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The Role of Small Enterprises in the Process of Innovation

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Abstract

This paper deals with firm-size and innovation[1]. The initial assumption is that empirical and theoretical statements particularly neglect the field of small and medium-sized enterprises. The result of this study is that definitions of innovation processes can be applied more easily to innovations in large enterprises. Besides, scepticism towards deriving the neo-Schumpeterian hypothesis from the works of Schumpeter by deducing four more hypotheses from it is supported. Finally, the analysis of the empirical literature basically verifies the initial assumption. The choice of indicators discriminates against informal innovations within smaller enterprises and favours data which have been collected over a long period of time and can be systematized, which is the case in large enterprises. Moreover, databases tend to neglect small enterprises because they either set the minimum size of the enterprises too high, the intervals between the surveys too long, or the conditions of entry for small and medium-sized enterprises too strict.

Topics for future research will be shown, and a basis for a critical assessment of aid programmes for research in large enterprises is provided.

I. Introduction

By maintaining the well-known hypothesis that large enterprises are more innovative than small and medium-sized enterprises, Schumpeter tied a Gordian knot for the industrial-economic innovation literature. Over the past 30 years, it has been intensively examined how to cut that knot (Kamien/Schwartz 1982; Stoneman 1983, p. 46 ff.; Baldwin/Scott 1987), but a solution does not seem to be in sight. The knot cannot be cut in this paper, either. Our starting point is different. To use the same metaphor, we would like to analyse the composition of the Gordian knot. We start to examine the correlation between firm-size and innovation by assuming that small and medium-sized enterprises are neglected definition-wise, theoretically, and empirically. In the following, we concentrate on a few important elements of this problem, which have been analysed in detail in a dissertation (Kassai 1987).

In part II, it will first be shown how certain innovation definitions affect specific firm-size classes. Then, a short description will be given of the theoretical foundations, particularly of Schumpeter's works (III). Finally, we discuss empirical problems, e.g. statistical variables, statistical methods or databases, and its firm-size specific effects (IV).

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[1] For the correction of an earlier version, I would like to thank Messrs Prof. Dr. R. Blum and PD Dr. F. Rahmeyer. For financial support, I am grateful to the Deutsche Forschungsgemeinschaft. For the remaining faults, I am responsible myself, of course.

II. What is Firm-Size? What is Innovation?

First, we turn to absolute **firm-size**. To define absolute firm-size, quantitative criteria like the number of employees and turnover are frequently used. Unfortunately, they only incompletely reflect the size of a firm. The turnover of an enterprise is often distorted by price variables which, in turn, might depend on the firm's market-power. The concept of employees can only be used if the enterprises are identically capital-intensive. Therefore, both criteria are doubtful because an equal inflation rate or labour intensity can be neither expected nor proved for enterprises of different size classes (BMWI 1985). Qualitative criteria to distinguish between different firm-sizes (legal status, organizational and management system) only indirectly specify a company (Marwede 1983; Storey 1984); however, they can be used as auxiliary definitions, e.g. concerning the diversification structure and the number of hierarchy levels, because they bear the advantage of avoiding the above mentioned problems. Nevertheless, qualitative criteria do not necessarily correlate with the size of the enterprise and depend on decisions of the company's management (Gebert 1979; Corsten/Meier 1983; Souder 1983). Because this aspect is obviously irrelevant in the innovation literature, we will not further elaborate on it.

Since Schumpeter, the term **innovation** represents the innovation process which starts with **invention**, continues with **innovation**, and finally leads to **diffusion** and **imitation**. Nelson (1959) and Arrow (1975) give a relatively broad microeconomic definition of the first phase by regarding the production of new information as innovation. Three problems are mentioned in this context: a) impossible acquisition, b) high uncertainty, and c) non-divisibility. These problems resulted not only in demands for a research policy, but also in the argument of the neo-Schumpeter discussion that large enterprises in particular are the solution for the failure of the invention market. The innovation itself, which disturbs the market equilibrium, was characterized by Schumpeter in a broad definition:

1. The introduction of a new good.
2. The introduction of a new method of production.
3. The opening of a new market.
4. The conquest of a new source of supply.
5. The carrying out of the new organization of any industry (Schumpeter 1936, p. 66).

Unfortunately, most Schumpeterian literature restricted these definitions in such a way that distortions could result or could be deduced for small enterprises. Regarding the production of inventions, many authors concentrate on describing the research department; the innovation is only the new product or

the new production process[2]. With a few examples and plausibility considerations, we would like to show that this procedure might result in firm-size specific distortions.

1. Pure research (pure or applied) is generally characterized as long-term research, that does not aim at usefulness - research for the sake of knowledge - (Juettner-Kramny 1975, p. 12 ff.)[3]. Only those enterprises, which can use the results (possible acquisition), will predominantly invest in pure research. Large, diversified enterprises with a long-term planning of research budgets are the target group of this definition (Nelson 1959). Small and medium-sized enterprises with a narrow production range in fact neglect this kind of production of new information; however, it cannot be deduced that they totally abstain from pure research (regarding the results).
2. Within the area of the OECD, applied research, or research and development (R&D) has been defined by the NSF (National Science Foundation). It is characterized by creative, systematic work to broaden scientific and technical knowledge (Junginger-Dittel 1983, p. 1). Such work, for which an R&D department is necessary, is only being done to a limited degree in small and medium-sized enterprises. Contrary to large enterprises, in the small and medium-sized companies it is neither referred to as research nor as development, but at best as construction (Ellwein 1980, p. 63 ff.). Nevertheless, research and development is being done, in fact by the entrepreneur himself (IHK 1975, p. 11; see Rothwell/Zegveld 1982, p. 78 ff.).
3. Product and process innovations are innovations, which concern the area of production. In general, process innovations are carried out by those enterprises that want to decrease production costs (increasing capital stock) on stagnant markets; product innovations are innovations on growing, restless markets (e.g. software market). It cannot be assumed that small enterprises make high, long-term process investments to lower per-unit costs, whereas large enterprises sell a high number of pieces on markets with an uncertain demand capacity and homogeneity (Utterback/Abernathy 1980). Furthermore, concentrating on these two terms, while omitting the other two of Schumpeter's definitions, is problematic in itself, if small enterprises secure their survival rather by innovative organization and by developing new markets than by innovations in the area of production.

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[2] "setting up and shift of production function" (Schumpeter 1936).

[3] Theories without any special hints for use (Machlup 1963, p. 37).

These examples show that the used terms in the innovation process tend towards a distortion against small enterprises and have to be applied with great care. According to the above mentioned dissertation, the problem of definition can be summarized in the following way:

Table 1: **The Innovation Process and its Stages: Discrimination of Large and Small Enterprises** (KASSAI 1987, p. 20 ff.)

The definition of stage (...)	discriminates against
- pure research	SME[1)]
- applied research	SME
- development	SME
- product innovation	Large Enterprises
- process innovation	SME
- novelty	SME
- uncertainty	SME

1) Small and Medium-Sized Enterprises

The result is, that these definitions generally discriminate against small and medium-sized enterprises because they mainly focus on those stages of the innovation process which happen in large companies. In the case of introducing a basic innovation, for example, the existence of pure research is regarded as a prerequisite, although only large enterprises and the government can afford it! Rall/Pfeiffer confirm these considerations. According to these authors, the usual innovation-phase scheme is a "procuristian bed of variables" (Baker 1980), which does not solve specific innovation problems of small enterprises, whereas other phases, like the above defined pure research or the zero series, are simply irrelevant (Rall/Pfeiffer 1981, p. 47).

Finally, a definition of the innovation process for all firm-size classes does not seem to be sensible, even if the different functions of the enterprises in the economy are considered in general. Therefore, it can be stated that different

firm-size classes participate in different phases of the innovation process according to their comparative advantages (Rothwell/Zegveld 1982, p. 43-54; see table A1 in the appendix), and that the innovation process is initiated by the co-operation of enterprises of different firm-size classes (Geiling 1982, p. 35). On the other hand, it has to be taken into account that the same phase of the innovation process works differently in enterprises of different sizes (without considering sectoral effects), and that therefore it is necessary to have a very broad and flexible definition, which varies from case to case.

III. "The After-Dinner Talk"[4] or the Theory-Deficit?

The study of the correlation between firm-size and innovation (processes) is based on the neo-Schumpeterian hypothesis and goes back to a considerable number of Schumpeter exegeses, starting with Galbraith, Villard, Lilienthal, and Nutter, then Nelson, Scherer, and Mansfield, and finally ending with the most recent works of Bond et al, Cohen et al, Pavitt et al, or Albach. The arguments and positions were summarized by Kamien/Schwartz and Baldwin/Scott. In addition, there are some German authors, whose results are partly identical with those of the above mentioned researchers (Kassai 1987).

Knowing the different results of this literature and having studied Schumpeter thoroughly, one can find arguments for almost all hypotheses. Different terms, partly due to translation problems, partly to a change in the economic language, add their share, and interpretations add another. Two examples in this context: Schumpeter defines **progress** generally as "capitalistic evolution" (Schumpeter 1976, p. 134). In this context, the following quotation has to be understood: Looking for the individual items "... in which **progress** (bold print by *the author*) was most conspicious, the trail leads ... to the doors of the large concerns - ... - (Schumpeter 1976, p. 82). Kantzenbach changes this quotation into: Large enterprises have become the most important supporters of **technical progress** (Kantzenbach 1970, p. 34).

Schumpeter, who strongly ties innovation to the function of the enterprise, writes in the **same book** although in another place: "Thus, economic progress tends to become depersonalized and automatized. Bureau and committee work tends to replace individual action" (Schumpeter 1976, p. 133). Here, Galbraith can conclude only to a very limited degree from Schumpeter: "Moreover, a benign Providence ..., has made the modern industry of a few large firms an excellent instrument for inducing technical change" (Galbraith 1980, p. 86).

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[4] This notion goes back to Joan Robinson's judgement on Schumpeter's different economic publications. In spite of admitting a contribution to economic theory, she calls his books an "intelligent after-dinner talk"

First of all, the objection of "early" and "late" for Schumpeter's works has to be considered (Freeman 1982, p. 212 ff.; Gerybadze 1982, p. 104), i.e. that views change in the course of time, the hitherto positive correlation later plausibly turns out to be negative. "We have to recognize, ..., that we are dealing with a process subject to institutional change and therefore must, for every historical period, see whether or not our model, ..., still fits facts" (Schumpeter 1939, p. 96 f.)

Moreover, the objection of a shift over time in Schumpeter's works, particularly for innovations, seems to be relatively weak. The "Theory of Innovation" rarely changes between 1911 and 1939 (!); in 1942, however, in his last work **Capitalism, Socialism and Democracy**, it changes considerably. What, then, is Schumpeter's opinion concerning this "irrelevant" - "mere size is neither necessary nor sufficient for it (i.e. innovation, *the author*)"[5] - correlation between firm-size and innovation?

1. First, it is derived from his work, that innovations are carried out by newly established enterprises and entrepreneurial personalities. The owner-entrepreneur of a medium-sized enterprise generally manages the personnel, and performs innovations. Such an enterprise is most likely to correspond with the picture that Schumpeter drew of a dynamic entrepreneur (Albach 1979, p. 547). People who establish a firm are Schumpeter-entrepreneurs 'par excellence' (Albach 1984, p. 131).
2. Next, it is stated, that innovations are not bound up with organizations but with persons, "...we must notice the case of big, particularly of "giant", concerns which often are but shells within which an ever-changing personnel may go from innovation to innovation" (Schumpeter 1939, p. 96).
3. Finally follows - as hinted above - the decline of the entrepreneurial personality, and consequently the decline of innovation and capitalism, too!

Summarized, after 40 years of exegesis, Schumpeter appears as follows:

1. **Small and medium-sized enterprises** are the **motors** of **innovation** (anti neo-Schumpeter 1).
2. **Large enterprises are the motors** of technical progress (neo-Schumpeter).
3. **Large enterprises restrict technical progress** (anti neo-Schumpeter 2).
4. Last not least: "The large scale establishment is simply the "new type of organization" which, in turn is one of the several "new combinations" with which Schumpeter identified the essence of entrepreneurship" (McNulty

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5 "Even in the case of what he termed "big" innovations, Schumpeter insisted that innovation was "independent of size of the innovating firm or firms"" (McNulty 1974, p. 630).

1974, p. 631). **Large enterprises are** the technical progress (anti-anti neo-Schumpeter).

Despite the ambiguous world of Schumpeter's works (more differentiated see Kassai 1987, p. 52-67; p. 100-134), the main direction of empirical literature assumes hypothesis (2). A simplification which clearly leaves its traces in empirical research.

Before we turn to this research, a last hypothesis shall be mentioned for the sake of completeness:

5. There is **no correlation** between firm-size and innovation (apocalyptic or agnostic neo-Schumpeter).

There is neither an optimal firm-size to create all inventions and innovations of an industry, nor is there such a size for all phases of R&D projects (Kaufer 1970, p. 464; Scherer 1979, p. 418). "We conclude therefore that there is no general and systematic connection between the size of firms ... and the possibility of technical progressiveness" (Schmookler 1959, p. 632; see Rosegger 1986, p. 125).

IV. Empirical Examination of the Neo-Schumpeterian Hypothesis

The empirical examination of the correlation between firm-size and innovation is actually a survey of the interrelation between large enterprises and R&D staff respectively R&D expenditure, as far as the empirical literature, particularly in the United States, is concerned. Arranged according to the year of publication, we almost completely list those studies, here, in particular to fend off Scherer's reproach to Fisher/Temin: "... they display considerable ignorance of the literature they criticize (and) do violence to both Schumpeter and common sense" (Scherer in: Link 1981, p. 30).

Table 2: **„Size of Enterprises and Innovation" - The Importance of Small and Medium-Sized Enterprises in Empirical Research on Innovation** (KASSAI 1987, p. 232a)

Year of Publication	Author	Database Number of Enterprises
1961	WORLEY	198 out of 500 „Fortune"-list
1964	HAMBURG	340 out of 500 „Fortune"-list
1965	SCHERER	448 out of 500 „Fortune"-list
1967	COMANOR	387 out of 500 „Fortune"-list
1968	GRABOWSKI	26 out of 500 „Fortune"-list
1970	ADAMS	300 biggest enterprises in USA/France
1971	JOHANNISSON/ LINDSTRÖM	181 bigger than 500 employes
1973/74	ANGILLEY	20 and 25 biggest enterprises
1974	PARKER	598 multi-national enterprises
1976	ROSENBERG	100 out of 500 „Fortune"-list
1977	LOEB/LIN	6 big enterprises
1979	SOETE	530 enterprises with more than 100 million turnover
1980	LINK	101 implicitly big enterprises
1984	GRILICHES/MAIRESSE	103 big enterprises

More recent literature recognized that, too. "While Scherer's sample appears to be an improvement over Hamburg's (sic!), it is still questionable whether limiting a study to the larger subset of the Fortune 500 firms is an adequate test of the Schumpeterian hypothesis" (Sullivan 1983, p. 43). Therefore, recent studies raise different problems and doubts about the older empirical literature and lead to a relatively heterogeneous result structure for the correlation between (size of) (big) enterprises and innovation, measured with R&D intensity. Cohen/Levin/Mowery (1987) trenchantly confront the findings of the 60s and 70s with recent results, followingly.

1. For a long time, literature was dominated by the opinion that, up to a certain limit, a growing firm-size corresponds with an increasing innovation activity. In companies, that exceed that threshold size, the innovation activity would no longer increase, but possibly even decrease[6].
2. This view has been doubted by recent surveys in different countries. Whereas Soete (1979) and Scherer (1984) observed empirical evidence for the neo-Schumpeterian hypothesis only for the largest enterprises, research by Bound et al in the USA, Cremer/Sirbu in France, and Pavitt et al in Great Britain showed that innovation activity falls with an increasing firm-size, and then rises again, so that both small and large enterprises surpass medium-sized companies concerning innovation activity[7].
3. The survey of Cohen/Levin/Mowery reveals "... that overall firm size has a very small, statistically insignificant effect on business unit R&D intensity; ... industry effects explain nearly half the variance" (p. 543; see Acs/Audretsch 1987, p. 109). Here, differences, particularly in the technological environment, play a decisive role. Two elements of this environment are 1) the ability to achieve R&D-backed innovations, which depend on the technological basis and the development of a sector, and 2) the possibility of private acquisition and exploitation of the innovation. The latter is determined by the market share, the possibility of price differentiation or secrecy, and by the imitators' ability to enter the market (Baldwin/Scott 1987, p. 106). In the future, empirical work in this field will have to be done: "Equally promising and difficult work remains to be done on the impact of the underlying technological environment, ..." (ibid., p. 112).

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6 "As summarized by Scherer and by Kamien/Schwartz, this consensus view held that firm-size is associated with increasing R&D intensity up to some threshold. (...) Among large firms, R&D intensity does not increase, and it may even decline, ..." (Cohen/Levin/Mowery 1987, p. 545).

7 "... they found that R&D intensity first falls and then rises with firm size. Thus both very small and large firms appeared to be more R&D intensive than those intermediate in size" (ibid.).

Our view is that the different results can be explained, at least to the same degree, by the different databases (Fortune 500 list, NSF statistic, Compustat tapes, Line of Business data), or that they are due to different methods of analysis up to the differing choice of indicators. In the following, some of these problems will be analysed according to their importance in literature.

1. Validity of innovation indicators

First, Soete remarks: "R&D employment, as inventive activity proxy, is accounting for less than a third in total R&D expenditure cost" (1979, p. 320). Regarding firm-size, he continues: "Evidence published by the NSF suggests that the R&D cost per scientist and engineer increases with size, from $ 35,100 for less than 1,000 employees size class to $ 72,300 for more than 25,000 employees size class" (ibid.). A confirmation of what Sullivan suspects: "It (R&D staff, *the author*) could lead to distortions if there are differences in labor and capital intensity of R&D outlays among firms" (Sullivan 1983, p. 34). Whereas R&D employees therefore rate small and medium-sized enterprises higher, Soete regards R&D expenditure as "neutral" concerning firm-size.

That may be doubted. Mainly, the difficulty concerning R&D expenditure arises because different firm-size classes subsume different meanings to the term, which are only sometimes identical. Uhlmann explains that the activity, called "research and experimental development" in R&D surveys, is mostly (in small and medium-sized enterprises) called "construction", and therefore, many enterprises are not aware of doing R&D themselves (Uhlmann 1979, p. 10; Assmann 1979, p. 45; Stifterverband 1978, p. 9, and 1986, p. 10 ff.).

Moreover, the fluctuation rate of small and medium-sized enterprises in the innovation process is higher than in large enterprises (Kamp/May 1981), which is partly due to the selection process, partly to short-term innovation plans, which e.g. cannot be captured by the bi-annual surveys of the Stifterverband[8]. Therefore, R&D expenditure seems to avoid the imbalance attributable to R&D staff, but it cannot offset the distortions in favour of large enterprises.

The distortions of the **patent indicator** concerning different firm-sizes have been discussed in different papers on hypotheses on propensity to patent.

The hypothesis of a higher propensity to patent of small enterprises traces back to Freeman, who deduces that patent statistics "tend to exaggerate the contribution of the smaller firms to inventive output" (Freeman 1974, p. 207) and therefore seems to be distorted compared to the neo-Schumpeterian hypothesis (Schmookler 1972, p. 38).

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[8] Germany's official institution to capture R&D data from industry.

Oppenländer (1984, p. 18), on the other hand, argues that particularly small and medium-sized enterprises have a low patent-propensity. Blum goes to the heart of the empirical results of Täger/Greipl (1982), who partly confirm this (p. 56): Particularly small and medium-sized enterprises contradict the patent statistic in personal interviews. They say, that one does not patent in order to become rich and big, but patenting can only be afforded by the big and rich (Blum 1981, p. 57).

Therefore, the validity of the patent indicator for small and medium-sized enterprises obviously depends on the actual differences in the propensity to patent between different firm-size classes. In this context, country-specific differences, due to different patent legislation[9], play an important role, too (Zimmermann/Zimmermann-Trapp 1986, p. 11).

Variables to measure the invention phase nevertheless should not hide the fact that they are used as surrogates for innovations of enterprises. They cannot answer how many new products or processes have been introduced; that is only possible when linear economies of scale are assumed, an assumption which causes more contradiction than approval. Whereas Cooper (1964) points to decreasing economies of scale with rising firm-size, Fisher/Temin differentiate for large enterprises as follows: "First, a larger R&D staff can operate more efficiently than a small one. Second, an R&D staff of a given size operates more efficiently in a larger firm" (Fisher/Temin 1973, p. 57; summarizing Mukhopadhyay 1985)[10].

Finally, it has to be considered, if and to what extent the indicators **product/process innovation** themselves are neutral concerning firm-size. Schatz argues against this neutrality: Various empirical studies show that large enterprises are particularly successful in process innovations, whereas small enterprises frequently aim at, and in fact succeed in, developing totally new products (Schatz 1984, p. 21). The domain of small and medium-sized enterprises is rather product innovation than process innovation, because their abilities are by far exceeded by the tendency towards increasingly complex, mostly large-scale technical systems (May 1980). Based on this hypothesis, most surveys concerning firm-size and innovation respectively imitation, are problematic insofar as they foremostly look at process innovation, as shown in table 3.

Moreover, it can be asked, whether the statements can be generalized for all sectors. Freeman is right, remarking that each sector has a different capital intensity, which demands either rather high or low process innovations, and which is advantageous for one or another firm-size class.

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9 The ability to handle patent legislation plays an important role for different firm-size classes, of course (Täger/Greipl 1982).

10 The superiority of large enterprises could be due to the fact that innovation results can be produced the cheaper, the larger the enterprise is (Schmalholz/Scholz 1985, p. 47).

Table 3: **Innovation Indicators (Product or Process) in Empirical Research on Innovation (or Imitation) and Firm-Size** (KASSAI 1987, p. 294 a)

Author	Innovations[1)]	Enterprises[1)]	Sector(s)	Kind of Innovation	Implementation faster in
ENOS 1962	9 35	35 first-time users	oil, ore processing industries	process innovation circa 50 % process innovation	
MANSFIELD 1963	14	295	steel, oil, coal	no explicit division (circa 50 % process innovation)	LE[2)] except steel
MANSFIELD 1963	diesel locomotive	30	-	-	LE
MANSFIELD 1968	150	12 (because CR_4)	steel, oil, coal	no explicit division (see Mansfield 1963)	LE
MANSFIELD 1971	1	97	tool industry	NC-tool machines	LE
GLOBERMAN 1975	1	90	tool industry	NC-tool machines	LE
GLOBERMAN 1975	1	23	paper industry	special press	SME[3)]
ROMEO 1977	1	152	10 sectors	NC-tool machines	LE
NASSBETH/RAY 1978	10	various	different	only process	7 LE
DAVIES (SAHAL) 1979	18	18	different sectors	predominantly process innovation	LE
KLEINE 1980	2	33 and 29	textile industry	process innovation	LE
KLEINE/EWERS 1983	2	903	mechanical engineering	process innovation	LE
TWAITES et al 1982	5	5 722	processing industries	3 process innovations	LE

1) number of cases observed, 2) large enterprises, 3) small and medium-sized enterprises

Finally, it can be stated that it is very difficult to find a bias-free indicator or the absolute indicator for entrepreneurial innovation processes. The choice of a second-best solution would imply that the distance to reality remains unspecified and can even fluctuate for every firm-size class within the same sector.

On the other hand, by giving up some of Schumpeter's definitions for innovation, like "conquest" of new sales and procuring markets, research sacrifices the measurement of the innovation activity of flexible and dynamic small enterprises. Then, empirical innovation research would be better off with indicators which concentrate on informal innovation activities (Kleinknecht 1987).

2. The problem of databases

Apart from those databases, which for reasons of practicability only include the largest enterprises and their innovation activities, in the following, the databases of the NSF, the Stifterverband, and the Science Policy Research Unit will be examined because of their relevance in literature. Summarizing, Schmidbauer writes about the NSF statistic:

- The NSF interviews all enterprises with thousand or more employees and takes only a sample of the enterprises with less than thousand employees.
- R&D is only included when it is institutionalized in the enterprise; research which is done "incidentially" is not taken into account.
- Private R&D expenditure is probably overestimated, when projects initiated by the enterprises are carried out in places which are supported by public orders. The likely result is a systematic overestimation of private R&D expenditure by large enterprises.
- The NSF data do not include expenditure for joint research which is a domain of small enterprises (Schmidbauer 1974, p. 554 ff.).

The data of the Stifterverband are burdened by a lack of constancy and changing representation. In 1965, when annual surveys changed to bi-annual surveys, the fluctuation rate, particularly of small and medium-sized enterprises, grew (Kamp/May 1981, p. 356 ff.); therefore, in the years 1973, 1975, and 1977 up to 40% of the surveyed enterprises of this firm-size class changed. From 1979 on, supplementary personnel-cost data were included, particularly for small and medium-sized enterprises; the result was that an additional 8.5% of these enterprises with up to 1,000 employees and only an additional 1.2% of enterprises with more than 1,000 employees were captured, compared with the share of employees in 1977 (Stifterverband 1985, p. 18). It has to be considered, however, that, by ending the supplementary personnel-cost programme, the usability of this statistic for small enterprises has been further put into question.

One of the most well-known data bases on innovation is the SPRU-sample (Pavitt et al 1987). It contains 4,378 innovations between 1945 and 1984 which have been identified as "significant technical innovations" by about 400 experts. Whereas the authors themselves question whether their data are representative, - "It is difficult to prove that such wide consultation has overcome bias towards innovations in large firms." (Pavitt et al 1987, p. 299) - it can be almost taken for granted that small and medium-sized enterprises describe their innovations as less important in order to keep big companies away from growing markets (Kassai 1987, p. 286). Therefore, they are represented in this database to a lesser extend.

Recently, in the United States the so-called "compustat files" have been used (Bound et al 1984; Sullivan 1983), whose composition is shown in table A2 (in the appendix). It is a database which includes, among others, turnover, employees and R&D data of enterprises of the manufacturing industry.

The problem whether the data are representative for small and medium-sized enterprises arises here, too, because of entry conditions for this firm-size class. According to Bound et al, only those small enterprises are included which have proven their success in recent years by growth, going public, etc, i.e. enterprises which are successful per se and probably "over-innovative", so that they are not representative.

Finally, it seems to be very difficult to find a database which is representative for both large and small enterprises regarding innovation. Kleinknecht recently tried to calculate the neglect of small and medium-sized enterprises in R&D statistics in an empirical analysis in the Netherlands. The comparison between the 1,842 enterprises of his study and the results of the OECD concerning the variable R&D staff shows that the share of large enterprises in the economy's R&D expenditure diminishes from 91% (official study) to 82.4% (comprising enterprises employing more than 50 people), respectively to 77.3% when enterprises with 10 to 49 employees are considered as well (table 4).

Hence, empirical research on innovation seems to have disadvantages, particularly for small and medium-sized enterprises, with the result that their innovations are captured only rudimentarily. If one does not want to concentrate on medium-sized enterprises (up to 500 employees) only, an empirical comparison between enterprises of different size classes is only possible with great restrictions.

Table 4: **Capture Accuracy of Official R & D Statistics of Small and Medium-Sized Enterprises** (KLEINKNECHT 1987, p. 254)

R & D Man years in 1981 and 1983					
	According to offical survey in 1981		According to our most cautions extrapolation (with downward bias)		
Firm-Sizes (employees)	Man-years	Percentages	Man-years	Percentages	
10 to 19	n.a.	n.a.	534	2.2	
20 to 49	n.a.	n.a.	967	4.0	
50 to 99	301	1.2	903	3.7	3.9
100 to 199	650	2.7	1,386	5.7	6.1
200 to 499	1,228	5.1	1,745	7.2	7.6
500 and more	21,992	91.0	18,839	77.3	82.4
Total	24,171	+ 100.0	24,374	+ 100.0	+ 100.0

3. Some remarks on empirical methods

When examining the correlation between firm-size and innovation, a causality from the first to the latter is assumed (short-term perspective); however, the reverse or a delayed influence between the variables cannot be excluded, neither a priori nor a posteriori. "Studies of feedback from innovation to industry structure have called attention to the problem of relating hypothesized causality to the results of regression analyses" (Baldwin/Scott 1987, p. 103/104). While simple regression analyses often neglect this problem, reverse causalities have been emphasized recently, particularly theoretically (Nelson/Winter 1982) and empirically (König/Zimmermann 1985). Besides, the endogenity of the variables has drawn much attention; especially their dependence on third variables has been discussed. "The theoretical reasoning ... suggests that in the long run both, the structure of a given industry and inventive activity are endogenous and that both depend on more basic characteristics such as demand conditions, nature of capital market ..." (König/Zimmermann 1985, p. 1; see Reinganum 1984; Gerybadze 1982, p. 99; Nelson/Winter 1982). Meanwhile, these theoretical considerations resulted in empirical studies that did not dis-

Table 5. **Highlights of Representative Empirical Tests of the Schumpeterian Hypothesis** (SULLIVAN, E.J. 1983, p. 46-49)

Industry Studies -- Listed by Year of Publication	Principal Analytical Technique	Control for Heteroscedasticity	Inclusion of Non-Size Variable	Principal Findings
HAMBERG (1964)	Rank correlation and Linear regression	Logarithmic specification	None	R&D employment increases more rapidly than total employment in 3 of 17 industrial groups tested
COMANOR (1965)	Non-Linear regression with quadratic term	Deflated measures of technical change and R&D by a size variable	Diversification and interaction variables significant. Interaction variable (R&D employment x sales) introduced to pick up separate effects -- problems of increased organization and overall size effect -- e.g. better marketing	There are substantial diseconomies of scale in R&D in the drug industry
SCHERER (1965)	Non-Linear regression with cubic term	Regressions also run using a semi-logarithmic specification	Diversification variable -- not significant	Inventive output increases with firm size, but generally at less than a proportionate rate
COMANOR (1967)	Linear regression	Logarithmic specification	None	The elasticity of R&D employment is never significantly greater than 1 and it is less than 1 in 7 of the 21 industry groups.

VERNON & GUSEN (1974)	Non-Linear regression with quadratic term	-	Diversification variable insignificant. Interaction variable significant	Larger drug firms are more effective in bringing about technical change.
MANSFIELD (1977)	Non-Linear regression with cubic term	-	None	Maximum occurs at the size of the largest firm for product innovations and at about the size of the seventh or eighth largest for process innovations.
SOETE (1979)	Non-Linear regression with cubic term	-	None	Global results support Schumpeterian hypothesis but industry results mixed
FREEMAN (1982)	Rank ordering for each of three size categories	-	None	Overall small firms proportionally less innovative than large firms. But small firms more than proportionally innovative in a few industries

V. Conclusions

Our survey showed that it is difficult, for the time being, to find definitions of innovations, which are meaningful for both large as well as small and medium-sized enterprises. On the contrary, our initial suspicion has increased, that definitions of innovation activity used in the literature can be easier applied to large enterprises, respectively that they can be used for small and medium-sized enterprises only to a limited degree or not at all.

The correlation between firm-size and innovation in the sense of the neo-Schumpeterian hypothesis and as a theoretically maintained correlation lacks a basis insofar, as particularly Schumpeter proves to be most unsuitable to support this hypothesis, while "free interpretation attempts" of his disciples turn his theory into something, which later not only becomes the foundation of empirical innovation research but also the argumentation basis for governmental support for research done by large companies in industrialized countries.

Finally, this perspective is proved by empirical research. The choice of indicators discriminates against cases of informal innovation within smaller enterprises, and favours data which can be systematized and have been collected for a long time, i.e. innovation activity in large enterprises is preferred. Furthermore, databases tend to neglect small enterprises because they either set the lower limit for the firm-size too high, the intervals between the surveys too long, or the entry conditions for small and medium-sized enterprises too strict.

In order to improve the representation of this firm-size in the innovation statistics, we agree with Kleinknecht: "..., we are able to say that there is a real need to improve the present R&D surveys and that this can be achieved by altering the survey methods so that more account is taken of the specific organizational settings of R&D in small firms. This would imply first of all a radical simplification of survey questionnaires" (Kleinknecht 1987, p. 256).

In the end, the correlation between firm-size and innovation also depends on the quality of empirical methods. Particularly the uncertainties concerning the causality and its direction catch the eye, but also the problems of specifying the "u-term" and its distribution.

If and to what degree the correlation between firm-size and innovation in fact exists, or if it is just a "Fata Morgana" of innovation researchers, can be proved only, when more innovative methods to measure innovation have been invented and introduced. Some stimulus has been given, here.

Appendix

Table A1: **Innovative Advantages and Disadvantages of Small and Large Enterprises**
(BESSANT/GRUNT 1985, p. 310)

Small Firms	Large Firms
Marketing	
Ability to react quickly to keep abreast of fast changing market requirements. (Market start up abroad can be prohibitively costly.)	Comprehensive distribution and servicing facilities. High degree of market power with existing products.
Internal Communication	
Lack of bureaucracy. Dynamic, entrepreneurial managers react quickly to take advantage of new opportunities and are willing to accept risk.	Professional managers able to control complex organisations and establish corporate strategy. (Can suffer an excess of bureaucracy. Often controlled by accountants who can become mere 'administrators' who lack dynamism with respect to new long term opportunities.)
Qualified Technical Manpower	
Often lack suitably qualified technical specialists. Often unable to support a formal R&D effort on an appreciable scale.	Ability to attract highly skilled technical specialists. Can support the establishment of a large R&D laboratory.
External Communication	
Often lack the time or resources to identify and use important external sources of scientific and technological expertise.	Able to 'plug in' to external sources of scientific and technological expertise. Can afford library and information services. Can subcontract R&D to specialist centres of expertise. Can buy crucial technical information and technology.
Finance	
Can experience great difficulty in attracting capital, especially risk capital. Innovation can represent a disproportionately large financial risk. Inability to spread risk over a portfolio of projects.	Ability to borrow on capital market. Ability to spread risk over a porfolio of projects. Better able to fund diversification into new technologies and new marktes.

Economics of Scale and the Systems Approach	
In some areas scale economies form substantial entry barriers to small firms. Inability to offer integrated product lines or systems.	Ability to gain scale economies in R&D, production and marketing. Ability to offer a range of complementary products. Ability to bid for large turnkey projects.
Growth	
Can experience difficulty in acquiring external capital necessary for rapid growth. Entrepreneurial managers sometimes unable to cope with increasingly complex organisations.	Ability to finance expansion of production base. Ability to find growth via diversification and acquisition.
Patents	
Can experience problems in coping with the patent system. Cannot afford time or costs involved in patent litigation.	Ability to employ patent specialists. Can afford to litigate to defend patents against infringement.
Government	
Often cannot cope with complex regulations. Unit costs of compliance for small firms are often high.	Ability to fund legal services to cope with complex regulatory requirements. Can spread regulatory costs. Able to fund R&D necessary for compliance.

Table A2: **Content of Compustat Files in 1976**
(BOUND et al 1984, p. 24)

Compustat File	Manufacturing Firms on Compustat Tape	Gross Plant Reported in 1976	Positive Gross Plant & Sales in 1976	Positive R & D
Industrial	1,299	1,294	1,248	770
OTC	489	472	458	292
Research	414	138	132	83
Full coverage	1,019	867	757	347
Total number of firms	3,221	2,771	2,595	1,492

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