PILOT

Policy and Innovation in Low-Tech

Towards a new understanding of innovativeness
– and of innovation based indicators

Staffan Laestadius
Royal Institue of Technology
Stockholm
staffan.laestadius@indek.kth.se

Trond Einar Pedersen
trond.einar.pedersen@nifustep.no

Tore Sandven
tore.sandven@nifustep.no

NIFU STEP Oslo

Contribution to the conference

Low-Tech as Misnomer:
The Role of Non-Research-Intensive Industries in the Knowledge Economy

Brussels
29 + 30 June, 2005

The PILOT project and the conference are financed within FP5 Key Action Improving the Socio-economic Knowledge Base (HPSE-CT-2002-00112)

The aim of this paper is to contribute to a new start of measuring innovativeness and creativity within the business sector and thus to widen perspectives in analysing and promoting capabilities and processes that contribute to profitable firms and growth. Basically it is a technical paper arguing for a renewal of our toolbox of indicators for capturing knowledge formation in industry. It starts with a discussion of the original Schumpeterian concept of innovation; a concept which has no necessary connection to science or technological originality at all. What counts is not the science base but all professional creativity which can attract the market. This opens for a better understanding of the creative processes taking place in so called low-tech manufacturing sectors as well as in many service sectors, not the least those labelled Knowledge Intensive Business Services. The core section of the paper is devoted to a discussion of an alternative to the system of technology indicators used within the OECD and the EU. The authors argue for a family of five indicators all of which may be based on a small set of variables. Instead of compiling these indicators to a composite index – which is common practice within the EU – the paper suggests that using them together may capture the variety of innovativeness within and between sectors. Indices related to design intensity, technological intensity, skill intensity and innovation intensity are supposed to add to the more traditional R&D intensity in the work to capture different aspects of firms capabilities to innovate and to stay competitive. The suggested family of indices is finally "tested" on Norwegian data. Although they have been collected for other purposes the test reveals that the suggested system of indicators is capable to show the variety within sectors and between firms as regards knowledge formation and innovativeness. In fact, this limited test, already, provides a more diversified picture on the innovativeness of the business sector than what is provided by the conventional tools.

> Begriffe, welche sich bei der Ordnung der dinge als nützlich erwiesen haben, erlangen über uns leicht eine solche Autorität dass wir ihres irdischen Ursprungs vergessen und sie als unabänderliche Gegebenheiten hinnehmen. Sie werden dann zu „Denknotwendigkeiten", „Gegebenen a priori" usw. gestempelt. Der Weg des wissenschaftlichen Fortschrittes wird durch solche Irrtümer oft für lange Zeit ungangbar gemacht. Es ist deshalb durchaus keine müßige Spielerei, wenn wir darin geübt werden, die längst geläufigen Begriffe zu analysieren und zu zeigen, von welchen Umständen ihre Berechtigung und Brauchbarkeit abhängt, wie sie im einzelnen aus den Gegebenheiten der Erfahrung herausgewachsen sind.
>
> (Einstein, Albert, 1916, Ernst Mach, *Physikalische Zeitschrift*, Vol. 17, No 7, p. 102)

1 Introduction

The innovation discourse still has its main focus in science and technology and in the linear model although, recently, many innovation researchers have made significant efforts to break away from the situation of "lock in" into a too narrow paradigm, which this research- and policy area has been sliding into. This has been discussed in several recent articles and the main arguments will not be repeated here (for an overview and references, see Laestadius, 2005a & 2005b). In short, however, this lock in still influences

European policy on knowledge formation as is shown by the Lisbon meeting 2000 and the Barcelona Summit, 2002[1].

It may, however, be argued that one means to dissolve present confusion on the character of the innovation process and what to include in the innovation concept – i.e. in practice the reformation of the Oslo Manual and what questions to include into the Community Innovation Surveys (cf . eg. Hauknes, 2004; Salazar & Holbrok, 2004) – is to return to the origin of the concept and to the difference between equilibrium economics and the fundamentals of economic development (cf. Schumpeter, 1911/64).

The aim of this paper is to show that starting the analysis in the original Schumpeterian understanding of innovativeness may have consequences for our collection and classification of data as well as for our classification of firms and industries. Not the least, it is argued, will this change of perspective contribute to the identification of growth potentials of firms and industries which, due to hitherto dominant classifications, tend to fall outside the attention of researchers and policy makers because they are labelled low-tech or happen to be identified as services. Such firms have been in focus of the PILOT project of which this paper reports some of the results.

The structure of the paper is simple. In section two we fulfil our promise to argue for turning innovation theory upside down or – which is more to the point – turning Schumpeter on his feet again. In section three we outline some possible consequences of that as regards data collection, indicators and taxonomies. These consequences are optional and not the only possible ones following from our approach. Nevertheless they illustrate how this new approach can deal especially with those firms that do not fit into the present innovation orthodoxy. By necessity this section is somewhat technical in its style. The fourth section is devoted to a short comparison with some recent reports on European innovations, reports which also explicitly deal with the general problem analyzed in this paper. In section five we analyze how existing data from Norway fit into the suggested structure of indicators. Section six, finally, contains our concluding discussion.

For being critical towards a dominating discourse there are not many references in this paper. The theoretical and empirical ground for our discussion is well documented in the reference lists of the papers referred to here, however. There is no need to repeat those positions ad infinitum (for an overview cf. eg. Laestadius, 2005 a & b). Recent reviews on the development of innovation indicators are also provided by Grupp & Mogee (2004) and Godin (2004).

2 Arguments for a new start

In a model economy close to what is normally identified as ”general equilibrium” – i.e. when all the conditions for perfect competition prevail and have been given time to work out – we do not expect to find any innovations. If all actors are perfectly informed no actor will have the opportunity to profit from deviations as regards products or processes. All products are thus homogenous which means that only production costs

[1] Cf. Meister & Verspagen (2005) for a short overview.

matter; that in turn creates problems as all producers are well informed also on best available production techniques and have similar capabilities to use them.

In short this is a gloomy world for business; all firms in this (close to) equilibrium economy will make profits which equal the market interest rate close to the marginal productivity of capital (which, for sure, is difficult to measure). Given that this is a good approximation of the economy – and in particular a capitalist one - as a whole there must be incentive problems. Why join a play where the expected outcome – well known by all (or most) relevant actors - is close to zero? As we all know, Schumpeter - in his famous 1911 treatise - developed the idea that the equilibrium model did not capture the fundamentals of capitalist dynamics. Schumpeters argument was clear: innovativeness keeps equilibrium away; as long as firms innovate – which is the function of the entrepreneurs – firms create and maintain higher profits than the interest rate. All innovations – identified as new and creative combinations of products, processes, raw materials, markets, organizational solutions etc. - count as long as they are not immediately copied. Until that is the case, innovators earn temporary monopoly profits; competition is not about prices primarily but on the opportunity to perform better tomorrow than the market leaders do today and thus to capture the markets of the incumbants or to profit from newly created markets. The Schumpeterian approach, also explicitly formulated in modern evolutionary economic theory (cf. Nelson, 1995), allows for heterogeneity and variety among actors, eg. as regards information, knowledge, capabilities, as well as among products and processes.

The mirror image of the state of the world presented above is that we, in a well managed economy with stable, non biased institutions favoring competition, must (at least have good reasons to) conclude that firms which earn profits (above market interest) are innovative. It does not matter if they conceive themselves as innovative or not - or if innovation researchers find them innovative when analyzing their innovation survey data: those who earn money reveal that they have managed to positively deviate from equilibrium – ergo they innovate!

Starting the analysis from that perspective we can easily conclude that innovativeness is what business is about. Realizing that profitable firms are innovative is a challenge to large parts of innovation research: instead of starting the analysis with “innovations” we may start with “profitability” or, which is more relevant from analytical perspective, from “value added”. Some may comment that this is to turn innovation research upside down although we argue that it, in fact, moves us back to original Schumpeterian thinking and away from the dominating S&T paradigm. Schumpeter was interested in all those dynamic processes and entrepreneurial activities which created diversity and thus kept firms (and the economy) away from falling down to equilibrium level revenues. And so are we in this paper!

Commencing in that, original, end contributes to placing many of the problems related to the role of R&D, the shortcomings of the linear model and the shortcomings of the Oslo Manual and the CIS surveys (which at least intended to break with the R&D focus in innovation research, cf. Smith, 2004 and Salazar & Holbrok, 2004) in the background.

In fact the relations between different S&T indicators and industrial transformation or growth become normal empirical questions instead of postulates with ideological overtunes. The stylized facts in form of weak connections between input and output, eg. the performance of innovation indicators on the one hand and economic growth on the other (cf. eg. EC, 2004:), becomes not necessarily a paradox but an incentive to investigate whether we ask the right questions.

We may start the analysis with asking how profitable firms manage to develop (create) the *capabilities* and / or competencies which make them perform better than their competitors or at least to survive on the market. Part of the answer may, of course, be possible to find in R&D activities (or what is identified / labelled as R&D) carried out by firms and / or financed inside and / or acquired from outside. Parts may be related to other activities of which some may be labelled innovations and others may be far from what innovation researchers normally focus on. As analysts we may want to identify and capture all these "profit enhancing" activities irrespective of how they are labelled. We may even, in our surveys, ask firms how they explain - or estimate - the roots of their profitability.

As researchers we should also be interested in "profit enhancing" – and "value added enhancing" - activities taking place in all firms irrespective of how these firms are classified in the dominating international industry classifications systems (ISIC, NACE). Although the cost disease of services once forecasted by Baumol (1967) is well known by most economists, we have in fact no a priori reason to assume that such a mechanism should be relevant for all those 70-80% of economic activity within the OECD area which now are classified as services. Even if the Baumol theorem is valid for strict human to human related services we may safely assume that important segments of the service sector may well be innovative and show growth of productivity, value added and employment comparable to manufacturing (cf. OECD, 2001 & Wölfl, 2003).

The growth of the service sectors as well as the servicization of what is left of the manufacturing sectors is in itself a phenomenon the details of which fall outside the scope of this paper to analyze. The mechanisms are, however, well documented (for an overview of the literature see Boden & Miles, 2000).

We have thus no reason to restrict our analysis of innovations to manufacturing or to base our analyses on concepts and theories most useful (or originally developed) for manufacturing sectors. Although Community Innovation Surveys nowadays include service firms and have questions related to service activities it may still be argued to what extent non manufacturing creativity is captured in these studies (cf. Tether, 2003a & 2004; Miles, 2004 & CIS IV, 2004).

The analytical implications of the approach discussed so far should not be underestimated. It can roughly be estimated that only about 20% of total OECD and EU value added is produced within manufacturing sectors and only about 3% of total value added comes from manufacturing sectors classified as high-tech (OECD, 2004:226). Even allowing for statistical errors it can be safely concluded that the high-tech manufacturing focus represents a neglect comparable to the ignorance once discussed by Abramowitz (1956) when introducing the technology factor to growth theory.[2]

The implication of the discussion above is also that it is of little relevance whether an innovation has “scientific originality” or “technology height”. What is important for patent offices is not necessarily of importance for the economy. Somewhat depending on how innovations are defined, it is not even important whether an innovation is “new to the world” or “new to the firm”. In a non-equilibrium world dominated by heterogeneity there are always local niches worth to exploit even with “old” technologies and solutions or skilfully customized applications of general principles. The core problem for innovation analysts following our approach becomes to identify creative activities (combinations) which providing diversity attractive to the market and thus contributing to value added.[3]

Another implication of this approach is that it naturally leads us to focus much more on all those diversity creating activities which normally fall outside the scope of today’s innovation analysts, like design and customization, like skilful professional practice, like organizational restructuring of business, like (out)sourcing and networking, logistical creativity, joint ventures and R&D cooperation; not to talk about more market oriented activities like branding and positioning on these heterogeneous markets.

In addition we may pay attention to the fact that although we can observe that there are differences in the average value added (and its growth rate) between industries there are also significant differences in value added within industries, not only on different levels of aggregation (i.e. a statistical phenomenon), but also between individual firms in the same industry. In short, firms – also within the same industry interpreted narrow - play their instruments differently; some are more creative than others.

The growing network character of the economy analyzed on macro level of analysts like Castells (1996/2000) but also identified since long by several analysts of transnational firms and international production (cf. Buckley & Gauhri, 1993 & Dunning, 2000 for a broad picture) and of roundabout production (cf. Young, 1928 for a classic text!) or of networking in general (cf. eg. Nohria & Eccles, 1992) should be mentioned in this context. In a global system of advanced division of labour and interdependence between research units, firms, industries and regions, it is increasingly difficult to identify what part of an industrial or technological system is the most essential. Existing innovation indicators still have problems to capture this phenomenon of distributed innovation processes (cf. Coombs et al, 2001)

The specialization of knowledge formation – as introduced to the modern discourse by Gibbons et al (1994) – adds another and cognitive dimension to this network-related

2 This may be illustrated with data from Sweden. Although Sweden is more specialized in high-tech pharmaceuticals than any other EU country (except Ireland!, cf. OECD, 2004) the value added from that industry is of the same magnitude (2002) as the low-tech food industry only. And on two digit level the B2B services is by far the most significant VA-producer (2002) in Sweden (SCB, 2005).

3 Cf. Tether (2003b) for a discussion with family resemblence to this.

interdependence argument: technologies from different fields of knowledge depend on each other to become industrial success stories. Although some technologies may be generic – i.e. pervade a lot of other technologies, applications and industries - they may not necessarily be useful alone. Technological development is thus – following Gibbons and due to increased specialization of knowledge production – more interdisciplinary (and thus more polytechnic) than ever before.[4]

This may be illustrated by functional food like ProViva which combines biotechnology and food manufacturing to a "probiotic" product (functional food). Likewise the probiotic tampon Ellen – potentially challenging transnational incumbents like Johnson & Johnson - using a lactic acid bacterium becomes an innovation due to the creative combination of biotechnology with traditional tissue manufacturing and intensive branding.

Starting the typology discussion in this end instead of in a Platonian inspired innovation discourse has a lot of consequences. Most important is probably that we get an opportunity to change the foundation for the analysis. In short, we may intentionally include all forms of creativity in all industries in our analytical framework – and thus also in our innovation questionnaires (CIS). At least we should be open minded to identify all different forms of creativity – irrespective of how they are labelled by those involved - which in one way or another may contribute to profitability or value added and thus, in the extension, to industrial transformation and growth.

3 Towards a new system of indicators for classification of innovativeness

Also classification schemes may be classified! Although the details of that are not of core importance in this context we may, following Bailey (1994), note that the term "typology" normally is used for conceptual classifications, i.e. theoretically based and/or related to "ideal types". The term "taxonomy", although often used interchangeably to typology, is normally used for the classification of empirical entities. In short, typologies are conceptual and taxonomies are empirical although that distinction is far from easy to upheld in practical analytical work (cf. Bailey, 1994, p. 5-6).

Bailey (1994) does not mention the term "indicator" in his study on "classifications". As mentioned in Laestadius (2005b) those typologies/taxonomies which are labelled or related to "indicators" are historically of a normative character, i.e. intended to direct or guide policy makers or other actors in their work.[5] Indicators, consequently, sort the classified entities according to ordinal or cardinal values. The indicator (system of indicators) may thus be looked upon as a tool for obtaining a typology (or taxonomy).

---

[4] It may be argued that Gibbons et al provide very little empirical foundation in the report for their conclusions which more have the form of conjectures than final research results.

[5] For an analysis on the history of high-tech indicators, see also Godin (2004).

All classification schemes, (typologies, systems of indicators) have to legitimize themselves. One of us have, elsewhere, identified five criteria which contribute to the legitimation process: a) simplicity; b) reliability; c) relevance; d) adaptability and finally e) community creation. An analysis of this in more detail is found in Laestadius (2005b). In short it may be argued that there is a strong momentum or path dependence in established indicators/typologies. As is the case with paradigms, they do not change unless there are fully developed constructs (models or systems) showing that alternative world views are possible - and work.

As mentioned, our point of departure is the original Schumpeterian (1911/68) one identifying a broad innovation concept including all forms of diversity creation which may contribute to profitability (and thus to value added). As is normally the case, we may find that some forms of creative action are more important than others – but let us for the moment leave the empirical questions aside.

As shown in the not so developed discourse on creativity that concept is far from easy to define or to make operational (cf. Boden 1996 & 2003). An exact definition of creativity is, however, not necessary to formulate for our further work. For our purpose it is enough to identify what we may call the *creation of capabilities,* significant parts of which may be labelled knowledge formation processes. Adopting the capability concept obviously moves to the direction of the modern theory of the firm and the “dynamic capability approach” (cf. Kogut & Zander, 1992; Foss & Robertson, 2000; Teece & Pisano, 1999/2001 & Zollo & Winther, 2002). As regards knowledge formation we may leave it open whether the set of creative actions in focus of our analysis is identical with what should be included in the knowledge formation concept or whether one or both sets has some area outside the other. As shown by Faulkner (1994) the later concept (knowledge formation) is – even if we restrict ourselves to more traditional industrial innovation - far wider than what is normally included in R&D. One important aspect of the Faulkner “Typology of Knowledge Used in Innovation” (Faulkner, 1994:447) is the distinction between knowledge related to design practice and knowledge related to experimental R&D. Her argument is strongly based on the research by Vincenti (1990) but is also in line with the arguments put forward by Kline & Rosenberg (1986, not referred to by Faulkner). In fact “design” in different forms is the core activity in the chain-linked innovation model introduced by Kline & Rosenberg (1986: 289 ff). Our ambition to integrate the views of Faulkner and Kline & Rosenberg into the system of indicators motivates the somewhat deeper analysis on the design concept below.

Explicitly including a design concept into the analysis of innovative activities does not immediately simplify analytical work. The meaning of the word “design” is much contested (cf. Julier, 2000, chpt. 2). In short the discourse includes definitions focusing on aestethics (adding aestethic measures – or even functions - to objects) as well as focusing on the creation of the object itself. The strong engineering thought style on design tends to focus on the later end (cf. eg. Vincenti, 1990, Ferguson, 1992 & Petroski, 1996).

Following Alexander (1964), who has written a fundamental text on design theory, the aim, or the task, of the design process is to create fitness; the form is the solution to the problem which is defined by its context (Alexander, 1964, chpt. 2). From this perspective the design process may be looked upon as a *synthesizing activity*, a creative problem solving act, where different fields of knowledge and sub systems are modified and integrated into a new entity – a physical or virtual artefact (cf. Rosell, 1990). This is also the position taken by Herbert Simon (1996:chpt 5) who explicitly argues that ”everyone designs who devices courses of action aimed at changing existing situations into preferred ones”. The activities – the creative processes - involved may be characterized as rational, as innovative and as artistic, the relative importance of which may depend on the designer herself as well as her task .

A broad design concept, spanning from “adding aestethics to the object” to “creating the object itself”, complicates the dominant definition of innovations in general and of R&D in particular. An independent definition of a design concept will include parts of what hitherto has been included in the “D” part of “R&D”. It may even be argued that most of the intentional creation of artifacts that characterizes engineering should be included in the design concept rather than in the (experimental) “R&D” fold. In addition even Faulkner may underestimate the area to be covered by the design concept as she is much focused on engineering, thus neglecting the aesthetic (fashion) perspective. In the extension it may be argued that the whole of intentional creation of artifacts (cf. Baxandall, 1985) is a design activity.

A preliminary conclusion from this short discussion is that explictly adding design as a category in innovation related typologies may necessitate a redefinition of R&D as it is presently identified in the Frascati Manual (OECD, 2002). In chapter two of the Frascati Manual “D” stands for “experimental development” (defined on page 30). The relation of that concept to design (which is not explicitly defined) is discussed on several places in the chapter although primarily on page 44 where it is concluded that the bulk of industrial design activities should be excluded from “R&D”. It may, however be argued that good design to a large extent is experimental in its character (cf. Thomke, 2003). In short we may thus argue that some experimental activities may be classified as design as well as R&D in a revised typology. As a byproduct we may obtain a somewhat more precise – or at least narrow - R&D concept.

Analogically this explicit acceptance of design will also impact on the presently used innovation concept in the Oslo Manual (OECD, 1997). The implication of the intentional focus in the Oslo Manual on technological product and process innovations (at least) new to the firm is that much of design activity is excluded (see p. 17 f.). “Technological” in the vocabulary of the Oslo Manual relates to the “objective” performance of products or processes thus locating “subjective” performance related activities to the non-innovation realm. The detailed OSLO-definitions on TPP innovations are delivered in chapter 3 of the Manual where the more analytical parts of the design process are integrated in the innovation concept while more artistic processes related to the appearance only of products are excluded from innovations (p. 60).

In short: adding an explicit "design category" to "R&D" and "innovation" will significantly increase our abilities to capture industrial creativity although parts of what will be captured in the "design net" is already captured in the "R&D (or Frascati) net" or in the "innovation (or Oslo) net". Design data may well be collected in the same way as R&D and innovation data are collected today. Data on expenditures on design, broken down to some sub categories (balancing form and function) and distributed e.g. on performed, used, sold to or acquired from outside, may be collected population wise or by sampling within sectors.

This simple widening of the innovation concept and redefinition of "D" in R&D may impact on the classification of firms as well as of some industries. The impact on industry level should, however, not be overemphasized. As is discussed below – and which also is fully in line with analyses by eg. Baldwin & Gellatly (1998) – variety seems do take place also on firm level within industries.

It is, however, possible to go further along this line although that may necessitate survey data collected in processes similar to the CIS work. Tentatively the starting point for this exercise may be the indicator system developed by Baldwin and Gellatly (1998 & 1999). Disappointed, as many other innovation researchers with the dominating OECD technology level classification (cf. Hatzichcronoglou, 1997 & Foray, 1999) they, unlike many other innovation researchers, developed a new system with three indicators rather than one: *innovation competencies, technological competencies* and *skills* (human capital development) respectively. Each indicator is based on a set of 5 – 10 criteria (variables) which may be collected using a five point Likert scale.

The details of the variables in their approach is of less importance than their approach as a whole. In short only the first indicator (innovation competence) is similar to our traditional innovation concept. The second one – technological competence – has no explicit connection to innovation at all but may be looked upon as related to a capability approach (although Baldwin & Gellatly seem not to discover that). This indicator identifies competencies in developing, importing, acquiring, purchasing and integrating new technologies in their processes.

The third indicator in the Baldwin & Gellatly system is – in its original form - rather straightforward, focussing on human capital development, on the creation of skills etc. Without going into details of the five variables included in their original contribution we may argue that an indicator like this, if well developed, may catch the professionalism and skill based customized activities which may make KIBS firms successful even if they do not innovate in traditional sense (cf. Tether, 2004).[6]

The Baldwin & Gellatly system of indicators can be further developed. The important thing here is that they add to the discrimination between firms as regards the capability of the firms to act creatively or to create conditions for creativity. As shown by the empirical tests performed by Baldwin & Gellatly their typology reveal the existence of

6 This searching for a skills related indicator is fully in line with ambitions within the European Trend Chart on Innovation work (cf. Lorenz, no date)

significant differences between firms – eg. between large and small firms - within industries. Their empirical tests also show that many firms score similarly in all indicators although there are firms which score high in one or two indicators and low on the other (Baldwin & Gellatly, 1999).

Combining the Baldwin & Gellatly approach with the Faulkner and Kline & Rosenberg inspired typology opens for a system with five (or under certain circumstances – see below – six) indicators. So far we argue that all firms in all industries may be analyzed in five dimensions which can be measured through quantitative data collection and/or surveys. We may thus classify firms according to their:

- R&D intensity
- Design intensity
- Technological intensity
- Skill intensity (Human capital orientation)
- Innovation intensity

Depending on how narrow a future innovation concept should be defined in the "innovation intensity" indicator above, the suggested five dimensional indicator system lacks any reference to organizational capabilities/competencies/innovations. It also lacks any reference to marketing, branding and positioning activities. Although it may be argued that the simplicity criterion (cf. Laestadius, 2005b) puts strong restrictions on the creation of typologies/taxonomies, this neglect – especially of organizational capabilities/ innovations – may be a problem. In fact Schumpeter already identified organizational innovations in his original contribution, and important significant dimensions of productivity increases may be labelled "organisational" rather than "technical" (cf. Taylorist and Fordist methods). In addition the empirical results from the PILOT cases indicate that many of the successful low-tech firms have developed advanced logistical capabilities; capabilities which sometimes seem to be part of their core competencies. There may thus be a strong case for including a sixth indicator, related to organizational skills/creativity. An alternative is to include variables on that in the innovation intensity indicator.

As regards marketing and branding we are preliminary of the opinion that these activities, if they are successful in the long run, may be looked upon as a capability to communicate capacities which are objectified primarily in the design/innovation process and thus can be captured primarily by the indicators already created in that area. We can also imagine that one or two variables in one of these indicators may be explicitly focused on the communication process.

So, this will end up with five indicators – or six if adding an organizational one - which together make up a profile for the individual firm and/or for an aggregate of firms, e.g. an industry or a "sector" aggregate of different industries (e.g. the "ICT-sector" or the "technological system for pulp and paper"). These indicators may require different sets of questions or data. The R&D intensity indicator is probably the most obvious: we may here stick to a revised – and, as mentioned above, a more narrow version of the Frascati manual. As regards design intensity we may include a broad design concept including parts of what hitherto has been included in the D of R&D. As a result of that reallocation of design activities, R&D intensity will, ceteris paribus, decline in the statistics. In addition the broadening of the design concept may have consequences for what aspects should be included in the new innovation intensity and thus have some impact on the further revisions of the Oslo Manual (OECD, 1997).

This system of indicators is not a typology of the classical kind as discussed by Bailey (1994) forming a conceptual world which is exhaustive and / or exclusive. We do not have to assume that these indicators are the only valid ones. Neither do we have to assume that firms / industries are either “R&D intensive” or “Design intensive”; individual firms may score high (or low) in all or one of the indicators above. Our basic assumption is that these indicators together will capture the bulk of creativity explaining successful firms and industries in manufacturing as well as in service sectors.

The five entries above are, so far in our discussion, not even exclusively defined, although further analysis may show that such an exclusivity may be desirable. Some data collected for the formulation of “design intensity” may – depending on our definitions - be similar or identical to those needed for specifying “technology intensity”. Purchasing e.g. a design solution to a process from a consultant may be reported as acquisition of design as well as captured as integrating foreign technology to own processes. And parts of R&D activities may, depending on how innovation intensity is defined, be included also in the innovation intensity indicator.[7]

How to handle such problems may be solved underways. Obviously there are two main paths two follow: either a) accepting this as a *family of indicators* telling different stories on the same phenomenon but not possible or reasonable to aggregate or b) to make them totally exclusive – i.e. locating all relevant activities to one and only one of the indices above - thus making it possible to aggregate them also to one single *composite indicator*. If overlaps are small they may be neglected in the aggregating exercises.

The primary arguments for the construction of composite indicators – of which the European already existing European Innovation Scoreboard, the Summary Innovation Index (SII) and Innovation Sector Index (ISI) – all based on roughly the same set of data (primarily from CIS) are good illustrations (see ETCI, 2004b; EC, 2004 & ETCI, 2004a) – are the strive for simplicity and maybe also for community creation (cf. Laestadius, 2005b). As regards simplicity one-dimensional indicators like the OECD high-tech / low-tech indicator has obvious pedagogical advantages: people remember them, they react on them and (at least believe that) they can identify the meaning of them. As regards community creation it may be argued that a simple one dimensional indicator with related typology / taxonomy can be identified as a focal point for orchestrated political

[7] This phenomenon is, by the way, not new for innovation surveyors. The European Innovation Sector Index (ISI) eg. contains a variable on innovation expenditures as a percentage of total turnover (based on CIS 3 data) which partly overlaps with the indicators on investments in machinery and equipment and R&D expenditures (ETCI, 2004a)

action: we can all unite on transforming Europe to a high-tech knowledge based economy.

There are, however, strong arguments favoring a family of related indicators rather than focusing on a composite solution. From a data acquisition point of view the problem is probably non-existent: a reasonable disaggregated data collection can serve as a base for several different indicators. The basic argument is related to the need to capture the variety as regards creativity which may exist between firms within different industries and countries. Just adding one or two variables on design to an aggregate innovation index will probably not capture the variety which exists between industries, still less catch what happens within industries.
A set of 5-6 different indicators which aim to capture different aspects of industrial creativity must in addition not necessarily consist of totally exclusive indicators. Finally it may be argued that composite indexes , depending on how they are constructed, may not only provide different pictures but also hide real problems (cf. Grupp & Mogee, 2004)

We can imagine that firms – and industries - may score differently in these dimensions although some firms and industries will have similar results along the whole vector of indices (cf. eg. EC, 2004 & ETCI, 2004a). What combinations of scoring that have the highest probability to indicate growth is, of course, an empirical problem.

Some of these indicators – like R&D intensity, design intensity and technological intensity - will include activities which can be measured in cost terms and related to sales, production or value added. We may here include data not only on activities performed within firms but also on acquisitions and sales. R&D intensity may thus be measured with the amount of R&D performed in the firm and the amount purchased by the firm from a consultant, i.e. a KIBS (Knowledge Intensive Business Service) firm. Sales of R&D work should be treated similarly. Design intensity may, likewise, be defined / constructed not only based on design activities performed within the firm but also on the design services bought from, or sold to, external actors. One implication of this is that firms may be asked to classify parts of their knowledge related transactions and make them available for future innovation surveys or other means of data acquisition. This is totally in line with the arguments once put forward by Cohen & Levinthal (1990). Firms which buy / acquire design solutions and R&D may indicate an absorptive capacity to transform knowledge into profitable activities as well as it may indicate networking in knowledge formation.

Indicators like these may, under certain circumstances, show problems of aggregation as some data may appear in several firms and industries. (Two firms may, e.g. acquire the same technology through buying it from a third firm.) Those problems have to be considered but are probably not severe. Among the advantages with this system of indicators is that it potentially captures the innovativeness of networks and inter-firm relations, something which for a long time - starting with Scherer (1982) - has been identified by innovation researchers (cf. Coombs et al, 2001).[8]

The present industrial classification systems (ISIC and NACE) are - as is clear from the problems to capture ICT activities within them (cf. eg. Laestadius, 2005a, for an overview) – not well equipped to catch the fundamental phenomena of the modern knowledge based economy. Especially service sectors are poorly developed and bluntly identified in the present classification scheme which – of course - is problematic in an epoch when much of creative activities are outsourced to knowledge intensive service firms or – which is the mirror image of this process – when manufacturing firms outsource their manufacturing activities thus transforming themselves into service firms. The broadening of the innovation / creativity concept as suggested above will hopefully make innovation analyses more relevant for more firms and industries than hitherto.

The problem with the industrial classification scheme will not be solved with this approach. As many analysts have argued, and what is concluded in Baldwin & Gellatly (1998) the analyses of innovativeness and creativity may preferably be carried out on firm level and maybe also on network / cluster level rather than on industry / sector level. The approach suggested in this paper is fully in line with this.

4 Recent work within the EU in this field

As noted in the introductory section and in several passages above there are parallel attempts among analysts to capture the weaknesses in the dominant S&T paradigm within innovation analysis. The seminar report on *Alternative innovation indicators and determinants of innovation* (EC, 1996) may illustrate that this process has been going on for some time. Here we focus shortly on just a few of recent exercises. In the *European Innovation Scoreboard 2004 – Comparative Analysis of Innovation Performance* (EC, 2004) the commission staff uses a composite index, Summary Innovation Index (SII), based on 20 indicators / variables taken from available statistics and from the Community Innovation Survey (CIS-3). These indicators are grouped into four classes (human resources for innovation, creation of new knowledge, transmission and application of knowledge and innovation finance). Although a new non-technology variable has been included (indicator 3.4[9]) from this year it may still be argued that this highly aggregated index, partly due to its composite character and partly due to the variables that constitute it, provides data that are far from easy to interpret: in short highly innovative countries show slow growth and many fast growing countries score low as regards innovativeness as it is measured (cf. EC, 2004:13).

[8] In the well known typology from Pavitt (1984) some sectors were supposed to be more enabling than others as regards knowledge formation. It is far from easy how to capture these flows of knowledge or technological dependence. One means, not free from methodological problems, is to measure inter-industry transactions as regards machinery, equipment and knowledge (cf, Pol et al, 2002).

[9] Indicator 3.4 is a composite indicator related to implementation of advanced management techniques and / or significant changes in the aesthetic appearance or design of at least one product (EC 2004:15)

The report discussed above focused on innovative behaviour aggregated to the national level. The paper *Exploring Innovation Performance by Sectors* (ETCI, 2004) analyzes innovative behaviour by sector. Using an Innovation Sector Index (ISI) based on 15 indicators from available statistics and CIS-3 data they aim to produce sector specific scoreboards, thus avoiding sector varieties to become hidden in the overall analysis. This approach was originally in detail developed in a technical paper from 2003 (ETCI, 2003). The results from both papers show that there is a significant variety between countries as regards sector innovativeness as measured by the composite ISI-indicator. In short the Netherlands, Belgium and the Nordic countries are not only innovative in high-tech sectors; they are also more innovative in the low-tech sectors. These sector analyses also show that there is a high correlation – using the ISI index - between the OECD taxonomy (high-tech….low-tech) and the taxonomies suggested by Pavitt and Castellachi (ETCI, 2004a: 14f).

The papers discussed here represent a significant step away from the to narrow S&T related path which has dominated innovation analyses. While widening the innovation concept far beyond the original OECD R&D based indicator they show the variety between countries and sectors as regards innovativeness. It may, however, be argued that improvements can be done on three levels

- The problem with the composite index.
- The problem with the selection of variables to widen the innovation concept
- The problem to capture variety within industries / sectors.

As we have shown in section three above, that is also the target for this paper.

5 A preliminary empirical test of this system of indicators

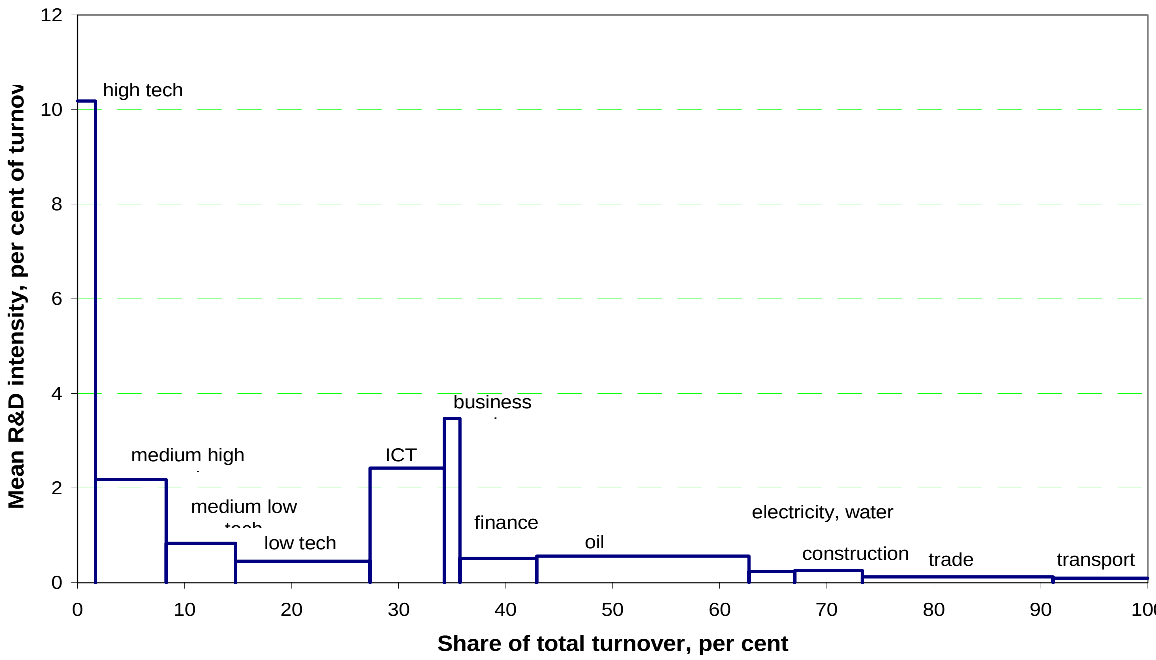
The proof of the pudding is the testing. Especially if the ambition is to introduce a new system of indicators as a substitute for an older and much criticized system it is important to analyze the usefulness and limitations of the new system. For the moment such a test is only partly possible as available data are collected according to existing standards and thus not fully capture the new dimensions suggested in this paper. This is not necessarily a big problem, however. Our aim here is not to provide new data series on innovations, sectors or countries but to illustrate that there are alternatives which may provide different information compared to the dominating indicators even when using the existing data. Below we show how Norwegian data – most of them from the CIS-3 round - fit into the suggested system. It should be reminded that the huge Norwegian oil industry may provide atypical biases on the result. The reason for using data from Norway only is simple: recent European data are not available on the same level of aggregation as the data we present here.

Our methodology is also simple. For each of the five indicators in our model, as developed in section three above, we have chosen a few reasonably close variables among those that are available. We have not aggregated them to a composite R&D or design indicator. Our intention is to show the variety – and similarities – within and between industries using this approach. Finally we illustrate possible implications of adding a sixth – organizational – indicator. Once again, it should be reminded that we use existing data – the next logical step should be to define the detailed content of each of the five (six) indicators; and we are sure they would deviate from our preliminary exercise here.

1 R&D intensity

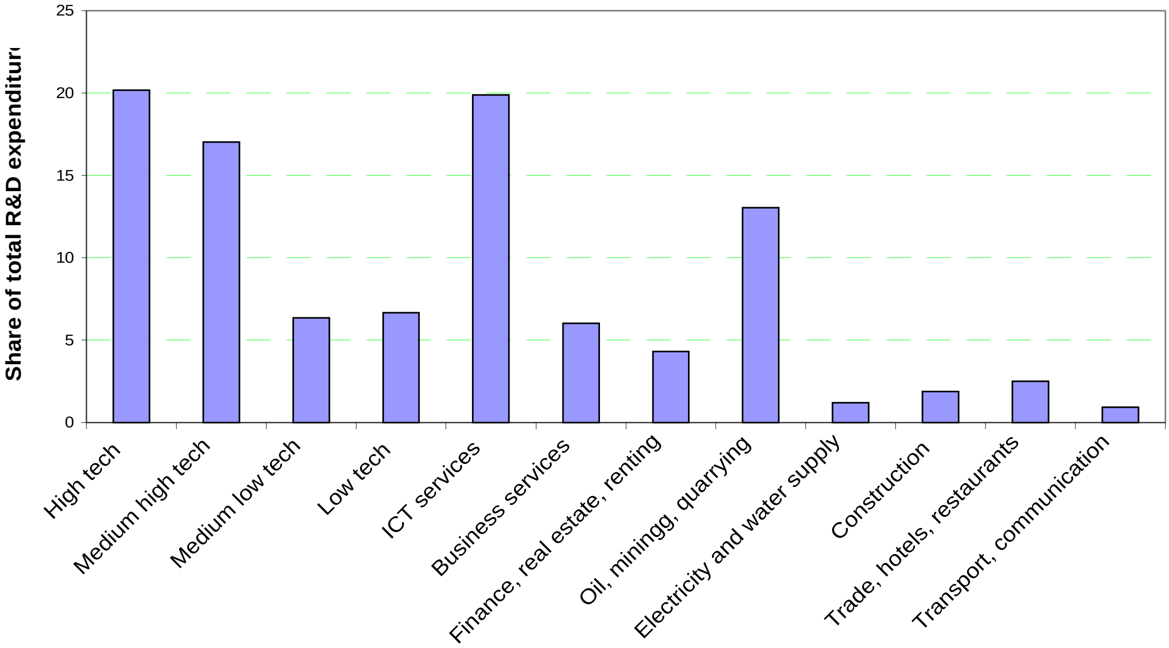
R&D intensity is the traditional yardstick for the technology level within manufacturing. There are, however, service sectors (ICT and Business), which show high R&D intensities. In addition, sectors differ widely in size, for instance as measured by turnover. This is shown in chart 1, where the size of turnover of each sector - including services - is represented by the width of the columns and R&D intensity is represented by the height of the columns.

Chart 1 *Industries' average R&D expenditures as share of turnover and the industries' share of total economic turnover*



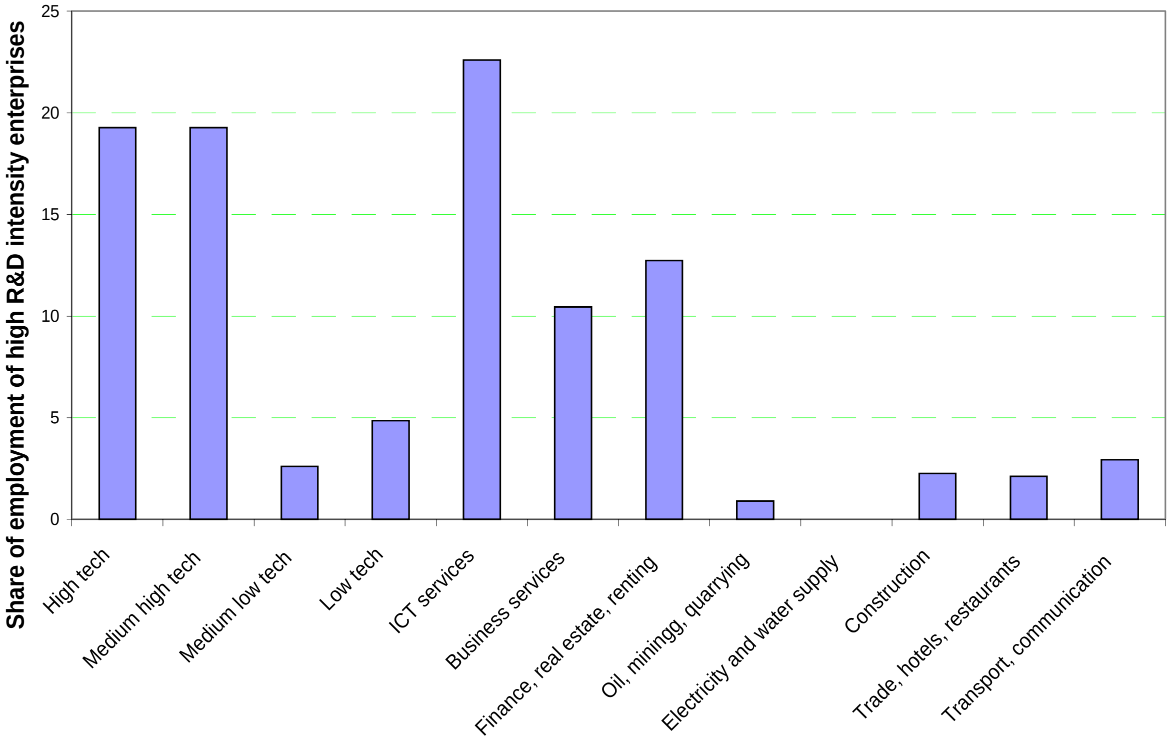
Since R&D intensity here is expressed as R&D expenditures as a proportion of turnover, the total amount of R&D in each industry is represented by the area of the columns in the figure above. We may observe that although high-tech industries have a high R&D intensity, the total amount of R&D performed by high-tech industries is not at all dominating in the economy. The distribution of R&D expenditures is shown in the next figure (chart 2), which shows what the column areas in chart 1 sums up to. Thus, because the high tech manufacturing sector is quite small, it only accounts for 20 per cent of business sector R&D expenditures. The ICT services sector accounts for roughly the same amount, and that is also the case with medium high tech manufacturing.

Chart 2 *Industries' share of total economy R&D expenditures*



We now turn from the more traditional concern of classification of industries in terms of industry averages and totals to the question of heterogeneity within industries.

Chart 3 *Share of employment in sectors accounted for by enterprises with high R&D*



This has to do with the question of variety within industries and with the point that there are high-tech firms also outside the high-tech sectors. In the following we will define a high-tech or high-end firm along the R&D dimension as a firm with at least 5 per cent R&D intensity. This cut-off value is somewhat arbitrary, of course, but it corresponds to the OECD industry classification definition of high tech industries as industries with at least 5 per cent R&D intensity.

Using that definition of high-tech firms we find (not shown here) that 54 per cent of employment is accounted for by high R&D intensity enterprises, while in the low-tech category the corresponding proportion is 1.9 per cent. Sectors differ in size however, and taking that in consideration we may e.g. show the share of total employment in firms reporting high R&D distributed on sectors (in Norway). This is shown in chart 3 above.

This gives an interesting picture: 22.6 per cent of all employment in high R&D intensity enterprises is found in the ICT services sector, while both the high-tech manufacturing sector and the medium high-tech manufacturing sector account for 19.3 per cent. Charts like this mirrors the structure within industries: we may e.g. assume that countries like Ireland with a large high-tech manufacturing sector (as conventionally classified) scores low as regards employment in high-tech firms.

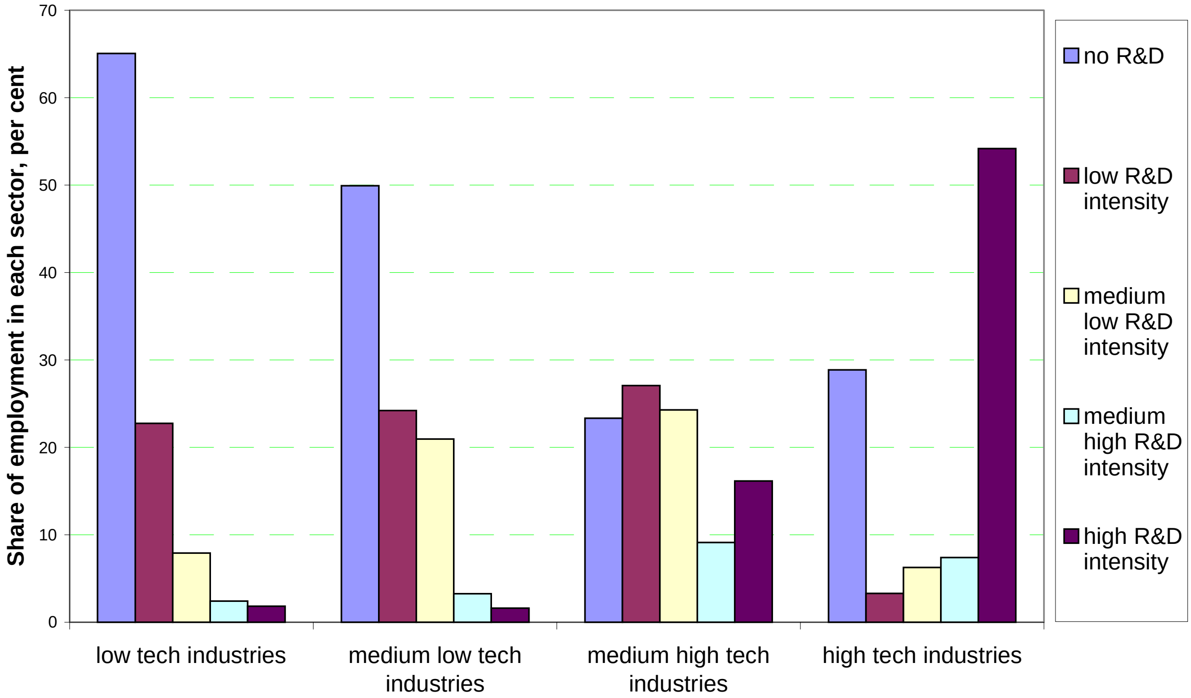
Following that track we can use the OECD definition of technological intensity of industries to classify the enterprises, and then see how large share of employment each enterprise category accounts for in each sector. We thus use the following definitions:

- No R&D: no R&D
- Low R&D intensity: more than 0, not more than 1 per cent R&D intensity.
- Medium low R&D intensity: more than 1 per cent, not more than 3 per cent R&D intensity.
- Medium high R&D intensity: more than 3 per cent, not more than 5 per cent R&D intensity.
- High R&D intensity: more than 5 per cent R&D intensity.

Thus, restricting ourselves to manufacturing, the following figure shows how large share of employment in each of the OECD categories along the high tech – low tech dimension is accounted for by each of the categories of enterprises defined by R&D intensity. The figure below shows (for Norway) that within high-tech industries about 54% of total turnover is accounted for by enterprises with more than 5% R&D intensity. It should be observed, however, that within high-tech industries almost 30% of the turnover is accounted for by enterprises with no R&D. At the other end of the figure, within low tech industries about 65% of turnover is accounted for by enterprises with no R&D, and as earlier mentioned only 1.9% of the turnover is accounted for by enterprises with R&D intensity of more than 5%.

To conclude this section, the traditional view of using industry level analysis of R&D as indicator hides the fact that the four industrial (manufacturing) sectors (low-tech ... high-tech) all include enterprises that are low tech and high tech if measured by R&D intensity. Within high tech industries almost 1/3 of total turnover is accounted for by enterprises with no R&D. And only about 54% of turnover is accounted for by enterprises with high R&D levels. The share of turnover within low-tech industries accounted for by enterprises with no recorded R&D is 65%.

Chart 4 *Share of employment in each sector accounted for by enterprises with different R&D intensities*



2 Design intensity

Data availability restricts our possibility to test this indicator in depth. However, as an indicator of design intensity we use the share of the enterprises reporting that they have protection through complexity of design. This is a mere occurrence-or-not variable. We will here look at number of enterprises, not the share of employment they account for. As chart 5 below indicates, costs related to product design do not alter the traditional order between high-tech and low-tech firms in Norway. Neither does protection through complexity of design alter the relation between manufacturing industries although several services industries seem to have higher shares of enterprises with more complicated design solutions than do medium and low tech industries**.** In fact the medium high-tech category has the highest share of enterprises with protection through complexity of design.

Also in this context we may consider the fact that sectors differ in size. This is shown in chart 6 below. We see that high tech enterprises with design protection represent a relatively small share of the total number of enterprises in the economy. Given the fact that low tech industries account for almost 20% of all enterprises with design protection, enterprises within low-tech industries represent the second largest category where protection through complexity of design is utilized. Low tech is only “beaten”by ICT services, which account for around 20% of all enterprises that apply protection through complexity of design. Only about 4% of all enterprises that apply protection through complexity of design are within the high-tech industries.

Chart 5 *Share of enterprises in each sector accounted for by enterprises with protection through complexity of design*

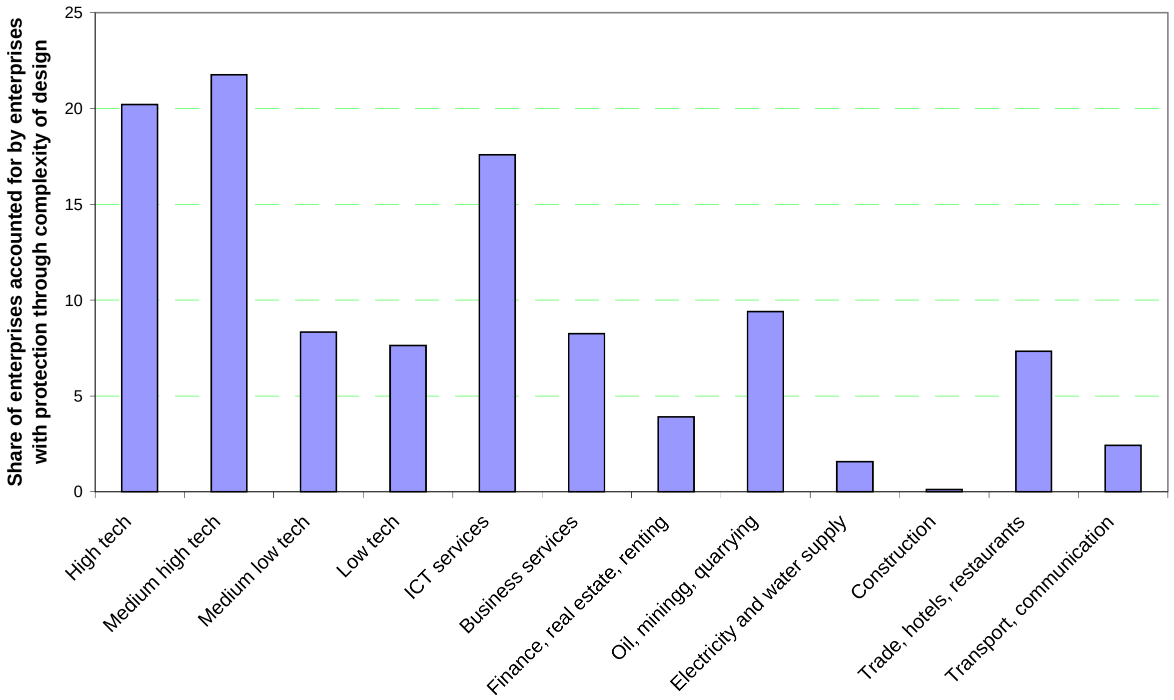
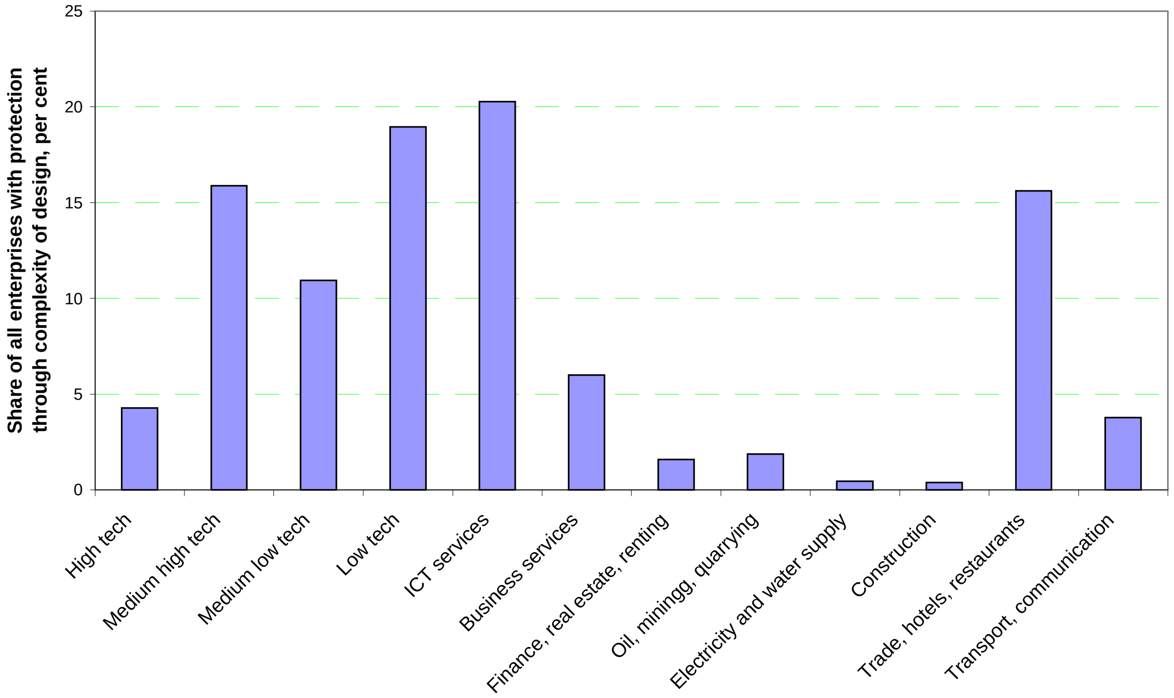


Chart 6: *Sectoral distribution. Share of all enterprises with protection through complexity of design.*



Summing up, even using such a blunt tool as this indicator of protection through complexity of design reveals another picture on innovativeness and competitiveness than the conventional. In fact: the change as regards ranking of sectors is significant.

3 Technological intensity

There are many possible ways of defining technological intensity. Applying a technical, hardware-related concept of technology we have utilized the variable expenditures on machinery and equipment in relation to product or process innovations. We define high-end enterprises as those that have reported at least 0.5 per cent units of their total turnover to the machinery and equipment category. We may call this acquisition of advanced machinery as part of their innovation, assuming that enterprises' investment in machinery indicates on their capability to install, learn and run the equipment. Chart 7 indicates that low-tech industries score relatively high, only second to high tech industries, when we measure the share of total employment in each sector accounted for by high end enterprises on the innovation machinery expenditures dimension. This means that, for the low-tech sector, innovative enterprises with at least 0.5 per cent units of their costs allocated to machinery acquisition, account for about 15% of the total employment in the sector.

Chart 7 *Share of total employment in each sector accounted for by high-end enterprises (with at least 0.5% of turnover allocated to machinery costs)*

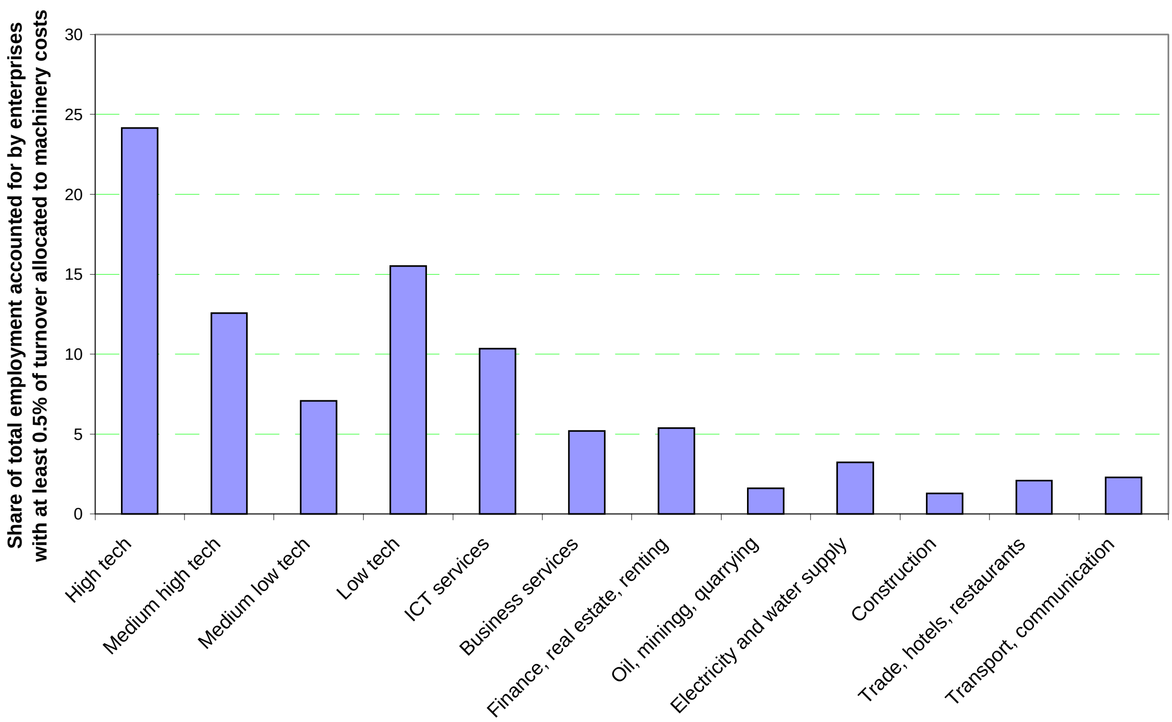
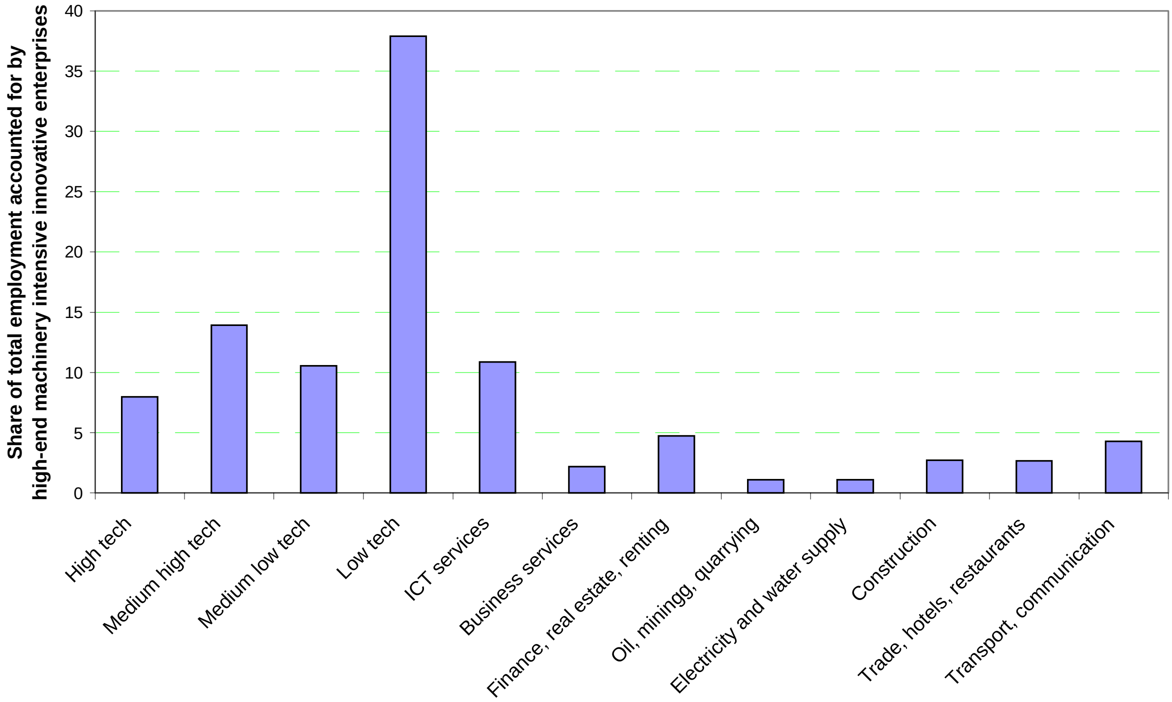


Chart 8 presents the same figures but weighted by total employment and transformed to relative importance in the total Norwegian economy. Now we get a better impression of the share of total employment the different sectors account for, and thereby the significance of innovative enterprises that spend more on machinery and equipment in their innovation. Because of the large low tech sector in terms of employment, the innovative and machinery intensive enterprises account for around 38% of total employment among all enterprises that are innovative and in the high end of machinery costs. In comparison, high tech industries account for about 8% of employment in all enterprises that are innovative and have at least 0.5 per cent units of their innovation costs allocated to machinery.

Chart 8 *Sectoral distribution. Total share of employment accounted for by high-end machinery intensive innovative enterprises.*



Summing up the technological intensity indicator, we have used machinery intensity in innovation, and we observe that this way of comparing sectors has the property of attracting attention to other sectors in society than those labeled high-tech

4 Skill intensity

We have used two indicators to test for skill intensity: 1) Share of technologists in employment and 2) Share of persons with at least one year post secondary education in employment. Here we utilize Norwegian register data, not CIS-data. We are fully aware that there are limitations as regards the relevance of our choice.

1) Share of technologists We have used a definition of high-end (high-tech) enterprise along this dimension: technologists account for at least 10 per cent of persons employed. Chart 9 shows share of total employment in each sector accounted for by high-end firms along this dimension.

Measuring skill intensity with share of engineers ("technologists") Norwegian data indicate not only what was expected (that high-tech firms have higher skill intensity than low tech firms) but that many service industries have much higher skill intensity than medium high and medium low tech industries. We see that high-end enterprises account for about 45% of total employment in high tech industries. ICT services have almost 35% and the technologists intensive oil and gas sector in Norway explains the third rank of oil, mining and quarrying.

Chart 9 *Share of technologists (High end = at least 10%) Share of total employment in each sector accounted for by high end enterprises.*

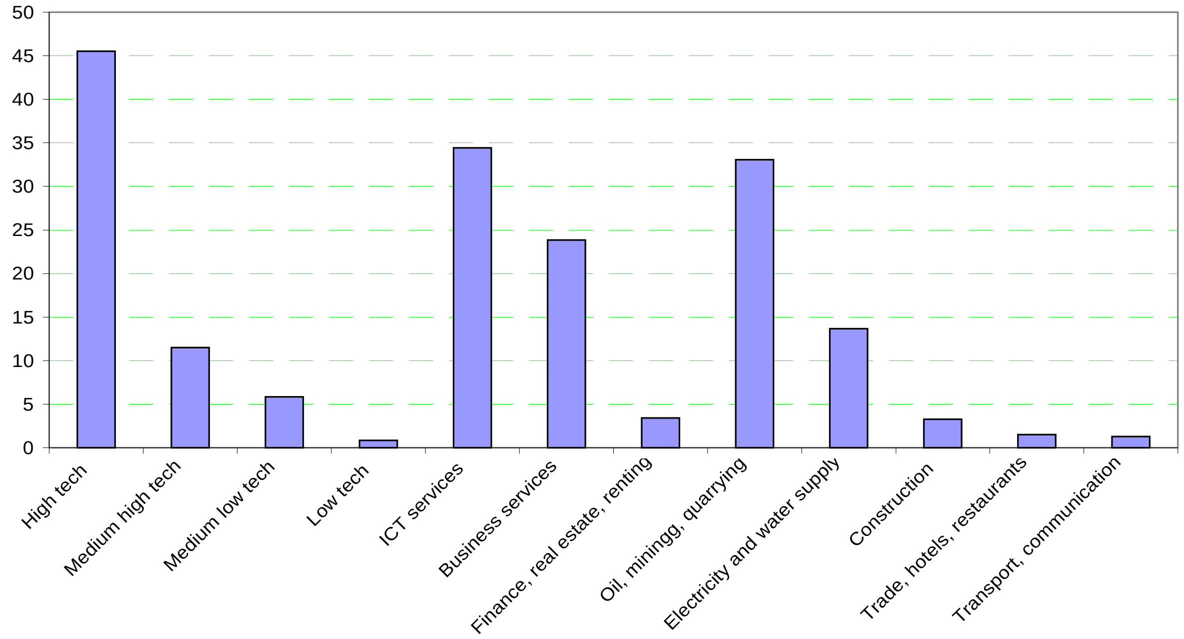


Chart 10 *Share of technologists. Share of total employment in each sector accounted for by high end enterprises. Weighted by total employment in each sector*

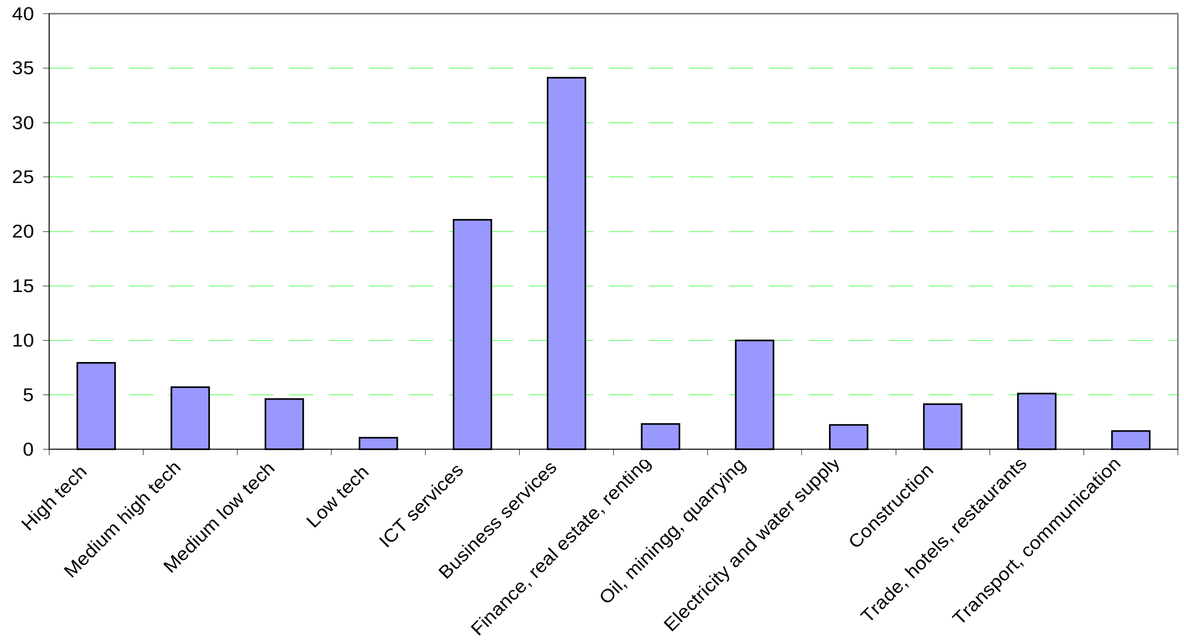


Chart 10 shows the same figures weighted by total employment in each sector and related to total employment in Norway: The relative importance of different sectors is obviously significantly altered when we apply shares of technologists as the indicator.

2) Secondly, attempting to develop skill intensity as indicator, we have also used the share of employment accounted for by persons with at least one year of post secondary education. With this way of measuring skill intensity we apply a somewhat lower threshold to defining high-end enterprises. We have defined high-end firms along this dimension: firms with at least 50 per cent of employment accounted for by persons with at least one year of post secondary education.

We see that the sectors that include the traditional manufacturing industries score low on this measure. In addition to the high score of the high-tech sector, this measure gives attention to services sectors in society. But chart 12, which shows the same figures but weighted by total employment in each sector, removes attention from the high tech sector, because of its small importance in terms of total employment. Consequently the larger sectors in society gain attention significantly, the manufacturing industries and above all the “forgotten” construction, transport and trade and accommodation sectors.

Chart 11 *Share of total employment in each sector accounted for by high-end firms along the post secondary education dimension.*

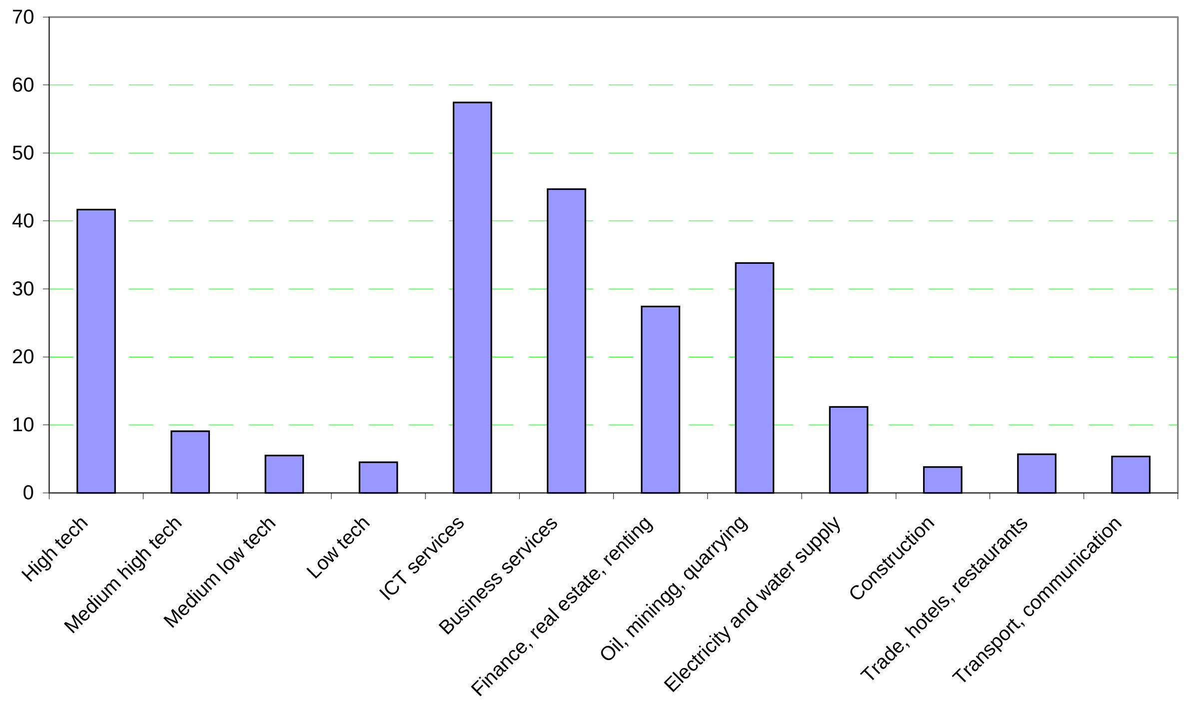
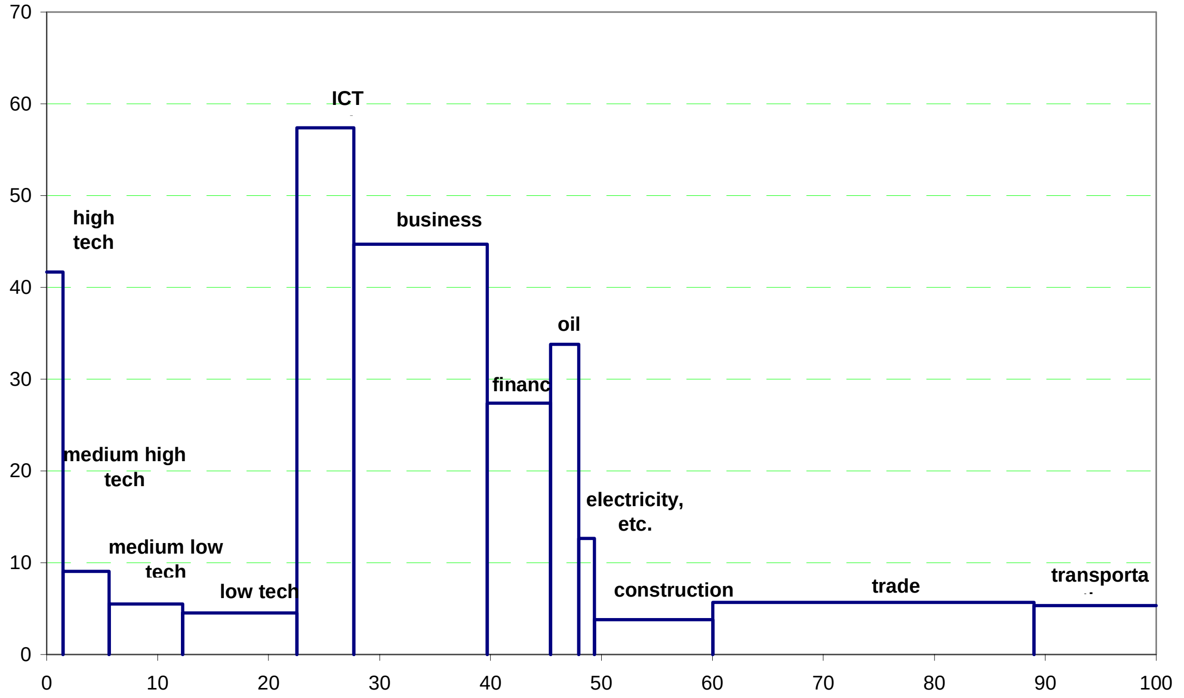


Chart 12 *Share of total employment in each sector accounted for by high end firms along the post secondary education dimension. Weighted by total employment in each sector*



Summing up, if level of education is the yardstick on skills the relative advantage of service industries compared to manufacturing increases. Business service firms are e.g. much more skill intensive than high-tech manufacturing firms.

5 *Innovation intensity*

We have measured innovation intensity by means of two indicators: 1) Enterprises with innovation: Enterprises with at least one product or process innovation in the course of the last three years (products or processes new to the firm, not necessarily new to the market 2) Share of turnover accounted for by product innovations (as defined in point 1 above).

1. Enterprises with innovation (innovative enterprises). This is a dichotomous variable (occurrence or not). Chart 13 shows that distribution of innovativeness (as defined in the CIS) does follow conventional wisdom although several services are more innovative than medium tech industries.
As discussed earlier, sectors differ in size. Allowing for these differences we may – as is done in chart 14 – show the relative distribution, by sectors, of innovative firms in Norway. It may be observed that the amount of low- and medium-tech firms which are innovative is much higher than the amount of high-tech firms due to their low relative share of the economy. In fact the innovative high-tech firms constitute a marginal share only of all Norwegian enterprises. We have no reason to assume that this should be a phenomenon specific for Norway only.

Chart 13 *Share of all enterprises in each sector accounted for by innovative enterprises.*

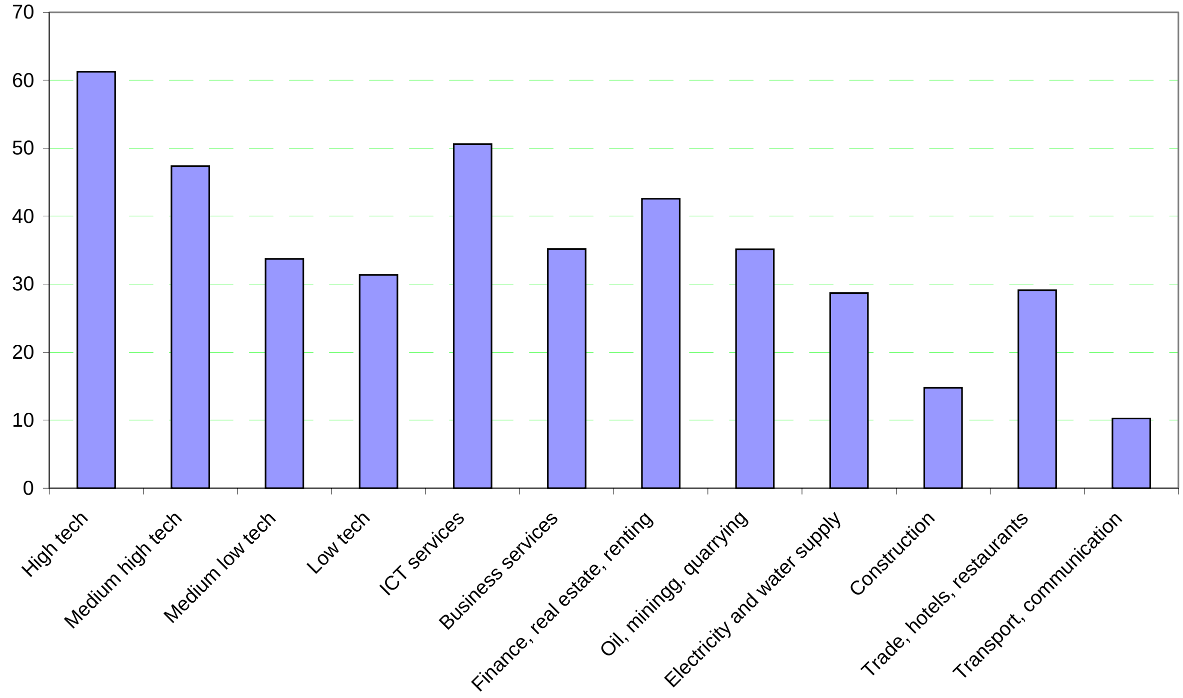
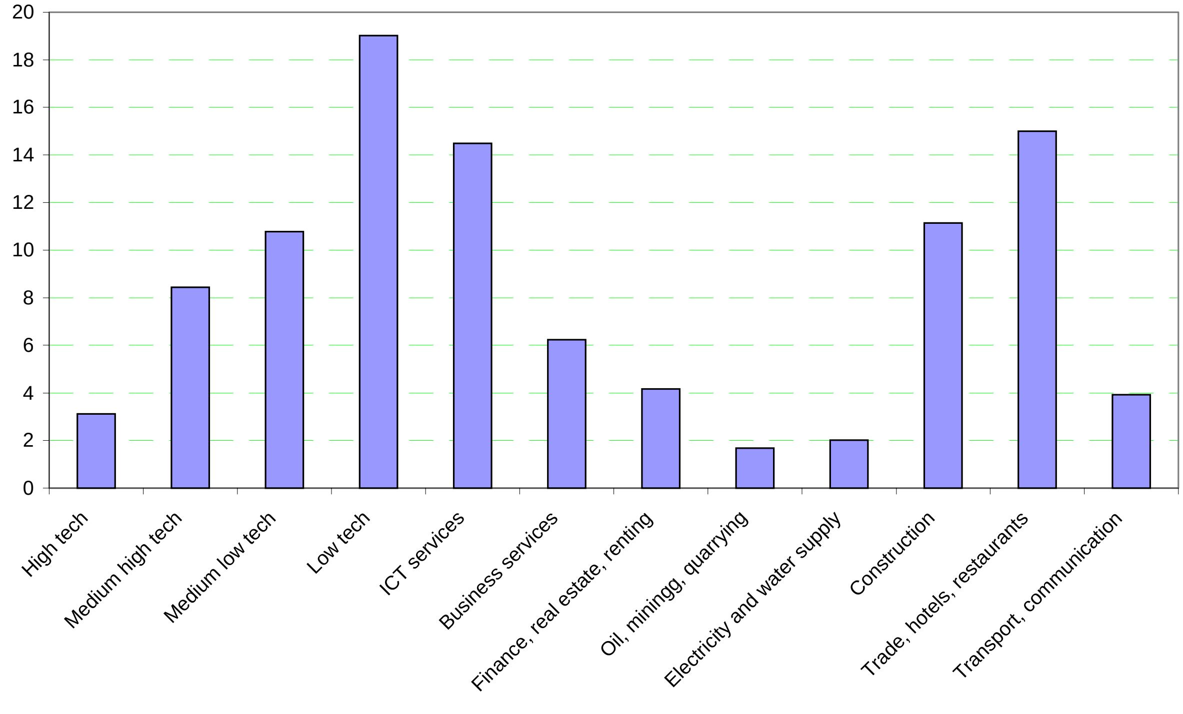
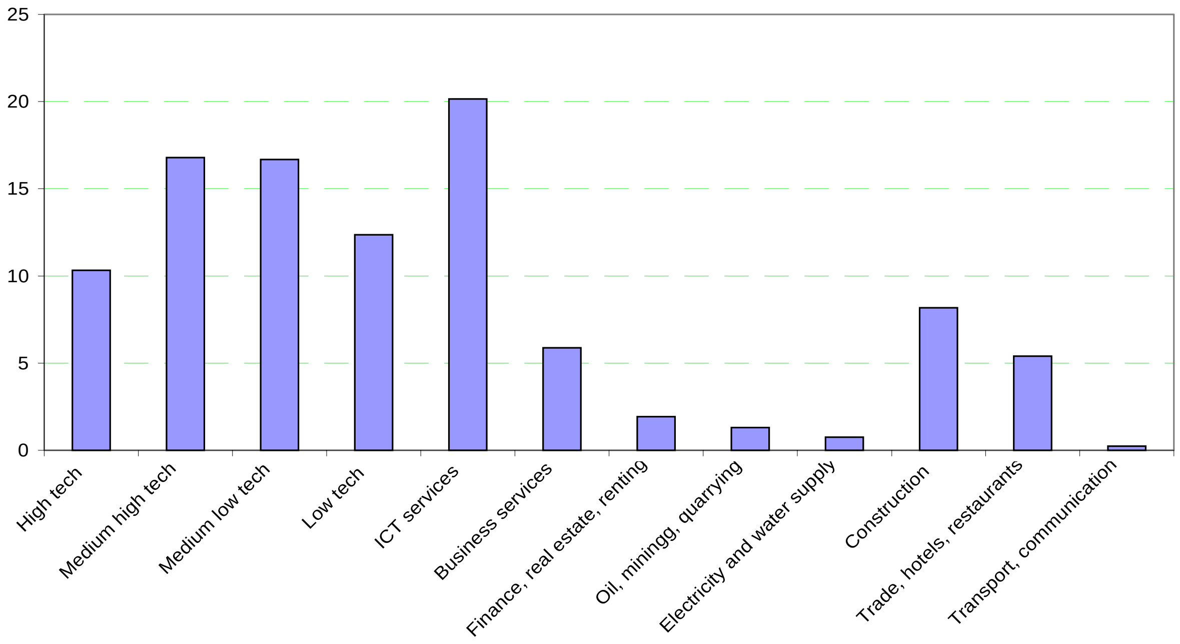


Chart 14 *Distribution of innovative enterprises across sectors.*



2) Share of turnover accounted for by new products. Our second innovation intensity measure focuses on share of turnover accounted for by new products. High-end enterprises are defined as those that have at least 25 per cent of turnover accounted for by new products. Similarly to what we have done above we may also here consider differences as regards size of sectors and present the innovative firms by sector and showing their relative distribution in the Norwegian economy. This is done in chart 15. Also this chart reveals the importance of innovativeness in non high-tech sectors.

Chart 15 *Distribution of firms with more than 25% of their turnover accounted for by new products*



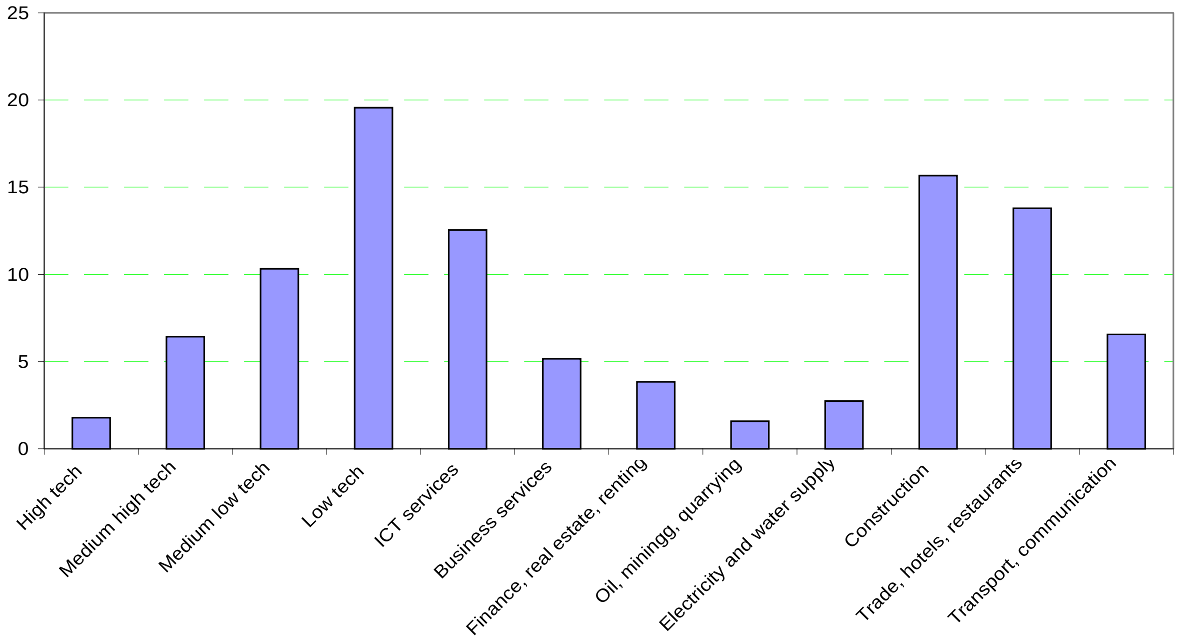
Innovativeness as measured by CIS gives very much a traditional picture of where we find the more advanced firms in the economy. Measuring share of turnover accounted for by new products draws attention to more than high tech and ICT services however. All manufacturing sectors are well represented. This measure primarily reflects the strong manufacturing and product bias in CIS.

6 Organizational issues

We have in section 3 above argued that there are reasons to identify an independent organizational indicator to capture organizational creativity. To obtain some ground for further discussions on that topic we have turned to the available data with relevance to organizational creativity / innovativeness. We have found a variable in the CIS-3 survey, asking for the degree to which enterprises have reported that they have implemented advanced management techniques. This is a dichotomous variable, either yes or no, independent of whether the enterprise has been reported innovative or not. We are fully aware that organizational creativity is more than what is captured here; nevertheless, this is what we have: chart 16 below shows the relative sector importance for Norway of firms having implemented advanced management techniques. We see that low-tech, construction and trade, hotels, ICT services, and medium low-tech are in particular significant when we apply this measure.

It may be argued that introduction of advanced management techniques – or similar organization changes - should be included in the innovation, skills or technology indices. The decision whether organizational creativity should constitute a sixth index of its own or be integrated in one or two or the other five is probably less important than the decision to formulate a set of relevant variables which can be used for this purpose. Anyhow, the distribution of advanced management techniques does not fully live up to conventional wisdom: our data show that low-tech firms are more advanced than high-tech firms!

Chart 16 *Distribution enterprises with implementation of advanced management techniques*



6 Concluding discussion

This paper has been design oriented in character. Not because it may be looked upon as a pleading for including design aspects into innovation analyses but because it aims to contribute to the design of the future capturing of industrial creativity and innovativeness. Basically the paper is in line with much of recent attempts from innovation researchers in their striving to reduce the high-tech and manufacturing bias in data acquisition and policy documents. On one important point we differ, however. Returning to the original Schumpeterian thought world we explicitly accept that innovative capabilities – we may as well label them dynamic – is what firms reveal as long as they are profitable. The implications from that is that we give no a priori priority to science based creativity before non-science based, no priority to technological creativity before non-technological, no priority to global uniqueness before local uniqueness. What counts in our world is that firms can create a profitable diversified niche of reasonable duration.

This creates a new point of departure for innovation researchers. Several – not all – of the paradoxes as regards bad fitness between innovation input (as hitherto recorded) and output (and growth) disappear. The many discussions on what constitutes an innovation, on what we mean with technological height or technological innovation or how to discriminate industrial / technical design from other design categories can be reduced.

Our approach assumes – also in line with modern evolutionary theory – that there is, or may be, significant variety between firms and thus within as well as between industries. We argue that to understand the mechanisms of industrial creativity it is necessary to capture that variety. As we have argued in other papers produced within the PILOT project – of which this paper is a part – the variety within the non-high-technological sectors of the European economy is much more important than what is recognized using the traditional OECD technology-intensity indices or even the CIS-based composite indices hitherto produced within the European Union.

We have shown that an indicator family of five to six indicators on industrial creativity and innovativeness based on already available data reveals significant aspects of the kind of variety we argue is important to understand when transforming Europe into a knowledge based society. If left to European statisticians for further refinement in coming community innovation this family of indicators may be significantly improved. As we have shown, it is our conjecture that reducing the indicators to one composite innovation indicator – which is the present tradition within Europe - will reduce its value as analytic instrument and foundation for policy making. Such a behaviour will also preserve the outdated view on what is an innovation, and what kind of activity that is high-tech or low-tech and – not the least – what kind of creativity and which sectors do contribute to growth.

That takes us back to the introductory quotation by Einstein. The innovation concept has obtained a free floating position in the discourses of analysts as well as policy makers; the original meaning of the concept is more or less forgotten and “innovation” is nowadays a “Denknotwendigkeit” which conditions our thinking and analytical work. Now, when we face that Asian firms compete with European firms in high-tech industries as well as in low-tech, is the time to analyze our concepts in detail and to evaluate whether the innovation concept could be widened to include those neglected aspects of professional and organizational skills, knowledge formation, design and creativity which – in addition to R&D – create the foundation for a profitable economy.

References

Abramowitz, Moses, 1956, ”Resource and Output Trends in the United States since 1870”, *American Economic Review*, Papers and Proceedings, May, pp. 5-23.

Alexander, Christopher, 1964, *Notes on the Synthesis of Form*, Cambridge, Mass. Harvard U.P.

Bailey, Kenneth, 1994, *Typologies and Taxonomies – An Introduction to Classification Techniques*, Sage Univ. Paper, London,

Baldwin, John & Gellatly, Guy, 1998, *Are There High-Tech Industries or Only High-Tech Firms? – Evidence from New Technology Based Firms*, Research Paper No 120, Ottawa, Statistics Canada.

Baldwin, John & Gellatly, Guy, 1999, Developing High-Tech Classification Schemes: a Competence-Based Approach, in Oakey, Ray et al, eds., *New Technology-Based Firms in the 1990s*, Vol. VI, Pergamon.

Baumol, W.J. , 1967, Macroeconomics of Unbalanced Growth: the Anatomy of Urban Crisis, *American Economic Review*, Vol. 57, pp. 415-426.

Baxandall, Michael, 1985, *Patterns of Intention – on the Historical Explanation of Pictures*, New Haven, Yale U.P.

Boden, Margaret, 1996, *Dimensions of Creativity*, Cambridge, Mass., Bradford Books.

Boden, Margaret, 2003, *The Creative Mind*, London, Routledge.

Boden, Mark & Miles, Ian, eds., 2000, *Services and the Knowledge Based Economy*, London & New York, Continuum.

Buckley, Peter & Ghauri, Pervez, eds., 1993, *The Internationalization of the Firm*, London, Academic Press.

Castells, Manuel, 1996/2000, *The Rise of the Network Society*, Second edition, Oxford, Blackwell.

CIS IV, 2004, *The Fourth Communuity Innovation Survey – The Harmonised Survey Questionnair*e, Final version: Oct 20, 2004.

Cohen, Wesley & Levinthal, Daniel, 1990, "Absorptive Capacity: A New Perspective on Learning and Innovation", *Administrative Science Quarterly*, Vol. 35,pp. 128-152.

Coombs, Rod; Harvey, Mark & Tether, Bruce, 2001, *Analysing Distributed Innovation Processes*, CRIC Discussion Paper,Univ. of Manchester & UMIST, mimeo., May 2001.

Dunning, John, ed.,2000, Regions, *Globalization and the Knowledge Based Economy*, Oxford, Oxford U.P.

EC, 1996, *Alternative innovation indicators and determinants of innovation*, Report EUR 16963, Nov. Brussels & Luxembourg.

EC, 2004, *European Innovation Scoreboard 2004 - Comparative Analysis of Innovation Performance*, Commission Staff Working Paper, SEC(2004)1475, Brussels, 19.11.2004

Einstein, Albert, 1916, "Ernst Mach", *Physikalische Zeitschrift*, Vol. 17, No. 7, p. 101-104.

ETCI, 2003, *2003 European Innovation Scoreboard: Technical Paper No 4, Sectoral Innovation Scoreboards*, Nov. 2003 (available on www.trendchart.cordis.lu)

ETCI, 2004a, *Exploring Innovation Performance by Sectors*, Dec. 8, (available on www.trendchart.cordis.lu)

ETCI, 2004b, *European Innovation Scoreboard – Methodology Report*, Dec. 21, (available on www.trendchart.cordis.lu).

Fagerberg, Jan et al, eds. 2004, *Handbook of Innovation*, Oxford, Oxford UP.

Ferguson, Eugene, 1992, *Engineering and the Mind´s Eye, Cambridge*, Mass., The MIT Press.

Foray, Dominique, 1999, *Characterizing the Knowledge Base: Available and Missing Indicators*, Working Party Presentation, DSTI/EAS/STP/NESTI/RD(99)9, Paris, OECD.

Foss, Nicolai & Robertson, Paul, 2000, *Resources, Technology and Strategy*, London & New York, Routledge.

Gibbons, Michael, et.al, 1994, *The New Production of Knowledge*, London., Sage Publ.

Godin, Benoît, 2004, "The obsession for competitiveness and its impact on statistics: the construction of high-technology indicator", *Research Policy*, Vol. 33, pp. 1217-1229.

Grupp, Hariolf & Mogee, Mary Ellen, 2004, "Indicators for national science and technology policy: how robust are composite indicators?", *Research Policy*, Vol. 33, pp.1373-1384.

Hatzichronoglou, Thomas, 1997, *Revision of the High-Technology Sector and Product Classification*, STI Working Papers 1997/2, Paris, OECD.

Hauknes, Johan, 2004, "Innovation and Economic Behaviour – Need for a new Approach?", mimeo, Oslo, STEP Centre for Innovation Research.

Julier, Guy, 2000, *The Culture of Design*, London, Sage.

Kline, Stephen & Rosenberg, Nathan, 1986, "An Overview of Innovation", in Landau, Ralph & Rosenberg, Nathan, *The Positive Sum Strategy*, Washington D.C., National Academy Press.

Kogut, Bruce & Zander, Udo, 1992, ”Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology”, *Organization Science*, Vol. 3, No. 3, pp. 383-397.

Laestadius, Staffan, 2005a, ”Innovation – on the development of a concept and its relevance in the knowledge economy”, in Kreinsen, Jacobson & Laestadius, *Low-Tech Innovation in the Knowledge Economy*, Frankfurt, P.Lang.

Laestadius, Staffan, 2005b, ”Measuring the right thing – the problem with S&T based indicatores and taxonomies”, in Kreinsen, Jacobson & Laestadius, *Low-Tech Innovation in the Knowledge Economy*, Frankfurt, P.Lang.

Lorenz, Edward, no date, *Developing Indicators for Skills and Innovation*, IDEFI-CNRS, Univ. of Nice-Sophia antipolis, mimeo.

Meister, Christoph & Verspagen, Bart, 2005, *European Productivity Gaps: Is R&D the solution*, DRUID Working Paper 05-06.

Miles, Ian, 2004, *Innovation in Services*, in Fagerberg et al, eds., 2004

Nohria, Nitin & Eccles, Robert, 1992, *Networks and Organizations*, Boston, Mass., Harfvard business School Press.

OECD, 1997, *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual*, Paris, OECD.

OECD, 2001, *Innovation and Productivity in Services*, OECD Proceedings, Paris, OECD

OECD, 2002, *Frascati Manual: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris, OECD.

Petroski, Henry, 1996, *Invention By Design*, Camb., Mass., Harvard Univ. Pr.

Pol, Eduardo; Carroll, Peter & Robertsson, Paul, 2002, ”A New Typology for Economic Sectors with a View to Policy Implications, *Economics of Innovation and New Technology*, Vol. 11, No. 1, pp. 61 76.

Rosell, Gustaf, 1990, *Anteckningar om designprocessen* (Notes on the Design Process), Stockholm, Kungliga Tekniska Högskolan.

Salazar, Monica & Holbrok, Adam, 2004, ”A debate on innovation surveys”, *Science and Public Policy*, Vil. 31, No. 4, pp. 254-266.

Scherer, F.M., 1982, ”Inter-industry technology flows in the United States”, *Research Policy*, 11, pp. 227-245.

Schumpeter, Joseph, 1911/68, *The Theory of Economic Development*, Cambridge, Mass., Harvard U.P.

Simon, Herbert A., 1996, *The Sciences of the Artificial*, third ed., Cambridge, Mass., MIT Press.

Smith, Keith, 2004, ”Measuring Innovation” in Fagerberg, Jan et al, *Handbook of Innovation*, Oxford, Oxford UP.

Teece, David & Pisano, Gary, 1999/2001, ”The Dynamic Capabilities of Firms”, in Dosi, Giovanni et al, eds., *Technology, Organization and Competitiveness*, Oxford, Oxford U.P.

Tether, Bruce, 2003a, ”The Sources and Aims of Innovaton in Services: Variety Between and Within Sectors”, *Economics of Innovation and New Technology*, Vol. 12, No. 6, pp 481-505.

Tether, Bruce, 2003b, *What is Innovation?*, CRIC Working Paper No 12, Univ. Of Manchester.

Tether, Bruse, 2004, *Do Services Innovate?*, CRIC Discussion Paper No 66, Nov. 2004, Univ. of Manchester, CRIC

Thomke, Stefan, 2003, *Experimenation Matters – Unlocking the Potential of New Technologies for Innovation*, Boston, Mass., Harvard Business School Press.

Vincenti, Walter, 1990, *What Engineers Know and How They Know It*, Baltimore, John Hopkins U.P.

Wölfl, Anita, 2003, *Productivity Growth in Service Industries*, STI Working Paper 2003/7, OECD, Paris.

Young, Allyn, 1928, "Increasing Returns and Economic Progress", *Economic Journal*,Vol. XXXVIII, Dec. pp. 527-542.

Zollo, Maurizio & Winter, Sidney, 2002: "Deliberate Learning and the Evolution of Dynamic Capabilities". *Organization Science*, Vol. 13, No. 3, 339-351.

Authors' postal address:

Prof. Staffan Laestadius
Royal Institute of Technology
INDEK
SE-100 44 Stockholm

Trond Einar Pedersen PhD
Tore Sandven
NIFU STEP
Hammersborg Torg 3
N-0179 Oslo