Olivetti, Philips Electronics, Psion, Sagem, Siemens and Thomson Multimedia.

But many other companies, such as personal computer makers from Taiwan or the USA, also compete in the European market, mostly via imported products.

Furthermore essential activities are run by various additional companies such as component suppliers. The latter include suppliers of integrated circuits such as Philips, ST Microelectronics, Infineon (formerly Siemens), and their large US and Japanese counterparts with European production sites. Also important are display producers (Philips, Thomson), software producers (including embedded software, operating systems (Microsoft or EPOC) and application software).

"Content" is critical for many CE products as it has strategic importance for the marketing of new CE goods. It comes from sources all over the world, and Europe has in certain areas, a good position. It is delivered in various ways (i.e. broadcast, on discs, on-line) by many companies. Likewise, services play an increasingly important role in the CE markets.

Box 1. Public policies

Numerous public policies have strongly influenced the development of the CE industry in Europe over the last few decades.

- Single Market policies: national markets have coalesced into European markets, impacting virtually all aspects of CE business (inward investment by non-European companies, concentration of industrial operations, logistics).
- Trade policies: national trade policies gave way to European ones whilst at the same time the World Trade Organization gained strength, effectively fostering the globalisation of the CE business.
- Deregulation of telecommunications: this has put an end to PTTs' monopolies, increased competition, lowered consumer prices and stimulated important markets such as the mobile telephony market.
- Media legislation: in many countries, existing media legislation has changed, resulting in the rise of commercial broadcasters, etc.
- RTD policies: in particular the Eureka Program gave new options for pre-standardization RTD (HDTV, DVB).
- Standardization: national approaches to standardisation gradually gave way to European approaches (e.g. ETSI).
- EU product directives: directives at EU level began to set mandatory levels for safety, interference, etc. for CE products.

Continued

- EU Competition Law: competition legislation began to influence mergers and acquisitions as well as alleged monopolistic behaviour of companies outside the EU.

The future of convergence and CE products and services

Considering the expected overall technological progress and the growing functional complexity of dedicated information appliances[3], the following technological developments and trends will underpin future trends in CE products:

- Improved functions, offering more and better performance than today.
- Integration of more functions into one single product of high functional complexity is the trend; allowing command, control and communication and, if intended for mobile use, information.
- Only some future products, such as e-books, will offer new functions, going beyond the improvement or combination of existing functions.
- Existing and future products will be interconnected and new "web-related" devices will be developed.
- The range of "mobile or wireless products" is, due to standardization and new techniques, expected to grow strongly.

A wide variety of services are offered through a range of CE products. In most cases, these services have a content component, which can be accessed as an integral part of the device, purchased on a separate carrier or accessed through a network. Today, specific products still deliver specific consumer services. Convergence in content is progressing slowly but is promising: email communication, MP3, "narrowcasting", etc.

"Content" is critical for many CE products as it has strategic importance for the marketing of new CE goods

As the sector develops, it is anticipated that services will be made available on a much wider range of CE products, and, conversely, individual CE products will offer a larger variety of services

Companies need to acquire new skills and deploy them along the full industrial chain, from design to after-sales service

European CE manufacturers face a number of challenges and their ability to invest in new products and infrastructure and to forge new alliances with content providers could be crucial

It is thus expected that services will be made available on a much wider range of CE products, and, conversely, CE products will offer a larger variety of services.

At the level of user acceptance and market demand, cost and usability are potential bottlenecks. However, cost and usability are only part of the conditions for the successful penetration of CE products. The conditioning of social norms, the establishment of an imaginary space of social capability of the product, and the creation of a fashion are as important. In this view, penetration of new products also entails *domestication*: the creation of a new user-configuration where consumers invest in making the product or service useful to themselves.

New opportunities for the CE industry in Europe

Convergence will affect the competitiveness of the European CE industry and threaten established market positions. However, it will also open up new opportunities and allow European firms to show their creativity.

- Convergence trends in traditional technology platforms point to the integration of several basic functions into one product. However, in many new functions, standards are not yet properly defined, nor have standard technology implementations been developed. This obviously threatens the continuity of planned new product generations of the existing manufacturers. Companies need to acquire new skills and deploy them along the full industrial chain, from design to after-sales service. Of course these convergence trends also offer excellent opportunities to escape the price erosion in the market by offering up-market, higher value-added products. Therefore, they present an opportunity rather than a threat to the European CE industry.

- Serious threats to European producers arise when the traditional platform becomes more software-based and hence open for influences of de facto software standards, e.g. as PC-based operating systems such as Windows-CE migrate into digital television. The same threats arise when the platform is split up into separate functions, as in the case of set top boxes for digital television or replaced by another platform like game players. In the former case, European manufacturers are confronted with competitors who have excellent skills in communications, data processing or software systems, though relatively little in terms of traditional television skills. However, the option of competing in this field exists for European suppliers. In the latter case, however, there is little to be done. The option of entering the games market seems non-existent for hardware makers, although Europe has important content developers in this field.

- Where emerging new products with integrated functions are concerned, European manufacturers are likely to tap into the Silicon Valley environment, certainly where Internet-related skills are required. It is important to note that many of these products will have to operate in a specific European service and user context, which may require substantial translations. This may compensate for some of the weaknesses of the position of the European CE industry in this field.

- In the mobile telephony market, where the European industry is very strong, a number of uncertainties exist regarding its ability to maintain this position. These concern the way the GSM-phone is best connected to the Internet, the operating system that will control this access and the implementation of a next-generation system. Regarding the latter issue, it is important to note the challenge the European mobile telephony service providers face in terms of ability and willingness to invest in the necessary new infrastructure.

- Many new products will support a variety of services. This poses a challenge to the traditional CE manufacturers, who often feel uneasy in the somewhat undisciplined world of content and service providers. Nevertheless, it is essential for them to familiarize themselves with the necessary knowledge and skills and integrate these properly into their businesses.

- With the increasing importance of content and services, players in this area will increasingly determine the developments in the CE market. Businesses tend to integrate along the value chain, but the traditional CE industry is usually not involved. This entails the risk of its becoming a low value-added supplier of boxes that are specified by others However, in Europe a significant content industry for television has developed, and the possibility for cooperation is an important option for the European CE producers.

A key factor in the future of "ubiquitous computing" is the availability of highly advanced telecommunications networks in Europe. For the consumer, "bandwidth at home" is the critical factor. The competitiveness of the European CE industry could be favourably affected by a strong European position with respect to consumer access to communications bandwidth. Though the USA is somewhat more advanced in ADSL and cable deployment, Europe has the lead in wireless connections (notably in GSM, but also in UMTS). A detailed investigation of European scenarios in the different countries versus those in the USA and Japan is needed to assess this balance with more confidence; European industry might better exploit European strengths to improve competitiveness. For instance, existing skills in design and in human interface techniques (and in particular speech applications) could be harnessed to increase the attractiveness and ease of use of new convergent products.

Future industrial structure of the sector

The CE industry is likely to change over the next decade and is increasingly expected to break down into two, partially overlapping sectors. On the one hand, a strongly knowledge-based CE industry will emerge focused on innovation and marketing on a global scale. Only few, very large, globally operating CE firms will survive and have the necessary broad knowledge and innovation resources, design, brand name, marketing and logistics power to keep up with the changing technologies, sales and distribution techniques and usage patterns. They will be in a position to recoup the high innovation costs on the very competitive global mass markets, whilst providing sufficient returns to satisfy shareholders. These companies also know their customers and are able to provide them with user-friendly products. Manufacturing may be an important part of their operations, although it is not necessarily an in-house activity anymore. New entrants will certainly come into the CE market, particularly in new "converged" product areas where the innovation rate is high. In order to achieve economies of scale, alliances in some form with the large companies will usually be needed. However, since for many computer-related products, key components and (operating system) software can be bought off the shelf there is room for low-added value companies that base their strength on clever combinations of e.g. design, marketing, outsourcing and logistics. In that respect, specialist niche-market players may survive too. For instance, where a premium price can be demanded for superior design or quality or if they are specialists in peripherals. But in most other cases

Although the US is ahead of Europe in terms of fixed broadband access, Europe has the lead in wireless applications (UMTS as well as GSM)

New entrants will certainly come into the CE market, particularly in new "converged" product areas where the innovation rate is high "innovative SMEs" will enter into alliances with larger players, either by licensing patents to them or having products marketed and sold through their channels.

Another feature is that a CE manufacturing industry will emerge which is partly knowledge driven –thus concentrated in a few knowledge intensive regions of the world– and partly, with regard to the commodity aspects, cost driven. This kind of manufacturing relocates quickly to the most attractive regions, where the sum of production costs and transportation costs are lowest. In addition, the manufacturing sector includes the producers of key components, of parts and additional components (from moulds and plastic parts to fully mounted printed circuit boards), software makers (in particular "embedded software") and service companies.

Although it is primarily the task of industry to identify the threats and opportunities and chart its course for the future, in view of the importance of the consumer electronics industry for the S&T base, a wider circle of stakeholders needs to be aware of the issues

This leads to three potential directions for the future of the European CE industry:

- Innovation based on a strong position in research and design, of highly complex hardware-software products that will be needed on the European CE market, in particular by the large players.
- Knowledge-intensive manufacturing, often related to the local availability of (a variety of) suppliers of key components, which could also be located in the new member states.
- The emergence of a "European Silicon Valley" for innovative SMEs in the new, ICT-related, product sectors.

Conclusions: convergence, competitiveness and public policy

As convergence impacts existing products and accelerates the introduction of new ones, it will strongly influence the competitiveness of the European CE industry. A different technology base will often be required, the needs of new customers must be understood, and other market approaches may be needed. Companies must acquire new knowledge and skills so as to become more agile and responsive.

It is in the first place the task of industry to identify the threats and opportunities and to chart its course towards the future. However, in view of the importance of the CE industry for the science and technology base and the quality of employment in Europe, a wider circle of stakeholders needs to understand the issues.

Public policy in Europe should therefore be focussed on an aggressive strategy to make the Union an attractive place for industry to be, not only in terms of sales, but also for innovation and production. The following key areas are suggested.

- Convergence creates new competitors. Companies easily cross diffusing borderlines between products and markets. New entrants often introduce new products. Sales methods and channels may change fast. For existing companies there is no guaranteed future, new entrants face enormous risks, both will face problems attracting and maintaining highly skilled personnel who are increasingly mobile and in demand in a global marketplace. *Policy focus on exploiting synergies and restructuring. creation and transfer of CE-related knowledge.*

- Convergence introduces new relations between CE producers, content owners and service providers. Collaborations or alliances must be revisited. Mergers and acquisitions take place, changing the rules of the game. CE companies' proven strategies may not be adequate tomorrow, or even today. *Policy focus on facilitating interactions between the service, content and CE sectors but also on standardization.*

- Convergence thrives on the existence of high-quality networks, with lively markets for content

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Nicolas Hazewindus studied physics at Delft University of Technology in The Netherlands, where he also obtained his Ph.D. in 1964. He worked for Philips Electronics from 1964 until 1997, and his last position was Director of Corporate Product Development Coordination, in which capacity he interacted extensively with the European Union's RTD programmes. After his retirement from Philips Dr. Hazewindus founded a consultancy firm, International Technology Policy Consulting.

and services, and used by informed and interested consumers. The competitiveness of the CE industry is critically dependent on the "health" of these environments, of which Internet is the most influential. *Policy focus on stimulating Internet usage, by enterprises as by consumersas well as optimizing the necessary fixed and wireless telecommunication and broadcasting infrastructures.*

- Convergence affects industrial operations and structures. Different branches of the CE industry use different innovation models and have different approaches to manufacturing, use different approaches to sales, etc. *Policy focus on enhancing collaborative R&D across Europe; and promoting high-value added activities.*

- Convergence creates a wealth of opportunities for small and medium-sized companies. Markets that are created for new products and new services –offered independently or in alliances with larger companies, directly to the consumer market or as supplier - have considerable potential. Rapid growth in the event of success is essential, taking advantage of Europe's high-quality labour market as it is becoming more flexible. *Policy focus on enabling start-up and growth of small innovative companies.*

Proper policy measures in each of these areas will help to draw the CE industry to Europe and create an innovative and competitive environment as well as new employment.

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Keywords

convergence, consumer electronics, industrial policy

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The team was lead by N. Hazewindus, (MERIT) and contained G. J. Nauwelaerts, (IPC), W.K. Hansen (Merit), P. Tang & T. Venables (SPRU), U. Jørgensen & F. Hansen (ITS-DTU), P. Ballon (TNO-STB), A. Puissochet (IDATE). J.C. Burgelman managed the project for the IPTS.

Notes

1. Based on Reed Electronics Research (2000) The Global Electronics Market Information Resource.
2. Meaning that their main "knowledge centres" are in Europe, The list has been drawn from the membership of the European industry organizations EACEM, the European Association of Consumer Electronics Manufactures and EICTA, the European Information and Communication Technology Association, and a few non-member companies.
3. See E. Cahill and F. Scapolo (1999) Technology Map. Futures Project series 11. IPTS, Seville and K. Ducatel, J.C. Burgelman *et. al.* (1999) Information and Communication Technologies and the Information Society, Futures Report Series 03, IPTS, Seville.

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Mobile Payments: Alternative Platforms and Players

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Issue: Wireless phones are becoming an attractive alternative platform for accessing the Internet, and therefore e-commerce. Thus, they are also starting to integrate innovative electronic purse functions for both real-world and online payments. Understandably, telecommunications operators are seeking to ensure a stronger role by capitalizing on their historical strength in network billing and supervision and have started numerous payment initiatives over their mobile networks.

Relevance: In view of the fact that technical developments in telecommunications could involve non-bank players in some traditional banking functions, regulators will need to follow progress as it unfolds. Prudential supervision of the new entrants may be justified to ensure financial integrity and consumer protection, but this will need to be carried out in a way that does not hinder innovation.

The rapid growth of mobile phone use makes these devices look attractive as a vehicle for a payment system

Introduction

With the soaring success of the Internet and the huge potential it represents for electronic commerce, Internet actors are working on new and secure methods of payment. These include electronic banking, electronic purses, electronic cash, electronic cheques, Electronic Bill Payment and Presentment, loyalty schemes, peer to peer payments and mobile payments.

Regarding the last of these schemes –payment carried via a mobile phone– the business case looks enticing if we take into account the (fast growing) penetration rate of mobile phones (over 45% in Europe). In comparison, personal computers, the traditional gateway to online services, have a 33% penetration rate in Europe and their installed base is growing more slowly than mobile phones. The portability feature of the mobile phone (the fact that people carry it with them) also makes it practical to incorporate cashless payment mechanisms that can be used in the real world as well. Whether through the highly advertised WAP (wireless access protocol) technology[1] or the third generation of mobile communications due to come onto the market in 2002[2], wireless is indeed becoming increasingly important as a means of accessing the Internet and therefore as an access device to purchase goods over the internet.

Table 1. Examples of mobile payment offerings[3]

Name, Country, Partners	How it works	Comments
	Real world payments via mobile phone	
Mobile Pay (Finland), Sonera	Payment via mobile phone currently used for fast food services and vending machines. The payment is invoiced on the phone bill as a call to a service number.	The service can be used by customers of all operators, and it can be used from all mobile phones currently on the market. Parking payment is a recent addition and is being run as a pilot in Helsinki.
Movilpago. 50% joint venture Telefonica & BBVA bank (Spain)	Low-value payments via a mobile phone. Compatible with prepaid phonecards and traditional phone bills. 1) the merchant enters the phone number of the consumer and the code of the product to be purchased via an *ad hoc* merchant terminal 2) consumer mobile phone screen shows the product description and price 3) consumer confirms the transaction by entering a PIN (personal identification number) 4) a confirmation message is sent to both the mobile phone and the merchant terminal.	This system does not require adaptation of either the SIM card or the mobile phone. In its initial phase, GSM users can access this service by subscribing to the services of Movilpago. It is not necessary to change banks or bank accounts. The PIN is sent over the SMS (Short Message Service) channel using USSD (Unstructured Supplementary Service Data) technology. Available in Spain in autumn 2000 and introduction in 30 countries is planned over the next two years.
Paybox. Experian, Oracle, arcom Deutsche Bank (50%), Lufthansa, HP, (Germany)	Payment via mobile phone, but not suitable for micropayments. Buyer and seller respectively need a mobile phone and a contract with Paybox. Paybox provides the user with a PIN. 1) Payer communicates his phone number to the merchant 2) The Merchant communicates this phone number + price to paybox 3) Paybox calls payer and asks for authorization of payment 4) Payer authorizes by his PIN 5) Paybox informs Deutsche Bank as credit institution to settle the payment using a common payment instrument (at the moment: direct debit).	Paybox is an open and neutral payment intermediary aiming at banks independent from telecom operators. Does not depend on PKI (public key infrastructure) structures and transmits the PIN via DTMF (Dual tone multifrequency) procedures but could migrate to PKI if widely available. Internet payments as well as other POS (point of sale) payments are possible. Peer to Peer payments between paybox users are also possible.
	Online payments: extension of the Internet to the mobile device	
Lloyds. Lloyds and BT Cellnet (UK)	Online banking on mobile phones from November 2000. The online PC service is adapted to WAP phones.	The venture will offer customers a free mobile handset, free off-peak Internet access and other incentives.
PayPal. X.com (USA)	Email-based money transfer and payment, eventually paid with credit card or bank debit but without divulging card or account numbers.	Currently available through PC-based email, Palm organizers and Internet-enabled mobile phones in the US. X.com plans to introduce PayPal in Europe soon. Customer base of over 2.7 millions in the US.

Continued

Hybrid payment solution using the specificity of the mobile phone to secure payment over the internet		
CB. France Telecom Mobile, CB (France)	Allows customers to shop at home on their PCs or fixed-line phones, then pay by inserting the debit/credit cards into smart card readers in dual-slot mobile phones, avoiding the need to type their card numbers and sending them over the air. Also solution to reload prepaid mobile phone accounts and pay bills using the CB charge cards.	Payment solution using dual slot mobile phones, one of the slots being for chip-based Cartes Bancaires charge cards. France Telecom is also extending the service to WAP phones, letting customers shop and pay securely on the same wireless device.
GiSMo /(G Internet) S M open. Millicom International Cellular (USA)	Like credit card purchases on the Internet, except that GiSMo technology uses your GSM phone to verify your identity at the time of the transaction. When paying with GiSMo, you will receive a transaction-specific code on your GSM phone that you must enter on your computer screen to complete the transaction within a limited period of time. It also offers online access to customer's account details.	The mobile phone is used as a complementary tool for extra security in an internet transaction since a hacker getting your GiSMo account number will also need to steal your mobile phone

To play a role as the payment device of the future, the mobile handset needs to improve security and user trust. The WIM card is one approach

Mobile payment solutions

The most immediate and easy-to-implement payment system is to transform cellular phones as a means to buy goods or services either through the prepaid phonecard for low-value purchases or the monthly phone bill for both low-value and larger amounts. More refined solutions include, among others, offering a real time gateway to bank transactions, a wireless internet banking service, or an additional security channel for PC-based online purchases to verify the identity of the payer and confirm a transaction through his/her mobile phone (see Table 1 for examples of mobile payment alternatives).

The mobile phone is not only an additional (wireless) gateway to carry out an Internet transaction through a WAP terminal or a new platform for electronic wallet transactions in the real world. It is also a hybrid solution integrating the payment card reader in the case of CB (Carte Bancaire), or offering a complementary, wireless channel to enhance the security of an Internet purchase through a PC-based online transaction in the case of GiSMo (see Table 1).

Security of mobile payments

Beyond these innovative services, wireless payment will have a bright future only if the mobile phone has inherent, built-in security hardware and software that users can trust. This is why additional security features will be integrated into the mobile handset (and network) to transform wireless communication devices into a secure means of payment (see Box 1).

Box 1: SIM and WIM – Identification at the core of the process

Two types of identification cards can be integrated inside mobile phones:

- The SIM (Subscriber Identity Module), which identifies the subscriber. It is a nail-sized "baby" chip card currently used in all GSM phones to identify the subscriber to the network. It can, among other things, act as a directory and provide billing information (for the monthly invoice or in real time for pre-paid cards) to the network operator.
- The WIM (Wireless Identity Module), which identifies the buyer. With the advent of mobile commerce, the WIM card has been introduced to offer an identity module which is stronger than the SIM and which contains a digital certificate that authenticates the buyer and enables him/her to sign electronically, based on wireless public key infrastructure (PKI)[4]

Whereas the SIM-card plays a central role in the GSM network in identifying the subscriber, the WIM-card is being introduced to convert phones into payment devices[5]. But the way these two chip cards are linked is not a trivial matter. Banks, operators and handset manufacturers face a choice of at least five potential handset designs that will be able to accommodate, amongst other things, bank debit schemes, electronic purse payments and credit card applications[6]. These options are:

- Dual-slot phone. The mobile handset comes with a built-in smart-card reader. Consumers insert their existing debit or credit card into the smart-card reader-slot and type in a four-digit PIN, issued by their bank, in order to authenticate purchases. The dual-slot phone makes sense in countries such as France, where credit cards already incorporate a smart microprocessor to authenticate payment, rather than using a customer's signature. One advantage of the dual-slot phone is that the consumer is using a proven and trusted payment method. France Telecom recently launched a dual-slot phone scheme with a number of banks and major credit-card companies[7]. This payment method allows a consensus approach between the bank and the telecom operator, where neither steps into the other's traditional role. It does, however, open the door to other organizations, such as supermarket chains, to step in with their own card (loyalty points, co-branded credit cards…).

- A second nail-sized banking-chip (WIM card) that slots into the back of the phone near the SIM card (see Box 1). This is also called a dual-chip approach. Merita Bank is currently implementing a dual-chip system[8]. A second chip enables banks to introduce commercial applications that may otherwise fall into the hands of the operator (or opening the door to other actors like supermarket chains through the dual slot). Merita Bank, for example, foresees the banking-chip holding loyalty-card applications from car-rental and airline companies. This handset design both keeps the handset simple (this is supported by handset manufacturers) and enables the bank to retain strong control over the credit and payment applications.

- An external WIM card reader. This design is appealing to handset manufacturers, as it simplifies handset design. But it presents the risk that consumers may find an additional device cumbersome. In its philosophy, it does not fundamentally differ from the dual-slot.

- All functions are lodged on a single, multi-application chip card that combines the SIM and the WIM cards. The disadvantage for banks and credit-card companies is that not only are their brands subsumed into this merged SIM-WIM card, but there is the question of who issues the card and thereby manages the relationship with customers.

Banks, operators and handset manufacturers face a choice of at least five potential handset designs intended to allow the incorporation of secure payment technology

The decision to choose one payment architecture rather than another has major implications for the respective role of banks, telecoms operators, retailers, and other intermediaries

With the advent of the new forms of online and offline payment, a payment transaction can no longer be summarized as a four-tier relationship between payer, payee, and their respective banks

Currently SIMs are issued and controlled by the operator. Understandably, banks are not keen. The advantage for manufacturers (and operators) is that only one card slot is needed in the phones. Swedish mobile operators are today considering replacing existing SIMs with SIM-WIMs. Even though this would be expensive, once subscribers become buyers the operator can become a seller of services. Only the mobile phone operator can manage that card.

- Payment software built into the phone. This would be the simplest solution for handset manufacturers. However, it raises serious security questions - a software-only solution would be the most open to attack by hackers.

Exploring bank and non-bank interaction

As we can see in the list of handset design, the decision to choose one architecture rather than another has major implications for the respective role of banks, telecoms operators, retailers, and other intermediaries. The central role of telecom operators in the mobile telephony networks gives them a privileged entry point to increase their role in payment solutions to the detriment of the banks. It is therefore not a surprise to see that banks and telecoms operators have started to back a number of distinct standardization initiatives[9].

One of the battlegrounds among the numerous and complex standardization debates is on where to stop the application layers on the SIM card: presumably operators will want higher layers (to allow scenario 4 and combine WIM into SIM[10]), whereas banks will not (favouring scenario 2 to keep WIM and SIM separate).

However, bank disintermediation can take place in many other ways. "Brick and mortar" retail chains (such as Tesco in the UK) have started to expand their core retailing activity to include petrol, pharmaceuticals, funerals, online banking, credit card (co-) issuance and insurance to offer a "one stop-shopping service" to their customers. When it comes to banking or insurance, they outsource these services to existing banks or insurance firms who have the expertise, but who agree to waive their brand and cede control over the interaction with customers[11] to the retailer.

Network access providers with critical mass and, more importantly, ***permanent*** access to their customers through easy-to-carry wireless devices, will be able to integrate a whole range of services like banking, insurance, ticketing, stock trading, advertising etc. into their portals. The financial aspects of this are significant as savings obtainable by using the Internet channel for activities such as buying airline tickets or performing banking transactions may be as high as 87-89% (OECD, 1999[12]). Some mobile operators may choose to capitalize on their partnering bank's brand but others will prefer to act as the sole service provider and deal with banks who will waive their visibility in the transaction (cf the Tesco example). This scenario is of course not specific to mobile operators but actually started in the PC-based Internet world. However, as mentioned above, the portability feature and the high penetration of wireless devices make them a convenient platform to bring together these online services under one brand (assuming that their currently excessively small screen will be progressively adapted to these new interactive services).

With the advent of the new forms of online and offline payment mentioned in the introduction, a payment transaction can no longer be summarized as a four-tier relationship (payer, payee, and their respective banks). New intermediaries are appearing and it is not simply a case of telecoms operators stealing business from the high street banks. At the same time, credit card companies' business is also at risk. If we consider the case of the Paybox system shown in table 1, mobile payment transactions are currently cleared by direct debit but could perfectly be allocated to a credit line granted by the bank[13]. The 3% fee currently charged by Paybox is lower than that credit card companies generally charge merchants. If we weigh credit card fees' unpopularity amongst merchants against their strong and recognized brand, which is their major asset, there is a window of opportunity for services like Paybox to become an alternative to credit cards. Although Paybox's strategy does not aim to compete directly with credit cards, the original intention to replace cash could hit credit cards as a side effect. Understandably credit card companies have initiated alliances with wireless device manufacturers (i.e. Visa and Nokia) and in other fora such as the Global Mobile Commerce Interoperability Forum, Electronic Mobile Payment Services and Mobey to extend their services to the mobile platform.

The fact that telecom operators could potentially implement an offensive strategy in mobile e-payments should not overlook the fact that most of the mobile payment services currently offered in the marketplace are actually partnerships between banks (and/or credit card companies) and mobile operators. The two sectors being so specific and complex, they may see it as being in both their interests to collaborate. Network operators have expertise in billing but banks havemore experience in cash-flow and card management.

Mobile phone operators could also look to the banks to help them increase customer loyalty and so reduce churn (i.e. the tendency to switch between mobile operators). The remote banking collaboration which started in 1997 between UK operator Cellnet and Barclays has enabled Cellnet to reduce its churn rate by 10% to 15%. This is a powerful argument, given that 25% of European mobile phone subscribers change networks every year (the consultancy firm Andersen Consulting estimates the cost of churn to be around 20 billion euros a year). After all, it is unlikely that banks will be bypassed by new intermediaries in the new electronic payments systems. One of their trump cards is that they will keep control of the settlement part of the payment transaction[14].

Nevertheless, some mobile phone companies do seem to be interested in competing directly with the banks (for instance, MobilCom AG has been granted preliminary approval by the Federal Banking Supervisory Authority to set up a banking unit). Considering the high price paid by mobile operators in the recent auctions for third generation services spectrum, one can indeed imagine that the successful bidders (and Mobilcom AG is among them) will be looking to as many strategies as possible to recoup their licence costs, and that could include a more aggressive strategy in mobile payment services.

Conclusions

One might argue that what is threatened by new technologies is not so much banking *per se*, but perhaps some of the established banks. Regulators may opt to screen new entrants to ensure they meet a checklist of requirements before they are authorized to carry out certain banking-type functions. For the sake of consumer protection, these might include security and data integrity requirements. However, if the regulatory burden is heavier than necessary, it risks slowing down innovation from non-banks in the mobile sector where Europe needs to fully capitalize on its competitive edge.

Also, the fact that mobile operators can implement electronic wallet schemes makes them fall within the scope of the Directive on Electronic

In general, mobile phone operators seem to be trying to enter the payments business in partnership with the traditional players rather than in competition with them

Money Institution[15] to the extent that the value stored on a prepaid card is accepted as means of payment by establishments other than the issuer. But, given that the EMI-directive specifically covers pre-paid forms of payment solutions, it is not entirely clear what would happen if the mobile payment is actually invoiced on the monthly phone bill (and is therefore not pre-paid). In some member states a bank licence may be needed. In other member states issuing a payment instrument does not in itself constitute banking and does not lead to additional supervision.[16] Clearly, these varying regulatory scopes and regimes may add a climate of uncertainty for innovating firms.

Finally, financial institutions are trying to influence the ongoing standardization initiatives and to circumscribe the innovation potential of mobile phone technology with a view to combining it with *existing* payment instruments. Because of their central role in the mobile networks, telecom operators are among the few outsiders powerful enough to push alternative options. The result is that banks, credit card companies and telecom operators are in some instances involved in parallel standardization initiatives for mobile e-payment. These differing agendas could slow down a process of development across industries in an area where Europe could benefit a great deal from fully capitalizing on the GSM success story.

About the author

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Keywords

mobile payment, mobile commerce, mobile banking, mobile finance, wireless internet, electronic purse, smart card, convergence, credit card companies, bank desintermediation

Notes/References

1. See **http://www.wapforum.org**
2. See **http://www.umts-forum.org**
3. These examples are taken from an inventory database of European electronic payment solutions, market actors and web-links. The inventory (under development) is part of the IPTS-led ePSO project (European Payment Systems Observatory) accessible at **http://epso.jrc.es/inventory** ePSO is part of a European Commission DG-ENTREPRISE project whose primary objective is to become an independent reference point for information on e-Payment Systems.
4. A public key encryption algorithm is one in which one key is made public and the other kept secret. Applications for this technology include digital signature, authentication and encryption of the message, document integrity, network access control and non-repudiation. More information in: **http://www.pkilaw.com**
5. Even if the SIM is a prepaid card and the mobile phone user is anonymous, the network operator only needs to know how much pre-paid airtime is left, and the actual identification of the buyer will take place through the WIM card. In the case of a micropayment, the anonymous user of a prepaid card can either choose to use the monetary value of its pre-paid airtime as anonymous electronic purse or (for larger amounts) go through the more secure bank-account-based WIM transaction where he/she will be identified as a buyer.
6. See also Erik Dahlström's article in the ePSO newsletter number1: **http://epso.jrc.es/newsletter/newsletter.html**

7. **http://www.francetelecom.fr/vfrance/actualite/commdosp/actu200600_2.htm**

8. **http://www.merita.fi/E/Merita/sijoita/uutta/990524.ASP**

9. Among them we can mention the Mobey Forum –backed by European banks and Visa– focusing on financial aspects of payment over mobile phones; and the ETSI Smart Card Platform (SCP) –backed by operators and manufacturers– aiming at developing a common standard for m-commerce. See also: **http://www.totaltele.com/view.asp?articleID=26214&Pub=CWI&categoryid=705**

10. See for instance the announcement by iD2 Technologies and Across Wireless of how a standard SIM card can perform digital signatures, **http://www.acrosswireless.com/4685.html**

11. See for instance: **http://www.tesco.com/finance/home.htm**

12. As quoted by the UK Government Ecommerce task force report (p.53), **http://www.foresight.gov.uk/servlet/DocViewer/doc=1155/**

13. For more information, see interview of Paybox COO in the ePSO newsletter number1, **http://epso.jrc.es/newsletter/newsletter.html**

14. See the BIS September 2000 report on Clearing and settlement for retail payments, **http://www.bis.org/publ/cpss40.htm**

15. Status of Codecision procedure on electronic money directive, **http://register.consilium.eu.int/pdf/eu/00/st03/03628en0.pdf**

16. See Simon Lelieveldt's article on the topic in the ePSO newsletter number1: **http://epso.jrc.es/newsletter/newsletter.html**

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Outsourcing of Business Services

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Issue: Over the last few decades the service sector has experienced unprecedented growth. Outsourcing of business services, which is one of the most dramatic trends occurring in private and public sector business in the 1990s. Increasingly, firms focus on those core activities where they have the greatest competitive advantage and hence can earn the highest rate of return. However, this process of outsourcing must be seen through the dynamics of the individual industrial sectors.

Relevance: The European heads of governments at the Lisbon European summit in March 2000 highlighted the role of services in the economy and their potential for growth and employment. A better understanding of the dynamics behind the growth of the service sector would help policy to deal with the employment and regulatory repercussions of outsourcing.

In recent decades there has been a shift in the relative economic importance of the manufacturing and service sectors, and today the service sector accounts for over 70% of economic activity in the EU

Introduction[1]

In recent decades there has been a change in the pattern of the industrial landscape. This change has been characterized by a decline in manufacturing industry and a parallel growth in service and information-based industries. As a result economies are becoming ever more service oriented. Today, the service sector accounts for more than 70% of economic activity in the European Union[2] while the average share of manufacturing value to GDP has declined to approximately some 20%.

This relative increase in services has not gone unnoticed by policymakers. At their recent European Council meeting in Lisbon, Europe's Heads of State and Government declared their intention to further develop framework conditions to fully exploit the employment potential of the services sector and industry-related services.

While jobs are being lost in the manufacturing industry and agriculture, services have been the only sector in the European economy able to expand the number of jobs over the past 20 years.

In addition to the employment perspective, the development of knowledge-based services in particular is also, for several reasons, a key source of economic growth: Firstly, services are responsible for the majority of business start-ups. Secondly, a large number of the new jobs created are high skilled with pay above industry averages.

Thirdly, services are the largest investor in the economy in gross terms and therefore also critical for the manufacturing sector. Fourthly, services play a significant role in the development of industrial competitiveness.

Services, however, cover a very diverse group of activities. It covers high technology and knowledge intensive sectors as well as labour intensive and low-skilled tasks. Within the service sector, business services have proven to have the largest potential in terms of job creation and value added. Growth rates for business services have by far exceeded almost any other sector of the economy.

One of the reasons for the spectacular growth of business services has been the consistent trend towards more outsourcing of non-core activities by established firms. Increasingly, firms focus on those core activities where they have the greatest competitive advantage and therefore can earn the highest rate of return.

Outsourcing is often defined along the lines of the strategic use of resources outside the firm to perform tasks originally performed inside the firm. The reality seen from the perspective of the firm is frequently somewhat different. Industry often interprets any activity or service that was purchased externally on an ad-hoc basis as outsourcing.

However, despite their importance for the economy, our knowledge about "business services" and the outsourcing process is relatively limited because of difficulties involved in adequate statistical monitoring and analysis.

Reasons for outsourcing

Companies are shifting more and more their business services away from in-house production and are making use of the possibility of externalizing business services. There are three main reasons for companies to do this (cf. Rubalcaba p. 254):

- cost reduction
- increased quality
- the need for specialization

The process of outsourcing of services reduces the in-house operational costs and converts fixed costs into variable costs. This provides the company with much greater flexibility, an important asset at a time where competitiveness and the possibility of a quick response to market demand changes are essential for companies' survival. However, outsourcing implies not only a moving from fixed costs to variable costs. Specialized external service companies can provide services at much lower costs than could be done internally. Lower prices through economies of scale and higher competition between specialized service providers are therefore essential for companies to reduce their overall costs.

In addition to the cost reductions by economies of scale, economies of scope improve performance and service quality. The competitive process raises the quality of services and the available choice. Both, the first and the second reason go along with a third one, the need for specialization. Specialization is necessary in order to remain competitive in the marketplace, which basically comes down to the ability to provide high quality products at attractive prices.

In addition, there are a number of secondary reasons for outsourcing that depend very much on the structure, situation, and sector of each company:

- Flexibility in the production and the flexibility of reaction to market changes require externalization. To concentrate on key tasks, which means focusing on those tasks which a company can do better than others companies, leads automatically to externalization of subordinate services. Often firms also appreciate the

Within the service sector, business services have proven to have the largest potential in terms of job creation and value added

Businesses are opting for outsourcing in order to cut costs, increase quality and focus more tightly on core business activities independence of external service providers. An external company can come up with decisions that would be impossible within a company, due to internal conflicts.

The process of outsourcing means for companies, to concentrate on core competencies whilst "non-core" activities are externalized to third party suppliers.

Box 1. The case of pharmaceuticals

In pharmaceuticals it is not really a case any longer of getting economies of scale (allowing for goods to be cheaper and brought more quickly to market) but of economies of scope – i.e. obtaining a broader range of target market groups and greater opportunity. In pharmaceuticals, one of the key areas is R&D. The last few years have seen the rise of CROs (Contract Research Organizations), which have increasingly deployed additional competencies and skills which have been commercially offered to pharmaceutical manufacturers e.g. clinical trials, contract specialist sales staff such that the manufacturer can concentrate on key core areas -research and development. Contract Research Organizations do the vast bulk of clinical trials for many pharmaceutical manufacturers having direct links with many clinicians even though major companies may have attempted to limit the amount of research of any one of these organizations.

Outsourcing can give firms greater flexibility as it allows them to undergo change without facing internal conflicts

One potential danger of outsourcing for firms is the "hollowing out" of the company, leaving nothing but a fragile shell

Outsourced areas

Many companies have already externalized non-critical and non-core activities such as, canteen services, industrial cleaning, security services. However, there is no general rule how to define core competence. A number of frequently outsourced areas are:

- Transport and shipping;
- Goods' warehousing and storage;
- Training, translation and health services;
- Promotional activities, marketing, sales and advertising;
- Non-specialist staff recruitment;
- IT services and consultancy Provision;
- Taxation.

There is a clear trend towards outsourcing in some sectors. In the pharmaceuticals sector there is strong demand for outsourcing of research and development, mainly with the intention of shortening the R&D development cycle. Also risk assessment is frequently externalized within the pharmaceutical industry. In the automotive sector uniform demand for services almost throughout the whole the value chain is apparent. This is mainly due to the time to market and the principle of "just in time" delivery of components. A particular emphasis for outsourcing of services in the automotive industry lies in technical design services. Within the sector of domestic electrical appliances there is less research and development, particularly in comparison with the pharmaceutical industry. As a consequence the focus of outsourcing is on services demand in post sales, the distribution sector, also as warehouse and retail and market research services.

Benefits and risks of outsourcing

Reduced costs, higher quality and the need to specialize together with higher flexibility and the ability to meet greater demands of changing customer markets are the clearest benefits of companies' outsourcing efforts. The experience of most of the firms interviewed was satisfactory, although some have remarked on the potential pitfalls that they had not recognized because they had not accurately calculated the possible financial cost savings. With some companies the actual cost of implementing outsourcing was higher than forecast, mainly because the whole issue has not been fully thought through. In general, however, there is little evidence of companies demonstrating the application of financial or other benchmarks to measure the benefits of outsourcing.

Outsourcing business services is not a win-win strategy. It can have a number of drawbacks. The most obvious and probably most dangerous one is the possible "hollowing out" of companies, reducing the organization to a fragile shell. Outsourcing everything removes all internal competence, skills and learning relating to the performance of that activity. This means also that any organization outsourcing irrespectively of its sector is faced with the potential problem of losing part of its control over the supply chain.

Box 2. A pharmaceutical company's concerns about outsourcing

"We have spent a lot of money and thought on the whole issue of outsourcing. It really is a question of having to find the right balance, of knowing what is your core business and what isn't. You don't want to end up losing key personnel because of purely cost considerations. Sometimes you can go too far down the line because you no longer have the right person who shares the company philosophy and vision. For example in terms of customer service, your employees' needs to know how to present the company. Subcontracting out means that they may project an unfavourable image because of the lack of shared values".

(Source: *Pharmaceutical company participating in the survey, see note 1).*

Frequently it is found to be difficult to assess the true costs of outsourcing. The potential loss of internal control over certain service functions could also have a negative impact on performance and product quality. The failure to distinguish between "core" and "non-core" activities and strategically critical business functions can have unfortunate consequences. The search for short-term profitability/cost cutting can also have pernicious effects in the future if key personnel are made redundant through "downsizing" or "divestiture" of business exercises.

A more political issue is the possible violation of competition rules by extensive outsourcing. Increasing power may come to be accumulated in the hands of several large, powerful outsourcing companies that seem to have gradually taken control of significant parts of public sector activities (cf. CRiSPS, page 3). - For example, the US-based company EDS controls more than 65% of UK government IT services on the grounds of cost savings thus raising questions of the balance in the power relationship.- In many cases it could prove to be difficult to determine the precise market power hidden behind a network of contractual constellations.

Outsourcing is like a partnership and companies in their euphoria of divesting what they see as non-core competencies can sometimes make big mistakes. On the other hand, outsourcing also means a contractual relationship and many companies are frightened of losing control. It is, therefore, a question of finding the right balance.

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Effects of outsourcing on employment

While there has been a relatively stable expansion of jobs in services for the period 1960-90 (over 2 per cent a year between 1960 and 1990 and 1 percent in the early 1990s) the growth in manufacturing and agricultural employment has declined since the 1980s. This development is fuelled by the sectoral shift from industry to services throughout OECD-economies. (see for instance Petit and Soete 1996).

In addition to the job creation effect, services have also been particularly successful in promoting social inclusion, especially for women, since many of these job opportunities have increased job flexibility.

According to Eurostat (1998), business services represent 18 per cent of total employment in the services sector in the EU. Business services and financial services are showing rapid employment growth rates. Moreover, the OECD (1996) shows that the industry experiencing the largest employment growth, during the period 1970-1993, was real estate with business services doubling their employment capacity between 1970 and 1993. Other types of services like financial and communication services also show greater potential in employment generation.

Although business services in terms of employment have apparently grown immensely, it is sometimes argued that this is due to a statistical fallacy. The argument is that outsourcing has only statistically "visualized" business services that were previously done in-house. This reflects a more general problem with business statistics. The majority of statistics on services take their starting point from the supply side. Therefore, the statistics are defined according to the economic activity of the enterprises offering services as their principal activity. Frequently this can be misleading. Many service providers do not have the provision of service as their main activity. However, customer service is becoming an ever more important business area for many companies.

A more general discussion on the employment effects from outsourcing is difficult as the available statistical information does not allow us to establish a direct link between outsourcing and employment growth in business services

An associated problem in this regard is that international comparison on levels of employment in manufacturing and services can be distorted. The level of outsourcing does, to a large extent, impact on the relative level of employment in manufacturing and services. Therefore, differences in service employment do not by default reflect structural differences in the economy but can also be due to differences in work locations.

A more general discussion on the employment effects from outsourcing is difficult as the available statistical information does not allow us to establish a direct link between outsourcing and employment growth in business services. In principle, one could argue that outsourcing is merely substituting in-house employment for external employment.

In contrast, there seem to be a certain consensus as to the positive net job creation effect from outsourcing. Gazier and Thevenot (2000) assumes firstly that job creation potential depends on the potential productivity gain by outsourcing and secondly, that the job creation potential also depends critically on the way business services are produced.

If one accepts that outsourcing is associated with positive productivity gains then one can mention at least three possible effects. Firstly, the enhanced productivity of the outsourced service would, if there is an inelastic demand for this service, lead to job losses due to specialization. Secondly, from the perspective of the industrial sector, outsourcing would give firms in this sector the opportunity to focus on core activities where they have the greatest competitive advantage and can earn the highest rate of return. This increased competitiveness could lead to increased employment. Thirdly, from the perspective of the services sector, the productivity gains would also enhance competitiveness and thus the possibility of job creation caused by higher demand from the industrial sector. The total effect on employment will of course rely on whether job creation due to higher demand exceeds job loss from specialization.

The second point mentioned by Gazier and Thevenot is that job creation depends critically on the way business services are produced. The higher the level of knowledge and the greater the element of "co-production" between the business services provider and the user, the higher potential for job creation. This argument lies at the heart of the so-called knowledge-based economy. For modern developed economies, the balance between knowledge and physical infrastructure has shifted so far towards knowledge that is has become perhaps the most important factor in determining economic growth.

The employment potential in business services does, however, also imply substantial shifts in the occupational and skill structure of the business sector (Petit and Soete, 1996). According to them, some broad trends can be expected that will largely affect work and occupation in service industries. This includes the need for staff to be responsive to customers, able to adapt to and offer new services, to be able to acquire new skills quickly, a need for life-long learning, expansion of opportunities in services, etc.

All these changes will undoubtedly have a great impact on the current nature of work and the organization of the workplace. The demand for constant flexibility and innovation is not without its costs (see Box 3).

Box 3. The experience of a pharmaceuticals company

"We have many concerns in this environment. It is fast moving with mergers and restructuring. People are concerned about their jobs. We can only forecast having a job for maybe the next 18 months. But we also have a lot of specialist skills who bring "best practice" in our operations. But we also have to acknowledge the ethical and regulatory environments. Producing drugs is not like producing a car, although of course safety criteria also apply there. We have to be stringent in all our practices, we cannot afford error but we also need to get product to market more and more quickly. Therefore it is important to recognize the need to keep staff motivated but outsourcing may produce the opposite effect if taken to an extreme. It now takes 18 months to get a product from clinical trials onto the market rather than the three years it used to take. People are working under intense pressure".

(Source: *Pharmaceutical company participating in the survey, see note 1*).

In the new context specific skills referring to the use of information become of strategic importance, for services this might imply the relocation possibilities for many routine functions. In particular, the international relocation potential of previously untradeable service function is made possible through the widespread use of the ICTs. As one company describes it: "If you can transfer product knowledge, you can produce anywhere in the world".

This mobility of services, including business services, is part of the general globalization phenomenon. Firms tend to choose to locate their activity wherever the framework conditions are most suitable. This could arguably lead to national erosion of particular sectors of the economy as firms relocate to areas better suited for their line of business, whether for economic or legislative reasons. However, globalization has not eliminated the importance of location. Globalization has also increased the value of non-transferable, geography-specific factors. Benefits of physical proximity and the direct exchange of information appear to be more important than ever. As a consequence, companies in particular sectors of the economy often tend to locate close to their competitors, forming so called business clusters or industrial districts. This development also applies to a certain extent to business services –especially professional services– where the level of interactions and tacit knowledge are prominent features in the producer-customer relationship.

The complexity of measuring employment effects from outsourcing was also reflected in the survey. Only a few companies were able to give any degree of accuracy regarding employee displacement through outsourcing. The highest figure quoted being 10%. In general though, it was confirmed that rapid restructuring is often leading to redundancies as companies divest

For modern developed economies, the balance between knowledge and physical infrastructure has shifted so far towards knowledge that is has become perhaps the most important factor in determining economic growth

The mobility of services, including business services, is part of the general globalization phenomenon. Firms tend to choose to locate their activity wherever the framework conditions are most suitable

"non-core" businesses. Moreover, this tendency seems to be applicable across all industries.

The indirect employment effect possibly gained through higher productivity has not been measurable amongst the participating companies. Perhaps, these types of calculations also have more relevance for policy makers than they do in the day-to-day business of individual companies.

Further analysis is required in order to understand the dynamics of the interaction between business services providers and users in different industrial sectors

However, even if one were to accept the hypothesis of Gazier and Thevenot that higher level of knowledge and "co-production" between business services providers and users would result in higher potential for job creation, its effects are not readily apparent on this level. It would still require an in-depth analysis to understand the dynamics of the interaction between business services providers and users in different industrial sectors. In essence, it is necessary to gain a better understanding of the dynamics of each of the key business sectors in particular and on the drivers of outsourcing in general.

Conclusion

Outsourcing as a business practice has been in existence for many years and in many parts of the economy. In sectors such as pharmaceuticals and automotive industry outsourcing has indeed been continuously developed over the last 20 years to meet business requirements. Outsourcing has also gained more political attention. The interrelationship between outsourcing and the size of employment in services have been highlighted in times when combating unemployment tops the political agenda. However, obtaining a better understanding of the dynamics of the links between outsourcing, services and employment is by no means straightforward. Today, policy-makers are hindered by the lack of substantive research and management knowledge of the implications from outsourcing beyond the level of individual organizations. Indeed, whether outsourcing has had a positive net job creation effect remains a matter of conviction since only limited employment data are available.

Although it is possible to indicate general trends which confirm the potentially high growth of business services in Europe externalization of activities or services must be understood in terms of the dynamics of each of the sectors and their particular requirements. Each sector (and indeed company) has its own characteristics in terms of its culture, market positioning, business practices and demand for business services. An in-depth understanding of these dynamics is a key to understanding the demand for business services. In addition, outsourcing as a business practice is not homogeneous throughout Europe. In the UK, for instance, outsourcing is further developed than in the countries of continental Europe. This is due to the strength of "social and employment" legislation in the latter, which have until now strongly impeded the growth of business services.

Outsourcing is, however, not a panacea for governments at large. An increased use of outsourcing can cause a number of unintended side effects. These include effects on employment, especially in relation to the migration of enterprises to countries with lower labour and social costs. Other concerns regard the possibility of unfair competition. Outsourcing of particular functions could lead to companies having a dominant market position that could also make market entry even more difficult for competitors. The identification of such possible violations of competition rules are particularly difficult to identify in business services where relevant data are hard to obtain due to the intangible nature of the products.

Work on related issues could facilitate policy decisions. This work could for instance include the following areas:

- Growth and job potential: What is the real employment effect of outsourcing? To what extent is the growth of employment in services a substitution effect?

- The location and mobility of business services;
- Business services and the enlargement process of the European Union: Little is known as to the structure of the service profile and its likely future development in candidate countries;
- How outsourcing affects competition.

Keywords

business services, outsourcing, employment

Notes

1. This article is based on a number (36) of interviews and accompanying questionnaires with firms. Five industrial sectors were selected: automotive sector, pharmaceutical sector, food & drink sector and the domestic electrical appliances sector. Report title: *Industry Value Added Services,* An IPTS study for DG Enterprise (Internal document).

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Technology Foresight: Visions of Future Developments in Information and Communication Systems

Cecilia Sjöberg and Anna Backlund, *Swedish National Board for Industrial and Technical Development (NUTEK)*

Issue: Globalization and internationalization are affecting the development of a number of technological fields. Since progress within Information and Communication systems is so fast and international, it is of paramount importance to build on Europe's current strengths and to enhance its innovation capacity in fields in which it does not excel.

Relevance: All European Foresight studies have emphasized IT among their national strengths and have emphasized different aspects. One of the panels in the Swedish Foresight, Information and Communication systems has identified and prioritized key areas of expertise with potential for growth and renewal within IT. These key areas could be a useful aid to policy decision-making at the European level.

The Swedish Technology Foresight project brought together experts to create a vision of technological development over the long term in a number of different fields

Introduction[1]

Foresight studies examining future trends have been carried out in a number of countries in recent years. New technology is increasingly selectable and adaptable, implying that there is substantial freedom of choice regarding the future path of technology. In order to strengthen a futures-oriented approach in companies and organizations, and to identify and prioritize areas of expertise with potential for growth and renewal, the Swedish Technology Foresight project brought together experts to create visions of technological development over the long term in a number of different fields. This article draws on the results of the Information and Communications Systems panel[1], and aims to suggest lessons applicable beyond the borders of one country.

The Information and Communications Systems panel identified seven key areas by formulating visions of future society and describing what technology would be required to achieve them. These seven areas will be of great importance to the future evolution of information and communications systems. The time perspective was 5-10 years. A starting point for the panel was that information and communication technology should support and facilitate the life and work of individuals and companies. This was expressed in issues and trends that the panel initially discussed, such as:

- "Computers become smaller and communicate easily with other objects. They will be built into products such as clothes, beds, books and sporting gear to facilitate production and use. The technology will be there, but invisible".

- "Computers will have senses. We'll see small computers that can interpret human expressions, can smell, feel, hear, see and taste. These functions can be built into a number of objects and systems, such as health care equipment, traffic systems, houses, schools etc."

- "There will be human and intuitive human-computer interfaces that mimic human communication."

The Swedish telecommunications infrastructure is well developed in comparison to that in other OECD countries. Sweden has the highest share of the population with access to a computer and Internet at home in the EU, as well as a high penetration of mobile telephones. These facts, added to the successful Swedish telecom sector, indicate that Sweden is well positioned to be an advanced developer and user of IT products and services.

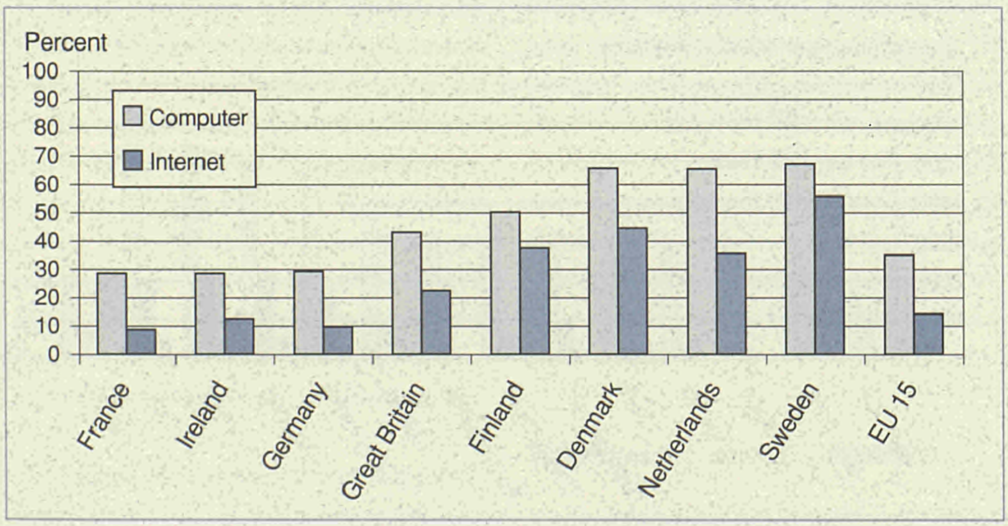
Nevertheless, Sweden, being a small country and heavily dependent on foreign trade, faces a major challenge in identifying new markets and achieving strong economic growth. Sweden, like the rest of Europe, must keep and attract skills and venture capital. The conclusions of the panel's work provide the basis for a number of strategies for the innovation and knowledge system. The purpose of these strategies is to serve as driving forces for developments in the key areas, which will attract people and companies to meet, work, invest and develop in Sweden (See Box 1).

Box 1. Comparative figures

In total, some 190,000 people were employed in the IT sector in 1997, which includes the electronics products industry and the IT-related service companies. The IT sector therefore represents 5 percent of the total number of employees in Sweden. The turnover of the Swedish IT sector amounted to 373 billion SEK (44.55 billion euros) in 1997, according to NUTEK and SCB. This was an increase of 15 percent on the year before. The IT sector accounted for 6.6 percent of Swedish GDP in

The Information and Communications Systems panel identified seven key areas by formulating visions of future society and describing what technology would be required to achieve them

Figure 1. Share of the population, aged 15+, with access to a computer and the Internet at home in various countries, in spring 1999



Source: European commission, Eurobarometer Report Number 51, July 1999.

Continued

1997, compared to 5.4 percent the preceding year. The export of electronics products in 1997 accounted for 16 percent of total exports of goods and showed a considerably higher growth rate. The IT sector is thus a very important part of the Swedish economy.
R&D expenses for 1997 totalled SEK 11 billion (1.31 billion euros) in the electronics products industry and SEK 3 billion (0.36 billion euros) for the IT-related service companies. The IT sector accounts for one fifth of the total expenses for R&D in Sweden.
In spring 1999, Sweden had the highest share of the population with access to a computer and to the Internet at home of all the EU countries (Figure 1).

The panel identified the development of home networks, wireless communications and the convergence of different media as important areas

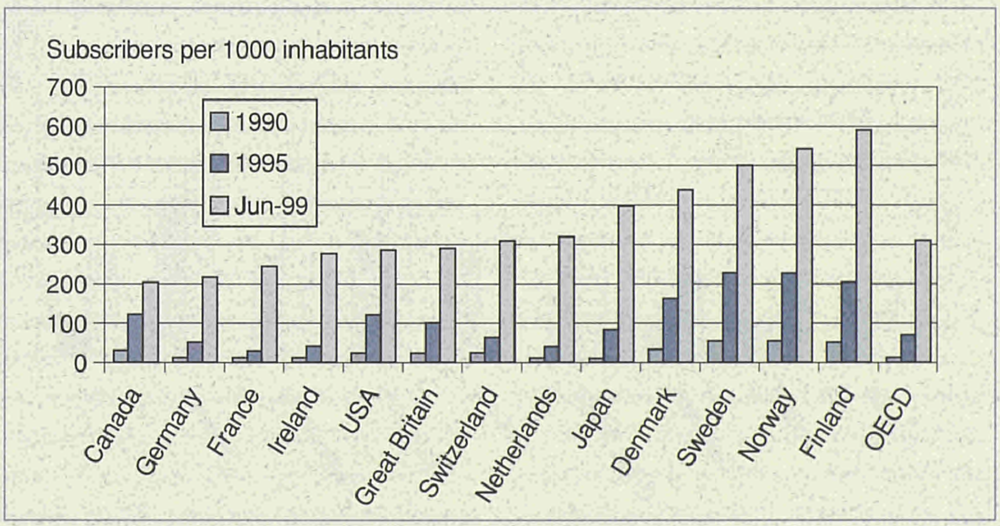
The use of mobile telephones is widespread in Sweden (Figure 2). The Scandinavian countries have been leading the development of mobile communications. In Sweden, mobile subscriptions are also increasingly substituting subscriptions to the fixed network. The mobile network reaches nearly the whole population almost, even though Sweden's geographical area is not covered to the same extent.

Key areas for the development of Information and Communications Systems

As mentioned above, the Information and Communications Systems panel identified seven key areas of great importance to the future development of information and communications systems.

The first key area that the panel identified, *Always Online*, describes a development in which people, independently of time and space, communicate electronically with each other, their homes and workplaces or with various services on the Internet. This does not mean that they always have to be reachable in person, but that their communication can be handled via a personal communicator. This area is characterized, among other things, by the development of home networks

Figure 2. Number of mobile subscribers per 1000 inhabitants in various countries in 1990, 1995 and June 1999



Source: OECD Telecommunications Database 1999 and **www.oecd.org** and wireless communications and by the convergence of different media. The area offers technological challenges, for example due to the need for greater bandwidth and new, improved interfaces between people and machines.

The area called *the Digital Assistant* singles out the need for software that can independently examine and interpret information and adapt it to the situation and requirements of the individual. The explosion of available information and the growth of e-commerce require advances in intelligent adaptive systems of this kind. In order to meet these demands, we need standards, sensors and improved techniques for retrieving, interpreting and evaluating data.

Current and future developments in IT clearly define a trend in which *More and More Becomes Software*. Large portions of the functions of hardware can be performed by software, which may be free standing or integrated into hardware. This increases the demands on the tools to produce software, and there is a need for new methods of programming, packaging, distribution and recycling of software. The design of intuitive interfaces is a major point.

The key area known as *the Services of the Future are Electronic* includes e-commerce in both physical and information-based products and services that presuppose electronic communication. New opportunities for bringing together buyers and sellers are driving the creation of new business models. This will increase the value of customer information and brand names. Important prerequisites for this area include greater bandwidth, new standards, better payment systems as well as improved systems for delivery and quality control.

Education and expertise are becoming steadily more valuable. More and more people have knowledge-intensive job assignments and thus a need for *Continuous and Immediate Learning*. Education and work will coalesce, in the same way that the entertainment and games industry will be linked with learning. With the help of IT, educational material can rapidly be disseminated to many people and yet at the same time be tailored to the individual. If advanced interactive educational programmes are to make a breakthrough and become available, they will require carefully conceived teaching methods, software tools for the production of educational materials, functional interfaces and greater bandwidth.

Developments in the borderlands where *the Technological and the Biological Worlds Meet* will be important in biologically related businesses. But biological knowledge also provides opportunities for new applications for the IT field. One strong driving force is the miniaturization of electronics. This area also includes biosensors and artificial senses, where such products as hearing implants and haptic (touch) interfaces already exist. However, numerous challenges remain to be mastered before biomolecules will be fully operational and commercially viable as electronic materials.

The last key area raises issues related to *Security and Privacy*. Increasing opportunities to gather information about individuals and their behaviour poses a potential threat to personal privacy. The society of the future will also be vulnerable, because central portions of it will be dependent on information technology. If the use of IT is to continue its positive growth, people have to trust the technology. This requires a new legal package, including a combination of laws, agreements and self-regulation, as well as technological solutions to ensure security.

Strategies for staying competitive

The purpose of these strategies is to serve as driving forces for developments in one or more key

The explosion of available information and the growth of e-commerce require advances in intelligent adaptive systems able to examine and interpret information independently

The new business models being created by e-commerce will create demand for new standards, better payment systems as well as improved systems for delivery and quality control

Society's increasing dependence on IT, and the associated security concerns, create a need for a new legal package, including a combination of laws, agreements and self-regulation, together with new technological solutions

The meeting of the technological and biological worlds is anticipated to be the core of many future technological advances

Increased reliance on IT and the network also creates the demand for more information exchange and collaboration on efforts to prevent attacks on the network

areas. The creation of *"IT universities"*, with an emphasis on mobile telecommunication systems, is one possible strategy that has been put forward. These universities should be organized in the form of a number of nodes linked together into a network, which also collaborate with other universities and higher education institutions as well as purely technical ones. The universities should collaborate with the business sector, among other things exchanging teachers and further education programmes. One important element of the university is a focus on multidisciplinary programmers who can develop software tools. Schools could be put online to promote development and stimulate new meeting places. Via the higher education and schools systems, policy-makers should first procure a backbone for all universities and colleges and thereafter extend it to the compulsory and upper secondary schools.

The meeting of the technological and biological worlds is anticipated to be the core of many future technological advances. Therefore, building up expertise and developing applications in molecular electronics, in which biomolecules are used as building blocks for electronic functions, could be valuable. However, the symbiosis between biology and IT requires multidisciplinary environments and programmes.

The development of IT interfaces for all is central to several key areas. In particular, interfaces for all the human senses are critical. Another area of interface development is systems science for groups of autonomous systems, where a project or research programme for such systems could usefully be launched. The programme could deal with both physical and mechanical robots, as well as software agents and autonomous systems. There is considerable potential for applications in areas that can interpret large quantities of data, for example e-commerce, health care or self care. Emphasis is warranted on developing interfaces and a network for security and privacy in information systems. Individual privacy and broader security concerns are important factors in the development of the IT field. The business sector has a commercial interest in protecting its digital infrastructures from both physical and network-related attacks. The public sector has the same interest. Thus there is an increasing need for exchanges of information and for collaboration on the building-up expertise related to threats, attacks and possible defensive measures. A network approach could be applied so as to set up an observatory responsible for follow-up and analysis of deliberate IT attacks throughout society.

Strategies to enable travellers and transport systems to be constantly online are also worth pursuing. This would involve, among other things, electronic services, sensors and adaptive systems tailored to travellers and traffic systems. Public registers could be made available on a mobile basis and provide information on the traffic situation and accident risks. At a later stage, the strategy could include parties such as the automotive industry and logistics companies.

Finally, a specific strategy for IT in the health care and social service systems would be advisable. One part of this effort is a programme for home health care. The programme should enlist researchers, companies and public institutions to jointly develop innovative products and services for caregivers, patients and other organizations involved. Because future health care will involve expanded patient contact on a remote basis and a larger element of home care, there is also a need for realistic experimental milieus where solutions of this type can be developed.

Conclusions

One aim of the foresight study which triggered this article was to create insights and visions about technological developments over the next ten years. Another aim was to identify strategies in education, and research and development. The insights and visions, i.e. the key areas, should be of importance for the future development of information and communications systems in general and not only applicable to one country. However, each country needs to form its own strategies to support its specific technological strengths. Many countries in Europe are strong in research but weaker in commercialization of those results. If European countries wish to make use of research output and develop their innovation capability there are lessons to be learned from the Swedish Foresight exercise. For example other -- particularly small- European countries it is important to involve the government, the research community and the private sector in the foresight process both at the overall level and in each panel.

Keywords
Technology Foresight, information technology, long-term development, strategies

Note

1. The Swedish Technology Foresight project on which this article is based was run by the Royal Swedish Academy of Engineering Sciences (IVA), the Swedish National Board for Industrial and Technical Development (NUTEK), the Swedish Foundation for Strategic Research and the Federation of Swedish Industries. It was implemented with support from the Swedish government and in close collaboration with companies, public agencies and other interested parties. The work of the project was mainly carried out within the eight expert panels:

- Health, medicine and care
- Biological natural resources
- Society's infrastructure
- Production systems
- Information and communications systems
- Materials and material flows in the community
- Service industries
- Education and learning

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ABOUT THE JRC

The Joint Research Centre (JRC), one of the Directorates General of the European Commission, carries out research and provides technical know-how in support of European Union (EU) policies. Its status as a Commission service, which guarantees independence from private or national interest, is crucial for pursuing this role.

The JRC implements its mission through specific research programmes decided by the Council upon advice from the European Parliament falling under the European Union Framework Programmes for research and technological development. The work is funded by the Budget of the European Union with additional funding from associated countries. The work of the JRC includes customer-driven scientific and technical services for specific Community policies, such as those on the environment, agriculture or nuclear safety. It is involved in competitive activities in order to validate its expertise and increase its know-how in core competencies. Its guiding line is that of 'adding value' where appropriate, rather than competing directly with establishments in the Member States.

The JRC has eight institutes, located on five separate sites, in Belgium, Germany, Italy, the Netherlands and Spain. Each has its own focus of expertise.

The Institutes are:

- The Institute for Reference Materials and Measurements (IRMM)
- The Institute for Transuranium Elements (ITU)
- The Institute for Advanced Materials (IAM)
- The Institute for Systems, Informatics and Safety (ISIS)
- The Environment Institute (EI)
- The Space Applications Institute (EI)
- The Institute for Health and Consumer Protection (IHCP)
- The Institute for Prospective Technological Studies (IPTS)

Further information can be found on the JRC web site:
www.jrc.cec.eu.int

ABOUT THE IPTS

The Institute for Prospective Technological Studies (IPTS) is one of the eight institutes making up the Joint Research Centre (JRC) of the European Commission. It was established in Seville, Spain, in September 1994.

The mission of the Institute is to provide techno-economic analysis support to European decision-makers, by monitoring and analysing Science & Technology related developments, their cross-sectoral impact, their inter-relationship in the socio-economic context and future policy implications and to present this information in a timely and integrated way.

The IPTS is a unique public advisory body, independent from special national or commercial interests, closely associated with the EU policy-making process. In fact, most of the work undertaken by the IPTS is in response to direct requests from (or takes the form of long-term policy support on behalf of) the European Commission Directorate Generals, or European Parliament Committees. The IPTS also does work for Member States' governmental, academic or industrial organizations, though this represents a minor share of its total activities.

Although particular emphasis is placed on key Science and Technology fields, especially those that have a driving role and even the potential to reshape our society, important efforts are devoted to improving the understanding of the complex interactions between technology, economy and society. Indeed, the impact of technology on society and, conversely, the way technological development is driven by societal changes, are highly relevant themes within the European decision-making context.

The inter-disciplinary prospective approach adopted by the Institute is intended to provide European decision-makers with a deeper understanding of the emerging S/T issues, and it complements the activities undertaken by other Joint Research Centres institutes.

The IPTS collects information about technological developments and their application in Europe and the world, analyses this information and transmits it in an accessible form to European decision-makers. This is implemented in three sectors of activity:

- Technologies for Sustainable Development
- Life Sciences / Information and Communication Technologies
- Technology, Employment, Competitiveness and Society

In order to implement its mission, the Institute develops appropriate contacts, awareness and skills for anticipating and following the agenda of the policy decision-makers. In addition to its own resources, the IPTS makes use of external Advisory Groups and operates a Network of European Institutes working in similar areas. These networking activities enable the IPTS to draw on a large pool of available expertise, while allowing a continuous process of external peer-review of the in-house activities.

The IPTS Report is published in the first week of every month, except for the months of January and August. It is edited in English and is currently available at a price of 50 EURO per year in four languages: English, French, German and Spanish.

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- ADIT - Agence pour la Diffusion de l'Information Technologique - F
- ARCS - Austrian Research Center Seibersdorf - AT
- CEST - Centre for Exploitation of Science and Technology - UK
- COTEC - Fundación para la Innovación Tecnológica - E
- DTU - University of Denmark, Unit of Technology Assessment - DK
- ENEA - Directorate Studies and Strategies - I
- INETI - Instituto Nacional de Engenharia e Technologia Industrial - P
- ITAS - Institut für Technikfolgenabschätzung und Systemanalyse - D
- MERIT - Maastricht Economic Research Institute on Innovation and Technology - NL
- NUTEK - Department of Technology Policy Studies - S
- OST - Observatoire des Sciences et des Techniques - F
- PREST - Policy Research in Engineering, Science & Technology - UK
- SPRU - Science Policy Research Unit - UK
- TNO - Centre for Technology and Policy Studies - NL
- VDI-TZ - Technology Centre Future Technologies Division - D
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