INNOVATION AND INSTITUTIONS

A PROGRAMMATIC STUDY

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An Attempt to Elaborate Upon the Concept of National Systems of Innovation, by Unpacking the Link between Innovation, Organizations, and Institutions, through the Investigation of a Variety of Possibly Relevant Literatures.

By the Members of the Themegroup 'National Systems of Innovation' at the Netherlands Institute for Advanced Study in the Social Sciences and Humanities, Year 1998-99.

CHAPTER 2. PROBLEMS OF MEASURING INNOVATIVE PERFORMANCE

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1. Introduction and Summary

The following report first gives an overview of the literature on innovative performance. Section 2 shows principal problems when measuring innovative performance. What an innovation is, whether it can be observed as it happens and identified as such, whether it can be clearly separated from imitation and diffusion, whether it can be measured without a theory are issues addressed in the beginning. Three types of innovation – product, process and organizational innovations - can be distinguished, which might have to be measured differently. Determinants of innovation in the economic literature are: a) demand conditions (customers influence product innovations more than process innovations); b) appropriability conditions (conditions to reap the benefits of the innovation. Capacity to take advantage of the response time of the competitor. Intellectual property protection and learning increase this capacity); c) sources of technological knowledge need inside absorptive capacities to use external knowledge; d) market structure, characteristics and strategy of the firm influence innovation. The literature on National Innovation Systems is a first bridge between traditional economic approaches and institutional literature.

Innovation can be measured in five ways: 1. through case study, as the early history of innovation studies of 1839 shows; 2. through trade journals and publications. These are called "Literature Based Indicators"; 3. through surveys with all the bias problems related to them; 4. through input indicators such as research and development expenditures; and 5. through output variables such as patents and sales of the product. The pros and cons of the different methods and what they really measure are discussed in Section 3. I conclude in section 4 with a discussion of a new typology of sector specialization that might prove to be quite useful for studying innovative performance and country-sector specialization.

2. Some Problems of Measuring Innovative Performance

2. 1. Innovation versus Diffusion

In the academic and business literature innovation means **to make an idea (an "invention") technically and commercially viable**, and accessible to larger production, in order to finally spread it around ("diffusion") either domestically or by means of exports. It is diffusion that finally creates economic growth, not innovation. This fact is important since Innovative Performance and Economic Outcome Performance do not necessarily point into the same direction. Some firms or countries are highly innovative, but not so prosperous in marketing and selling their innovative products. The Dutch e.g. import innovation and are good in selling, as the large amount of patents from intermediary firms for imported products show (see Kleinknecht 1993). Diffusion and Innovation are not a linear sequence but a forward and backward looping process, so that it is even more difficult to measure the different steps in, what Hollingsworth and Hage (1998) call the idea innovation chain.

The following section deals with innovative performance evaluation. However, since the specific connections between innovative and economic performance are as crucial as the debate around innovation and diffusion shows, economic performance indicators such as productivity rates and profits should also be part of a performance measuring. In particular, because innovation and diffusion are so tightly linked. It is often the final economic outcome - growth, competitiveness, profits, welfare of nations - that we want to explain when we study innovations.

2.2. Innovation versus Imitation

One question that should be asked is, "Is the product or process new for the firm, the industry, the nation or the world?". Some empirical studies talk about the "imitating" firm when the product/process is not new for the sector anymore (see CIS data, Kleinknecht 1996). Others, such as Debresson (1996) would still call this an innovative activity. As we will see later in the survey studies of the European Community (CIS), about 70%-80% of what firms interpret as innovation is not new for the sector, i.e. is imitation.

2. 3. Ex Post Identification of Innovation

How can one identify innovations? Shall the researchers look at the products and ask firms, clients, politicians business associations, technicians whether they consider them a novelty? The increasing amount of survey studies should help them.. In addition, data collection has definitely improved in the last decade. But after the survey studies are conducted, the problems have only begun. What is being measured? Is it innovation, or something else? If the latter, what is the relationship between what has been measured and innovation? The methodological problems are intractable, because there is one major problem: determining whether something is an innovation or not, can only be evaluated long after it has happened. Debresson (1996) argues that the **time bias** in evaluating the importance and significance of an innovation is a pervasive and insurmountable problem. What an innovation is, turns out only much later. **One cannot measure innovation *as it happens*.** It is a specific act that only occurs once and that can only be judged much later. Many actors suffer from this time bias. Expert respondents will identify many more innovations within the most recent decade than in the two or three preceding decades. The near past seems always more important than the distant past. There are diverse reasons for this: that they only remember the most successful innovations from long ago, and that alternatives that have been overwhelmed are forgotten. Whether today's innovation will stay successful over a longer time cannot be judged at this time. "The proof of an innovation is in its adoption" and this takes time. Debresson (1996) suggests to measure "innovative activities", endeavors, and attempts, rather than "innovations", and to include adoptions and imitations. Time will tell ..."whether they are acts that disrupt existing practices and routines and induce growth and structural change. This will depend on the extent to which they are adopted, adapted, improved, or induce complementary and auxiliary support techniques - that is, on the cumulative effect of other reinforcing innovative activities" ...(Debresson 1996, p.14).

Debresson's skepticism with regard to identifying innovations was mainly concentrated at the macro-level. His criticism is in particular important for radical innovations. But the other extreme, to count any new combination as an innovation, permits one to end up with a large number of innovations such as the change in color of the wrapping paper, that one might not have intended to analyzed. Nevertheless, innovative performance of the world, countries, sectors and firms is too important of an issue to drop because of methodological problems.

2. 4. No Measurement without Theory

Since the innovation process is often not directly observable, it is a transformation process of an idea into an outcome, a complex organizational link between different departments, firms and the environment, the perception of what an innovation is and what one should study, depends on the theory one has (explicitly or mostly implicitly)in mind. What one perceives as suitable proxies for the not directly observable "innovation process" or whether one is content with just looking at the final innovative outcome - the finished product or new process - is shaped by how the stages of the innovation process are perceived and of the research question in mind. Also whether one focuses on the national innovations or on the firm level results from theory. Main stream economics of earlier times focused on the macro-level, Schumpeterians focus on the firm. Measuring innovation, therefore, always necessitates some theoretical concept, whether the empirical researcher is aware of it or not.

Researchers can trace empirical literature on innovation back to some basic concepts of thought that shape the way in which "innovations"'and "innovativeness" are perceived and studied. They also determine what has been measured.

2.4. 1. Mainstream economics

Mainstream economics until the 1970s was mainly occupied with measuring aggregate production functions. The relation between input and output and the effect of a change of the relation between these two factors were in the center of attention. Macroeconomic research dominated but with little attribution to innovation. As Rosenberg (1982) once put it: "Economists have had much more success in dealing with the consequences of technological change than with its determinants" (Rosenberg, 1982, p.141). Main stream economics had problems to explain innovation, mainly seen as technological innovation. But where the technological change came from was left to other disciplines, to engineers and to sociologists. In the 1990s endogenous growth theory escapes the unrealistic assumption of exogenous technological progress by making, e.g. the rate of investment dependent on growth rates, and tries to account for "innovations" in a limited way. Measuring innovative performance is, however, not the strength of this rather mathematical approach.

2.4.2. Input-Output analysis

Input-output analysis goes back to Wassilij Leontief, who could deal with technological change in the sense that coefficients of the input-output matrix change over time. New path breaking literature is emerging in this field with regard to innovation. Today there are a variety of innovative activities that are put in supplier-user matrices. In each matrix some type of activity is related to some type of actor. Each of these activities put into relation the different organizations in the economy. The activities can be scientific papers, patented inventions, innovative outputs, exchanges of through puts, or capital goods. The acting institutions can be government, departments, public services, universities, research labs, industries or individuals. Debresson (1996) gives an overview of the diverse matrices that have been established and investigated in empirical research. Best known are the works of Scherer (1982) who followed Schmookler's example and suggestions and who had to code the probable use of patented inventions in order to compile **a patent matrix**. Later Leontief (1993) compiled another input-output matrix with data on citations by and from scientific journals as an output and linked it to R&D as inputs. He looked at relations between disciplines (as analogs of industries) and journals (as analogs of firms) through the origins (analogs of supply) and citations (analogs of demand). The advantage of this matrix is- as opposed to the traditional Leontief input output matrix which is very cumbersome to establish - that it can be easily updated. Input output analysis with supplier-user matrices for innovative activities are done in the **seminal** paper by Debresson and Townsend (1978), but also the works of Pavitt (1984), and Kleinknecht and Bain (1993) fit into this category (see Debresson 1996, p.72 who gives an overview of the input-output literature on technical change in Table 5.1). The latest report of the OECD shows many results of input output analysis on innovation and gives a good insight into the variety of data creation that is possible. "Flows of technical information on innovative activity",and "networks of innovation" are presented in international comparison (see OECD 1998, p. 58ff), mainly referring to Debresson. (Unfortunately, Finland and Austria have not been part of these studies).

The advantage of this approach is that it deals with innovative activity and does not claim to measure the unmeasurable "innovation". It furthermore, does not suffer from the rigidity of the old matrices. The studies either rely on science based literature, on patents or on surveys. The criticism concerning these three methods (see below) therefore also applies to I-O-analysis. A major problem is the definition of sectors. In order to allow comparison of the two sets of matrices (economic and innovative), the industrial classifications are taken for the supplier and user of the goods and services, on the one hand, and for innovative activities on the other. Respondents in a firm know both in which industry they work and for which industry a new product is destined. The Standard International Classification (SITC) corresponds at the four digit level fairly closely to input-output classifications. However, the **sector definitions get more and more problematic** and blurred. For example important sectors, such as biotechnology, cannot be found in these classifications, since it is partly pharmaceutical, medical, partly agrofood, horticulture, detergents etc. Other sectors, such as telecommunication, change rapidly and melt together with other sectors. Furthermore, it is a quite cumbersome technique. When using patents, the heavy critique applies that not all inventions are patented, and that there might be a serious bias with regard to sectors and firm size, with regard to product and process innovations.

2.4. 3. Schumpeterian Theory

Interesting developments on innovation can be found in the systemic theory of technological change (see e.g. Freeman 1994, and Dosi 1988) and in the evolutionary theory of technological change (see e.g. Nelson and Winter 1982, Metcalfe 1995 and Saviotti 1996). Both have their roots in Schumpeter and are labeled "Neo-Schumpeterian". Freeman (1994) and Cohen (1994) give a detailed survey about the empirical results of Schumpeterian analysis. Schumpeter's (1939) hypothesis about the **"pioneer"** entrepreneur that creates an innovation and the "imitators" that adopt the new product or process - Freeman (1994, p.466) calls it a "superman" theory - has kept empirical and theoretical research busy for several decades. Today the view is favored that it is not the individualistic Darwinistic struggling that accounts for an innovation, but that innovations take place in an environment and that innovations are interdependent. Later Schumpeter also stressed the predominant role of large oligopolistic firms in technical innovation. He had observed that specialized research and development departments played an increasingly important role in the innovation process. The controversy on innovation, **firm size and market structure** rumbled on for decades. The predominant view since the works of Pavitt, Robson and Townsend (1987) is that small firms contribute to invention and innovation. Today questions arise more around the fact in which field, sectors, organizational environments small firms are active and innovative (see overview of the Delft 1999 conference for most recent empirical studies). Freeman (1994) gives an overview of the empirical studies done until the early 1990s. Factors explaining **why industries differ in their innovative activities** are seen in the **market size** (Schmookler's 1966 demand aspect), in **technological opportunities**, spill overs and in **appropriability conditions.**

Schumpeter's "idea"-"invention"—"innovation"—"diffusion" chain still influences the perception of how the innovative process takes place, though today more emphasis is put on the loop backs, as expressing itself in labels such as "Innofusion" and "Diffovation". Measures of input, throughput, output, and diffusion are derived from the linear view, since they imply a clear **linear sequence of the innovation process.**

Also Schumpeter's concept of innovation as "a new combination" versus a "true innovation", his creative destruction and novel combination distinction, gave rise to the important distinction between "new to the firm" and "new to the sector" and "incremental" versus "radical" distinction. The empirical research on this and in particular on **"incremental" versus "radical"** innovation comes now in vogue, since data have been collected at large scale for many countries.

2.4.4. Schmookler's Demand Theory

Schmookler's (1966) demand-pull hypothesis started another long lasting controversy about technology-push versus demand pull determninants of technical change. With the use of US patent statistics, Schmookler found out that the peaks of inventive activity lagged behind the peaks of investment activity. He stressed that users of products and processes determined technological change and not scientific and technical knowledge. Pure demand theories for innovation were met with skepticism. Mowery and Rosenberg (1979) gave rise to the cremation of the demand pull hypothesis. Apart from the fact that Schmookler's results could not be reproduced empirically (the same data showed the lag in peaks much weaker than he had claimed), they pointed out at the confusion of "needs" and "demand" in the literature. Since human "needs" are extremely varied and often unsatisfied for long periods, they cannot explain the emergence of particular innovation at a particular time. Innovation should not be viewed as a linear process, whether led by demand or by technology, but as a complex interaction **linking potential users with new developments in science and technology.** As empirical sector studies on petrochemicals, dyestuffs, drugs, synthetic materials and robotics show that one has to distinguish between different phases of the innovation process. They analyze the economic development (investments) and the development of innovations (patents) as well as the output of scientific publications and find an anti-Schmookler pattern typical for the early stages of innovation. While later, when the industry "took off"" a more Schmookler resembling pattern occurred. This means that in the early stages science and technology is more important for innovation while in the later stages demand plays a larger role (see Freeman 1994, p.480). The Schmookler demand idea has led to the burial of linear innovation models and to much more sophisticated models which embody demand and supply factors in feedback looping models, during innovation and diffusion. Empirical research has shown that the **old distinction that suppliers are responsible for innovation and users for diffusion does not hold,** but they both determine one another. For diffusion, suppliers are important for product improvement, diversifying new models, enlarging the market, promoting applications research, training potential users, and coping with institutional barriers.

2.4.5. National Systems of Innovation and the Idea Innovation Chain

Some of the new Schumpeterian approaches also stress "institutional change", in particular training and skills. Which role does the institutional environment play for harmonisation, regulation, standardisation and **routinisation** in order to avoid chaotic instability. The literature on **National System of Innovations** (see e.g. Lundvall 1992, Nelson 1993, Dosi 1994, Edquist 1997) was a break through in bringing institutions into the innovation literature. Schumpeterian analysis traditionally concentrates on the firm. These new approaches try to bridge the gap between macroeconomic and microeconomic analysis. Special attention in the empirical research is paid to skills and financial markets for innovativeness. However, the approaches become more and more advanced as the latest TSER- projects of Soskice, Dosi, Malerba, Casper and the NIAS Project group Van Waarden, Hage and Hollingsworth show.

2.5. Types and Determinants of Innovations

One can distinguish product innovations, process innovations and organizational innovations. The issue, which kind of innovations are performed by firms, is a current topic in the economic literature since firm level data are available. But while the distinction between product and process innovation is stressed lately, organizational innovations are still missing in the analysis. From the literature one can derive the following hypotheses (see the survey by Le Bas 1999):

- **demand conditions**

- Demand should influence product innovation more than process innovation (Lunn 1986)
- Heterogeneous demand directed toward series should enhance product innovations (Pavitt 1984)
- High price elasticity of demand should stimulate process innovations.
- Low price elasticity should stimulate product innovations (Spence 1975)
- Innovation elasticity of demand should stimulate product innovations thus resulting in an increasing concentration level (Gomulka 1990)

- In an initial phase product innovation should be the main type of innovation, followed by product/process innovation and then by process innovation (Utterback, Abernathy (1975). This is due to diminishing uncertainty. First, firms will innovate the product in order to discover which are the right solutions. Later, when producing at larger scale, process innovations will take place.

- **appropriability conditions**

- Intellectual property protection and learning opportunities favor product over process innovations (Levin et al 1987)
- Product innovations is sensitive to the capacity of the firm to take advantage of the response time of its competitor (von Hippel 1982)
- Complementary assets reinforce the appropriability of product innovations (Teece 1986). Process innovations can be considered complementary assets of product innovations. They are more secret and enable firm to reap the benefits of its innovative activity.

- **sources of technological knowledge**

- External sources of knowledge are important inputs for the building of the technological ability
- Inside "absorptive capacities" are essential to use these opportunities
- Progress in scientific knowledge should influence both. (Levin et al 1987). This would be the reason why product & process innovations are more frequently in science based industries (Pavitt 1984).
- Connections to research institutions should stimulate product and process innovation
- Connections to suppliers should be more conducive to process innovations than to product innovations (Levine et al 1987).
- Connections to users should be more important for product innovations (Pavitt 1984, Lundvall 1988)
- National sources of technological knowledge should favor product innovation (they use these sources to discover their potential market) in a National System of Innovation framework (Leo 1996)

- **market structure**

- Concentration should be a characteristic for process innovation (Scherer 1983) but not for product innovation (Lunn 1986). Recent literature shows that if the high quality firm is a Cournot (quantity) competitor it opts for product innovation, if it is a Bertrand (price) competitor it opts for process innovation. The low quality firm acts in the opposite manor (see Bonanno and Haworth 1998 quoted in Le Bas 1999)
- Intensity of the technological competition: progressive sectors are more intense in technological competition than other sectors.

- **characteristics of the firm**

- Large firms invest more in process innovation than small firms
- The more diversified the firm, the more product and process innovations take place. The degree of diversification is more important for product than for process innovation (Lunn 1987)
- Product innovation requires workers with more diversified skills than process innovations (Leiponen 1999).

- **firms strategy**

- Rely on own inside the firm capability or on outsiders
- Rely on laboratory research or non laboratory development of its technological ability
- Firms oriented towards improvement of product and process technical characteristics induce process innovations. Trajectories characterized by the filling of demand result in product innovations (see Klevorick 1995)

From this literature one can conclude that **in the two science based industries product and process innovations should occur**. The high **demand orientation of telecom should result in a dominance of product innovations.** The lack of analyzing organizational innovations which is obvious from the above results should be given special attention and should be filled with interviews in later steps of our TSER- project.

2.6. The History of Innovation Studies: From Case Studies to Survey Studies

The history of innovation studies dates back to the nineteenth century. The concept of innovation was coined by the German economist Riedel (1839) and sociologist de Tarde (1890). Up to the 1930s there was little more than theoretical debates in economics about innovation. In the 1930s, however, sociologists and economic historians started to write **case studies** and industry monographs. The advantage of case studies is that they account best for the multi-dimensionality of the phenomenon. The limitation is that it stays unclear, whether they are representative. Even a multiplicity of case studies will not answer the question of representativeness with confidence.

Quantitative surveys, because they aim at breadth rather than depth, can be designed to be representative. One way is to start with a **census** covering the whole population. Having once covered the whole economy with a survey, one can use this first survey as a reference point for any other representative survey on the innovative population. The Italian and the French are leading with regard to census data. The 1991 French survey of innovation is as yet the most extensive and the most representative of any national economy, industrial sector, or size of firm and region (see Debresson, 1996, Appendix 1 p.378).It included 30.000 reporting enterprises. (Lately 60.000??? see Delft conference, check). Another route is to cumulatively establish a list of all known significant innovations in a period **through trade journals and industrial experts** and then perform an industrial **survey.** The limitation of these surveys is a direct consequence of their strength: in order to be representative of the economy, interviews or mail questionnaires must be short. Therefore, they cover only a few dimensions of innovative activity. In the 1960s universities started fairly extensive surveys of innovation, in particular in the US (Mansfield 1968 in Pennsylvania, Myers and Marquis 1969 at the MIT surveyed 500 innovations in five industries). In Sussex ,UK, Freeman (1971) and Townsend (1981) surveyed thousands of innovative outputs from 1945 to 1969 and later extended the coverage to 1983 using surveys of industrial experts and firms (Debresson 1996, p.9). The Canadian survey borrows the methodology of Freeman (1969) and Townsend (1981), the pioneers in this field. They focus on the concrete manifestation of a change in product and process innovations. Industrial experts are asked to identify significant innovations in their sectors of competence for the last decade and to identify the key firms involved in each innovation. The information is then validated with the concerned firm. Later the data are graded by experts. Freeman and Townsend relied on many different sources, not only on the answers of the firm alone (see Debresson 1996, p.367).

Large surveys on innovative activity have been done recently by the European Community (CIS -Eurostat). In the Netherlands these data have been applied by Kleinknecht and Eric Brouwer.. (see Delft conference 1999). They are in particular interesting, because they allow for international, inter-industry comparisons.

There have also been quite extensive studies on **Literature-based Innovation Output Indicators**. They have the advantage that the researcher can collect the information that s/he wants. Kleinknecht and Bain (1993) present an overview of the use of these indicators in diverse countries. In the Netherlands, Kleinknecht, Reijnen and Smits (1993) took all product innovations reported in the complete 1989 volume of each of the trade journals and tried to identify the innovative firm. The assumption was that firms have an incentive to make their new products public, and that journal editors select those new products that are most interesting and which they consider "innovative". Out of 82 journals, 36 fulfilled the selection criteria (firm retractable, useful details about the innovation, "new product" column in the journal). The advantage of this Literature Based Innovation Output Indicator was that it included 34 sectors from the manufacturing industry and also service industries. It differentiated between radical and incremental innovations, accounted for novelty and complexity of. the product, and defined a list of 22 properties of the innovation (e.g. is it more efficient by saving on labor, raw material, time, transportation costs, capital costs, does it have new functions, or improved function such as being more precise, stronger, quicker, more flexible, safer, longer life-time etc.). Furthermore, the most important potential buyers of the product were identified (final consumers, other firms, government, others). Once the framework was set up, students could do the actual data collection. They ended up with 6325 innovation events in the Netherlands in 1989 (see Kleinknecht, Reijnen, Smits 1993, p.77).

The disadvantage is that it only covered product and not process innovation, since there is much more secrecy about process innovation. Other disadvantages are that it is cumbersome to create the database, and that the comparison with journals of other countries is not possible.

Kleinknecht, Reijnen and Smits (1993) use these data for interesting testing of other innovation measures. They find a positive relationship of their **innovative output measure with R&D** (0.68), though they find a "threshold"at the sectoral level: only sectors which are above the threshold of one man year of R&D per firm account for an increasing number of innovations with an increasing number of R&D man years (see p. 52). More skeptical are the results in regard to patents. In particular, service sectors (repair services, transportation, communications, banking and insurance and other commercial service) are outliers. They seemingly have a high share of non patentable innovations. Other service sectors (ship transportation, wholesale trade and intermediary trade firms) develop a few innovations themselves but apply for patent protection of the products they are selling (p.55). The Netherlands has a high share of **imported innovations**.(4182 of the 6325 innovations, i.e. 70% of the innovations on the Dutch market were developed abroad in 1989 and sold by an intermediary firm, often a trade firm). Only 3.6%

were radical, only 2.5% were classified as highly complex. **Firm size does not affect innovation, but sector does.** It seems that SMEs produce a considerably higher amount of innovations per unit of R&D input than big firms do. 80% of innovative products are sold to industrial customers (often as investment goods).The Dutch are mainly innovative in agriculture, process technology, banking and insurance, textile and leather, installation, and hotels and restaurants. Despite the fact of large multinationals, **chemicals and electronics do not display a high innovation share of Dutch origin.**

The availability of data certainly influences research, as the newest young boost of fascinating empirical research with Community Innovation Survey data demonstrates quite impressively. The fact that large new data sets allow to model spill over effects and to work with larger econometric models in international comparison, certainly enhances research (see the TSER-Project conference organized by Alfred Kleinknecht in Delft, February 1999). On the other hand, empirical research also enhances improvement in data collection, as the standardization of R&D measures by the OECD in the 1960s (the so called Frascati Manual) or the recent Community Innovation Survey (CIS I and II) Studies by Eurostat demonstrate. The OECD STI Review of December 1992, vol.11 reports the results of innovation measurement and survey work in six countries, Norway, Sweden, Italy, Germany, France and the Netherlands.

2.7. Biases of Survey Results

Though we are content with the increasing amount of survey data, there are still some serious methodological problems remaining. All surveys of innovation find an unexpected number of respondents who claim to have introduced new or improved products or processes that were not only new to the firm but also new to the country and even to the world. Debresson (1996, p.47) quotes surveys, where 20% to 40% of the national first respondent firms claimed that they were also world firsts. "One can be skeptical about respondents' view regarding their own accomplishments and be reasonably sure that they are biased in claiming that they have done what is good, right and fashionable to do - innovate" (Debresson 1996, p.47).

Beside this psychological factor of self-esteem, some further cognitive psychological facts play a role: our perception is dependent on the reference system. The answers are likely to overemphasize the local, closer environment. Also the time factor can bias the results. Whether an innovation is a true innovation turns out later. Furthermore, innovators often do not know whether the industry also innovated, i.e. they cannot distinguish whether an innovation is new to the firm or to the industry. Doubts with regard to this get even reinforced when we look at the results for the world. If innovators do not know whether their product is new to the world or to their nation how should they then distinguish sectoral and firm level?

2. 8. Too many Innovations? Innovation as New Combinations

Not only survey studies overestimate the amount of innovations, but also trade journal and expert interviews come up with a much larger number of innovations than Schumpeter's theory of the heroic entrepreneur, the pioneer, would suggest. Debresson (1996, p.48) gives an interesting explanation for this result. It is the fact that innovations can also be only "new combinations" and not radically innovations. The number of potential combinations of inputs in order to produce different outputs is quite high. In particular, if the sequence with which these inputs can be used can vary. When compared with cooking, with three ingredients: flower, yeast and oil, one can cook a great variety of foods, as the law of combinatoric and the rich Bohemian cuisine with its diverse dumplings shows.

3. The Choice of Indicators

3.1. Input versus Output Indicators

Theory determines what we want to measure, whether we focus our attention on the **Input and/or the Output** indicators or on the innovation process, whether we concentrate on product innovation (what you produce) or process innovation (how you produce). The Input-Output literature of economics concentrates solely on factors that appear in a production function: Input of R&D, Labor (amount and skill) and Stock of Capital (or cumulated sum of investments) and product output. Process innovation, i.e. improvements of how one produces, would only appear as a change in the technological relationship between input and output. What can be measured, is hence, technological process and product innovation, but not innovation through sourcing (that operates through factor markets, e.g. access to new raw materials), through access to new markets or through organization (e.g. better time management). Another big problem is the fact that innovation in the service sector (where input is identical with output) cannot be measured with an input-output concept. A further problem is that this concept cannot distinguish between imitation and innovation, in both cases the production function and the input output relation would change in the same way. The process that leads from "knowledge" via "experimentation" and the creation of "infra- technology" to a change in technology is not studied. When one concentrates on Input and Output data, exactly what one wanted to study is left out: the process of innovation. Nevertheless, most of the commonly used indicators are either input or output variables.

Freeman (1994, p.488f) states that Neo-Schumpeterians have made original and ingenious use of a wide variety of statistics for the measurement of various aspects of technical change (scientometrics, which uses scientific journals, quotations etc in order to measure output, technometrics, patents, R&D expenditures and personnel, innovations, diffusion rates etc).Freeman (1994) sees three essential gaps in data.

1. R&D oriented measures cannot deal with activities of the firm that are directed towards knowledge accumulation. There are measures of capital intensity, technology intensity, but not of **"knowledge intensity".** Late attempts try to measure the stock of knowledge and spillovers (see Delft conference 1999 below).
2. Too little attention has been paid to the **service sector**, although it counts for an increasing amount of total employment and is affected by new technologies, in particular information technologies (see Freeman 1994, but also Hage 1998).
3. **Network and interfirm relations**, evolutionary micro-macro-models should be developed. From the new empirical research one can conclude that knowledge and networks have become more popular. Models of innovation and their diffusion, various appropriability regimes, heterogeneity of **agents**, learning by interacting, quality improvements, dynamic efficiency etc are en vogue. The service sector is however still under-represented (see Delft conference 1999).

3.3. Pro and Cons of the Three Most Widely Used Innovation Indicators

3.3.1. Research and Development

R&D is the most heavily used indicator of all innovative performance indicators. Traditionally, a distinction is made between basic (or fundamental) research, applied research and experimental development. The Frascati Manual (OECD 1994) defines **basic research** as "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view". **Applied research** is defined as "original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective". **Experimental development** is defined as systematic work, drawing on existing knowledge gained from research and practical experience, that is directed to producing new materials, products and devices, to installing new processes, systems and services or to improving substantially those already produced or installed". Problems can occur with the interpretation of these rather complicated questions in surveys. OECD (1998, Science Technology and Industry Outlook, p.167) shows the development of Basic Research as a Percentage of GDP from 1980-1995. In the Netherlands, e.g., basic research has fallen, both in % of GDP and in percent of total R&D.

The innovation process entails much **more than R&D, notably design, marketing, tooling, and prototyping**. Therefore, the input factor R&D accounts for only a small amount of developing costs. Market surveys, trial production, tooling-up, training, , the preparation of the distribution chain, designs, patents and licenses all account for total product innovation expenditure.

Kleinknecht (1996) measures the unmeasurable, by estimating the type of expenditure by firm size. He shows that product related R&D accounts for only 40% of total product expenditure of small firms, with 10-49 employees, and 60% in firms of 50-199 employees. In larger firms, R&D expenditures are 51% of the total. **Roughly speaking, R&D accounts only for about half of the innovation expenditures.**

3.3.2. Patents

Patents are a widely used indicator for innovation, although it is the result of invention and not of innovation. It is not clear whether it is an input or an output, since it can also be a throughput. Cohen and Levine (1989, p.1063) point at the significant problems with patent counts as a measure of innovation, some of which affect both within-industry and between-industry comparisons. Most notably, the economic value of patents is very heterogeneous. A great majority of patents are never exploited commercially, and only very few are associated with major technological improvements. Moreover, a patent might consist of several related claims, each of which might be filed as a separate patent. US inventors tend to bundle claims into one patent, while the Japanese typically file separate patents for each claim. Even if they were of the same economic value, their use in econometrics is problematic, as Hausman, Hall and Griliches (1984) point out. They are integer-valued and their distribution across firms is highly skewed. It is therefore not possible to make standard assumptions about a normal distribution of the error term and to apply a standard regression in order to explain patent activity.

The propensity to patent varies across industries. **In the electronic industries**, e.g., entire categories of economically significant innovations are typically **not patentable**. Computer software, for example, is normally capable for copyrights, but not for patent protection. There is a serious trade-off between patenting innovations and keeping them secret. In some industries, patents reveal information to the competitor that cannot be ascertained by other means (e.g. reverse engineering the product). By contrast patents may be preferred, where they serve as "signals" of technological competence to sponsors and suppliers of capital. For a critical discussion on the use of patents as an indicator for innovation, see Pavitt (1985), Griliches, Hall and Pakes (1987), Griliches (1990) and Kleinknecht (1996). A short overview can be found in Cohen and Levin (1989). They review the study by Cockburn and Griliches (1988) that found that stock market reactions to changes in a firm's R&D expenditures are stronger than to patents. However, how highly patents are valued, varies between industries. A survey study by Mansfield (1986), who interviewed 100 firms from 12 (2 digit) industries, whether patent protection was important for their innovations, revealed that **patents are very important for the pharmaceutical -and chemical industry**. Patents were judged to be essential for 65% of commercially introduced inventions. Levin et al (1987) found out that only 4% of industries regarded product patents as highly effective, 80% regarded investments in complementary sales and service efforts as highly effective in capturing competitive advantage from their R&D activities. The CIS I data survey of the Netherlands of 1992 confirms this. Only 10% of the 1008 sampled Dutch innovative firms find patent protection crucial, while 19% find the time lead on competitors crucial. Surprising also that 47% find patents insignificant. Copyright is not seen as important. Only 2.8% find it crucial as opposed to 61% who find it insignificant. (see Kleinknecht 1996). If the importance the Dutch give to different mechanisms of protection is ranked, time lead on competitors comes in first place, followed by keeping qualified people in the firm, secrecy, patent protection, complexity of product or process design, copyright and related laws and last certification. Teece (1986, 1987) emphasized the importance of investments in co-specialized assets for appropriating the returns from R&D and provides details of several specific cases. Problems arise with the fact that national patent offices do not classify patents by industry but by products. Sectoral patent statistics have, therefore, first to be composed.

3.3.3. Sales and Exports

Sales of Innovative Products is the only direct indicator of innovation. The problems that arise with it are listed in the table below. In particular the overestimation bias (time bias and others) that has been discussed in the beginning, is problematic here.

Exports are another important indicator in order to measure innovation or rather diffusion. Very often this measure is used for competitiveness and specialization comparisons of countries. Balassa's (1965) Revealed Comparative Advantage index (**RCA**) shows the relative share of a sector in a given country's total exports compared with the relative share of the sector in world's (or total OECD) exports. The weighted index for each country in each year is by definition one. The Dutch competitiveness with regard to flowers is, for example, measured (Export flowers NL/Total Exports NL)/ World Export Flowers/World Exports). The indicator has the advantage that the problem of sector definition does not occur, since trade statistics are available by product. In particular for sectors difficult to trace, such as biotechnology, this indicator is helpful. Disadvantages are that big countries, such as the US might be much less dependent on exports than small open economies. Domestic sales have the same positive effect on GDP as foreign sales do. Furthermore, exports do not tell us much about innovation, but rather about diffusion. A country with a large amount of raw materials can be a heavy exporter, but not innovative. Indicators such as **technology intense exports or technology balances** (exports - imports) try to account for this problem. One problem with all trade statistics is that they are heavily biased. World Exports minus World Imports should, theoretically add up to zero. But even if we account for differences in calculation, (free on board - FOB -, or cost, insurance, freight included -CIF) it is striking that the World Balance has a deficit of 70 billion of US Dollars. Fraud, custom declaration mistakes etc. all add up. Nevertheless, Exports in % of GDP or export of technology intense products and technology balances are - together with R&D and Patents - the most heavily used innovative performance indicator at the macroeconomic level.

Table 3: Pros and Cons of the 3 Most Widely Used Innovative Indicators Summarized

Indicator	Pros	Cons
R&D in percent of employees or of total expenditure	• regularly collected since 1950 • standardized and internationally comparable • can be subdivided into basic - applied -developmental research • easily accessible a • analysis of inter-sectoral technology flows is possible	• input indicator, does not measure the result of innovation • accounts only for 40%-50% of total innovative input (design, trial production, tooling-up, market analysis, training, investment in fixed assets...) • undercounts small firm's R&D • big measurement problems due to subsidy schemes • problem with the interpretation of the Frascati definition • difficult access to micro data due to secrecy problems • hard to desegregate by region (multi plant firms)
Patents Granted or Patent Applications	☐ long time series available •no secrecy problems • relatively consistent over time • classification by technical field is possible • citation analysis is possible	• Measures the result of an invention and not innovation • unclear whether an input or output indicator. Can be a throughput, an input for next step of production or final result • patent application include those that are refused • patents miss non patented innovations • bias by firm size. Threshold for smaller firms • propensity to patent differs by sector • propensity to patent differs by firms that do or do not collaborate • patents are a strategic variable, they are public, hence trade off with secrecy • propensity to patent products different from propensity to patent processes • not available in sector classification but only by products

Sales of Innovative Products	• direct measure of innovation • only successful innovations included • allow to distinct between imitation and innovation • allows to combine it with input indicator and to tell something about the efficiency of the innovation process	• refers only to product and not to process innovation • in surveys often overestimated by respondents due to psychological bias "it is good to innovate" • problems of interpreting the definition with regard to reference system due to cognitive perception • inter-sectoral comparison difficult due to differences in the life cycle • often suffering from low response rates

Sources: Kleinknecht, sheets presented at the Delft conference 1999 and Kleinknecht (1996)

4. Final Note: A New Classification of Sector Specialization

A new and very interesting and helpful sector classification for manufacturing was done by Michael Peneder for the EU - DG III (Peneder 1999). He wants to take into account differences in intangible assets - R&D expenditures and expenses for advertisement - across sectors and their impact on competitiveness. Countries that are specialized in sectors that are low in R&D usually are classified as "less innovative". However, as Peneder shows, high R&D expenditures are only to be expected in "technology driven industries". In other sectors, the expenses for advertisement can be high, thus overall performance can be good even with low R&D.

Peneder analyses 100 sectors at the 3 digit level in regard to the following variables, the first two representing exogenous, tangible, inputs, the last two intangible, endogenous inputs to production.

1. *Labour intensity*: Average ratio of gross wages and salaries to value added from 1990 to 1995.
2. *Capital intensity*: Average ratio of total investments to value added from 1990 to 1994.
3. *Advertising sales ratio*: Average ratio of advertising outlays to total sales from 1993 to 1995.
4. *R&D sales ratio*: Average ratio of expenditures on research & development to total sales from 1993 to 1995.

In the end, having applied cluster analysis, precisely 100 NACE 3-digit manufacturing industries were categorized under the following five, mutually exclusive groupings:

1. *Mainstream manufacturing* (i=MM): This residual category was created out of 25 industries, in which input combinations did not show a pronounced reliance on any particular input factor. Summing up all manufacturing industries in the European Union, Japan and the USA in 1996, this group generated 24.54 % of total value added, 27.33 % of employment, 24.09 % of its exports, but only 15.83 % of imports. The archetypal example is the *machinery* sector. Among others, this group also includes *articles of paper*, *plastic products*, *electronic equipment* and *motorcycles*.
2. *Labour intensive industries* (i=LI): Comprising 25 individual 3-digit industries, the common share of total employment in the triad in 1996 amounts to 22.1 %. This is contrasted by a rather low share in total value added of about 14.6 %. Its shares in the total exports and imports of the triad are 10.2 % and 15.6 %, respectively. Typical examples are such sectors as *textiles & clothing*, *wood processing*, *construction material* and *metal processing*.
3. *Capital intensive industries* (i=CI): In this subgroup, only 9.9 % of the triadís total manufacturing employment produces 13.4 % of its value added. A share of 16.9 % of total exports corresponds to 17.5 % of imports. Typical examples are *pulp & paper*, *refined petroleum*, *basic chemicals* and *iron & steel*.
4. *Marketing driven industries* (i=MDI): This category comprises 23 advertising intensive industries, together accounting for 22.2 % of the triadís total value added and 22.1 % of total employment. This is in sharp contrast to the low shares of only 10.0 % in the triadís total exports and 14.1 % of total imports. The archetypal example is the *food* sector, which is allocated entirely to this category. Other industries within this category produce articles associated with leisure and entertainment such as *perfumes*, *sports goods*, *musical instruments* or *games & toys*.
5. *Technology driven industries* (i=TDI): The 14 industries within this group are

characterised by particularly high expenditures on R&D and account for 25.3 % of total value added as well as 18.6 % of total employment in the triad. Research intensive goods are more highly traded than the products of any other category. Although similar in size to the other categories with regard to value added and employment, their share in total exports and imports amounts to an outstanding 38.8 % and 37.0 %,respectively. Industries concentrate around three distinct technology fields: (i) *chemicals and biotechnology*; (ii) *new information & communication technologies*, and (iii) *vehicles for transport*.

The numbers below can be used as a benchmark. They show the average of EU, Japan and the US. If a country has more value added, employment or exports and imports in one of the categories, it can be labeled "specialized" in this field.

Table 4: Shares in manufacturing: EU-Japan-USA 1996 in %

Industry type	Value added	Employment	Exports	Imports
Mainstream Manuf. (MM)	24.5	27.3	24.1	15.8
Labour intensive (LI)	14.6	22.1	10.2	15.6
Capital intensive (CI)	13.4	9.9	16.9	17.5
Marketing driven (MDI)	22.2	22.1	10.0	14.1
Technology driven (TDI)	25.3	18.6	38.8	37.0
Total manufacturing	100	100	100	100

Source: Peneder for European Communities (1998).

Like any broad classification, this new taxonomy must be interpreted with some care, since industries within the five categories are still very heterogeneous in nature. One particular concern can be raised with regard to the surprisingly neat designation of cases into each of the four chosen dimensions. Certainly, all the industries produce their output using all four input factors, but with different degrees.

Table 5: The WIFO taxonomy of manufacturing industries by Peneder

NACE Industry	skill type	capital	labour	r&d	advertising
		share in value added/net turnover in %			
Mainstream manufacturing (MM)		**6.28**	**37.83**	**2.17**	**2.35**
1730 Finishing of textiles	LOW	6.56	40.70		
1770 Knitted and crocheted articles	LOW	6.00	43.49	1.98	2.89
1750 Other textiles	LOW	7.30	37.22	1.73	1.14
1760 Knitted and crocheted fabrics	LOW	8.64	42.41	1.98	2.92
2120 Articles of paper and paperboard	MED/ WC	6.69	36.01	3.40	3.01
2430 Paints, coatings, printing ink	MED/ WC	3.88	24.25	2.66	2.69
2510 Rubber products	LOW	6.81	38.67	2.54	2.03
2520 Plastic products	LOW	8.86	37.90	2.01	2.98
2610 Glass and glass products	LOW	8.84	35.62	2.55	3.37
2660 Articles of concret, plaster and cement	LOW	5.94	41.45	1.21	2.05
2680 Other non-metallic mineral products	LOW	6.41	30.93	1.89	1.82
2720 Tubes	LOW	7.40	41.68	2.04	2.01
2870 Other fabricated metal products	MED/ BC	6.07	43.31	1.44	3.03
2910 Machinery for production, use of mech. power	HIGH	6.22	39.77	2.30	2.57
2920 Other general purpose machinery	HIGH	5.21	43.60	2.01	1.60
2930 Agricultural and forestry machinery	HIGH	4.02	30.41	3.35	1.12
2950 Other special purpose machinery	HIGH	5.33	45.33	2.49	2.68
2960 Weapons and ammunition	HIGH	6.14	44.11	1.70	2.08
2970 Domestic appliances n. e. c.	MED/ WC	5.78	31.46	1.51	3.11
3110 Electric motors, generators and transformers	MED/ WC	5.30	41.06	2.65	1.36
3130 Isolated wire and cable	MED/ WC	6.62	35.18	2.29	2.11

3140 Accumulators, primary cells and primary batteries	MED/ WC	6.89	32.24	2.29	2.11
3150 Lighting equipment and electric lamps	MED/ WC	4.15	35.39	2.29	2.11
3540 Motorcycles and bicycles	MED/ BC	5.66	36.22	2.06	2.16
3550 Other transport equipment n. e. c.	MED/ BC	6.32	37.21	1.82	3.37
Labour intensive industries (LI)		**5.00**	**44.75**	**1.44**	**3.30**
1720 Textile weaving	LOW	9.33	45.97	0.69	4.79
1740 Made-up textile articles	LOW	4.59	44.02	1.60	3.16
1810 Leather clothes	LOW	0.83	43.18	2.70	3.40
1820 Other wearing apparel and accessories	LOW	2.17	40.81	1.45	3.86
1830 Dressing and dyeing of fur; articles of fur	LOW	3.23	37.68	3.96	2.95
2010 Sawmilling, planing and impregnation of wood	MED/ BC	7.02	39.97	0.19	3.57
2020 Panels and boards of wood	MED/ BC	6.30	39.01	0.69	4.37
2030 Builders' carpentry and joinery	MED/ BC	4.08	47.04	0.67	3.23
2040 Wooden containers	MED/ BC	4.91	48.18	1.06	3.57
2050 Other products of wood; articles of cork, etc.	MED/ BC	3.37	40.78	2.70	3.11
2620 Ceramic goods	LOW	5.60	41.80	1.04	4.45
2640 Bricks, tiles and construction products	LOW	7.35	44.02	0.22	2.38
2670 Cutting, shaping, finishing of stone	LOW	5.18	46.89	1.10	2.74
2810 Structural metal products	MED/ BC	3.63	46.73	0.44	1.57
2830 Steam generators	MED/ BC	4.53	47.23	0.92	0.94
2840 Forging, pressing, stamping and roll forming of metal	MED/ BC	6.12	47.07	1.59	1.77
2750 Casting of metals	LOW	6.84	50.63	0.78	3.08
2850 Treatment and coating of metals	MED/ BC	6.00	44.67	2.60	4.62
2940 Machine-tools	HIGH	4.55	43.38	2.31	3.27
3160 Electrical equipment n. e. c.	MED/ WC	5.58	41.55	2.92	5.66
3420 Bodies for motor vehicles, trailers	MED/BC	9.31	52.54	0.70	2.53
3510 Ships and boats	HIGH	2.90	55.25	0.97	3.11
3520 Railway locomotives and rolling stock	MED/ BC	4.88	43.74	1.48	3.10
3610 Furniture	MED/ BC	3.94	45.30	1.32	4.62
3620 Jewellery and related articles	LOW	2.72	41.22	1.79	2.77
Capital intensive industries (CI)		**14.01**	**33.43**	**1.46**	**1.64**
1710 Textile fibres	LOW	12.36	44.98	1.60	2.98
2110 Pulp, paper and paperboard	MED/ WC	21.28	30.43	1.05	1.91
2310 Coke oven products	MED/ WC	13.74	38.98	1.11	1.38
2320 Refined petroleum products	MED/ WC	25.73	16.85	0.68	1.38
2410 Basic chemicals	MED/ WC	14.33	21.52	3.55	2.49
2470 Man-made fibres	MED/ WC	12.94	28.83	3.15	1.14
2630 Ceramic tiles and flags	LOW	10.65	38.49	0.22	2.38
2650 Cement, lime and plaster	LOW	10.53	27.29	0.54	2.74
2710 Basic iron and steel, ferro-alloys (ECSC)	LOW	13.71	39.0	11.10	1.19
2730 Other first processing of iron and steel	LOW 1	0.41	36.17	0.88	0.18
2740 Basic precious and non-ferrous metals	LOW	11.13	35.31	1.04	0.67
3430 Parts and accessories for motor vehicles	MED/ BC	11.33	43.29	2.62	1.28
Marketing driven industries (MDI)		**5.11**	**30.15**	**1.26**	**7.58**
1510 Meat products	LOW	6.36	36.33	0.28	5.86
1520 Fish and fish products	LOW	7.13	33.19	1.00	7.23
1530 Fruits and vegetables	LOW	6.75	21.9	10.78	7.30
1540 Vegetable and animal oils and fats	LOW	8.55	18.93	0.15	7.09
1550 Dairy products; ice cream	LOW	6.27	24.82	1.67	5.46
1560 Grain mill products and starches	LOW	7.18	14.47	0.94	8.72
1570 Prepared animal feeds	LOW	5.09	18.28	0.94	8.72
1580 Other food products	LOW	5.29	22.39	0.65	6.93
1590 Beverages	LOW	5.88	18.40	0.76	6.47
1600 Tobacco products	LOW	1.58	6.33	0.47	7.61
1910 Tanning and dressing of leather	LOW	5.16	41.86	0.92	6.62
1920 Luggage, handbags, saddlery and harness	LOW	2.06	39.49	0.92	6.62
1930 Footwear	LOW	2.37	39.53	0.92	6.62
2210 Publishing	MED/ WC	3.93	31.10	3.16	6.41
2220 Printing	MED/ WC	5.60	40.59	1.36	6.22
2230 Reproduction of recorded media	MED/ WC	9.99	27.83	1.58	6.64
2450 Detergents, cleaning and polishing, perfumes	MED/ WC	4.61	14.58	2.78	9.45
2820 Tanks, reservoirs, central heating radiators and boilers	MED/ BC	4.14	44.11	0.40	5.15
2860 Cutlery, tools and general hardware	MED/BC	5.53	45.06	1.88	10.49
3350 Watches and clocks	MED/ WC	3.03	37.70	0.99	9.33
3630 Musical instruments	LOW	2.36	45.25	0.87	7.33
3640 Sports goods	LOW	4.20	31.89	1.70	5.73
3650 Games and toys	LOW	4.96	31.72	2.95	14.48
3660 Miscellaneous manufacturing n. e. c.	LOW	4.54	37.90	2.13	9.39
Technology driven industries (TDI)		**6.91**	**31.21**	**5.85**	**2.64**
2420 Pesticides, other agro-chemical products	MED/ WC	7.63	11.87	1.21	2.73
2440 Pharmaceuticals	HIGH	7.19	16.35	12.97	5.93
2460 Other chemical products	MED/ WC	7.71	24.01	3.41	2.98
3000 Office machinery and computers	HIGH	7.07	31.63	6.91	1.49
3120 Electricity distribution and control apparatus	MED/ WC	4.91	37.25	4.63	1.68
3210 Electronic valves and tubes, other electronic comp	MED/ WC	12.16	33.30	7.12	2.20
3220 TV, and radio transmitters, apparatus for line telephony	MED/ WC	5.64	33.93	9.15	1.52
3230 TV, radio and recording apparatus	MED/ WC	10.42	30.88	5.54	3.48
3310 Medical equipment	MED/ WC	5.58	32.73	7.15	1.41
3320 Instruments for measuring, checking, testing, navigating	MED/ WC	4.23	43.82	5.30	2.61

3330 Industrial process control equipment	MED/ WC	4.95	43.19	4.02	0.83
3340 Optical instruments and photographic equipment	MED/ WC	6.35	26.69	6.09	4.27
3410 Motor vehicles	MED/ BC	7.86	25.78	4.31	2.03
3530 Aircraft and spacecraft	HIGH	5.06	45.56	4.14	3.74

NB: MED/BC.. classified as `medium-skilled blue-collar industries ; MED/WC.. `medium-skilled white-collar industries.
Source: DEBA, COMPET, Peneder 1999

According to the findings of Peneder (1999). **marketing driven industries are characterized by lower investments in R&D**. They differentiate themselves primarily through the **creation of new product** varieties. They depend much more on horizontal rather than vertical product differentiation. The relocation of production is more of a concern (supply of raw material, distribution) whereas technology driven industries are bound in their location choice by the available human resources. While in technology driven industries joint ventures and cooperation between firms are common ways of achieving an efficient pooling of knowledge, marketing driven industries are less cooperative. They long more for vertical than horizontal integration, which indicates that to secure control over the distribution system is more important for mergers and acquisitions than knowledge based or efficiency oriented motives (see Peneder 1999).

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