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The German Mechanical Engineering Industry and the NIFA-Panel[1]

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1. An overview of the project

On January 1, 1989 a large-scale interdisciplinary research project funded by the Deutsche Forschungsgemeinschaft (DFG) involving engineers and social scientists from a variety of subfields like economics, sociology, political science and psychology began. This date was also the birthday of the NIFA-Panel. The overarching goal which brought together an interdisciplinary group of scientists based at the Ruhr-University in Bochum was to study the potentials of semi-autonomous flexible production systems to make firms and companies of the German mechanical engineering industry more competitive. The specific task of the panel study was to collect data on firm level with respect to the options and restrictions involved in implementing these modern production systems. In addition, the panel was asked to monitor the diffusion process of computer-based production technologies, concepts of work and firm organization like teamwork and other components of the "lean production philosophy" in the industry. Table 1 presents an overview of the major themes the panel has covered.

Table 1

The NIFA Panel 1989 – 1999

Central Topics
- Production Technology
- Work Organization and Team Work
- Firm Organization
- Corporation among Companies

[1] NIFA is an acronym based on the title of the research project funded by the DFG: „Neue Informationstechnologien und Flexible Arbeitssysteme" (New Information Technologies and Flexible Work Systems).

While the interdisciplinary research project – also known as Sonderforschungsbereich 187 – was closed at the end of 1995, the panel received funding until December 31, 1999. During the eleven years of funding eight yearly panel waves, starting in 1991 and ending in 1998, have been completed. From 1993 on firms and companies located in Eastern Germany have been included in the sampling base. After a thorough discussion it was decided to conduct the surveys on the basis of a questionnaire sent by mail. The size of the questionnaire was limited to 12 pages for all panel waves. The project team essentially followed the "total design method" as suggested by Dillmann (1978) in order to receive feedback from as many firms as possible. The questionnaire was sent out to all firms and companies with twenty or more employees in the industry. This decision was made because the questions asked were focussed on industrial conditions and not suited for a craftsman type of environment in small businesses. Our sampling base (population) consisted of addresses of firms and local branches of larger companies held by the Bundesanstalt für Arbeit (Federal Labour Office). All firms and companies with at least one employee are required by law to report their addresses and other statistical information to the Bundesanstalt. Therefore it is a rather reliable data base which allows to compare sampling distributions of certain variables with their distribution in the population (for example the number of employees), thereby assessing the quality of the sample obtained. Between 6000 – 7000 questionnaires have been sent out every year to all firms with twenty or more employees listed in the data base. The size of the self-selecting sample the project was able to realize every year varied roughly between 1500 and 1600 filled-in questionnaires – in other words around 25% of the population. Over the eight panel waves more than 5000 firms responded at least once. 250 participated in each of the eight waves. For 1000 firms and companies data are available at least for two years (consecutive or with longer intervalls). It should be mentioned that the population changed over time: the Bundesanstalt updates the data base every year by eliminating the firms which have been gone out of business and by including those which have been newly established in the past year. Our population received another dynamic element from the fact that growth and down-sizing processes could bring firms over or under the threshold of 20 employees. These dynamic changes of the population have to be taken into account when evaluating the stability and size of the sample over time. Clearly other factors like the written form of the survey also contributed to higher drop-out rates compared with personal interviews.

For all samples it is crucial to test whether the non-respondents have characteristics systematically related to the topics of the survey or whether they are randomly distributed. While the samples obtained quite nicely

match known parameters of the population like the number of firms within a defined range of employment, this result does not tell anything about the crucial question whether the non-responding firms have, for example, less computer-aided production technology or are less inclined to adopt lean production strategies in reorganizing their production processes. In order to answer this question we made several efforts to get relevant information on our non-responding firms. With a minimal questionnaire on a postcard and additional telephone calls we were able to reach about 90% of a sample drawn from the list of non-respondents. The results have been quite reassuring: compared with the firms in our sample we could not find systematic differences with respect to crucial variables.

Table 2 summarizes the key methodological aspects of the NIFA Panel.

Table 2

The NIFA Panel 1989–1999

Methodological Features
Mail Questionnaire
Classical Panel (8 Waves)
Sampling Base: appr. 600 Companies
Realized Interviews: appr. 1500 per Wave

2. Concepts and their operationalizations: a closer look at the data base

As mentioned above, the NIFA-Panel was set up to monitor technological and organizational changes in the German mechanical engineering industry. The theoretical concepts which constitute the basic design of the questionnaire stem from industrial sociology, organizational theory and institutional economics. Operationalizations of these concepts together with general information about the firms (like number of employees, ownership, turnover and utilization of computer-aided production technology) represent the core of panel questions which were repeated every year or in longer intervalls. In addition to these core questions specific topics have been included on a cross-sectional basis. In the following I will concentrate on the core set of concepts and how they have been measured.

In industrial sociology there exists a lengthy discussion on the concept of division of labour which has its roots in the debate on Taylorism. According to a number of authors – most prominent Kern / Schumann (1984) – the tay-

loristic strategy to control the output of employees by dividing labour into extremely limited tasks was only successful during the period of mass production of relatively simple products. After entering the period of so-called quality production in the seventies new concepts of work organization were demanded. Now the employer should make use of the full professional skills of the individual employee and no longer treat him as a "robot". A substantial reduction in the division of labour both on individual workplaces and among subdivisions of firms and companies was asked for. The panel reacted to that debate by including variables which measure the degree of autonomy individual workers have in organizing their work and to what degree their job was enriched by additional tasks carried out by specific units or subdivisions under the tayloristic system (e.g. programming lathes or maintaining machinery). The most prominent organizational strategy to reach the objective of a reduction in both professional and functional division of labour was and still is the introduction of teamwork (Gruppenarbeit). Teams are set up to take over responsibility for the production of a whole product or individual components of it. Within certain limits the team members are given the freedom to organize their work in a semi-autonomous way as long as they achieve a defined output. It was of peculiar interest to the panel group how the concept of teamwork would spread in the industry and what principles would guide their operation.

Another of the basic theoretical assumptions of the panel was derived from organizational theory – more specifically from contingency theory. Following the pioneering work of Woodward (1965), Lawrence / Lorsch (1967) and others we assumed that technology and environment have a major impact on organization. In the case of the German mechanical engineering industry this meant to survey the technological constraints of the production process and the specific market conditions very carefully. We therefore included variables like average batch size, weight of specific manufacturing techniques and number of customers.

After the closing of the "Sonderforschungsbereich" interests shifted to a certain degree away from technical questions (for example computer-aided manufacturing) to issues of organizational restructuring and interorganizational cooperation or networking. Theoretically this shift was guided by institutional economic theory. Following Coase (1937) Williamson (1975) argued that the efficiency of transactions is highly dependent on their specificity and the institutional setting in which they are conducted. Basically he argues that highly specific transactions characterized by infrequency of occurence and other elements are more efficiently carried out under hierarchical control within an organization. The less specific and the more frequent transactions are, the more they can be conducted in a market type of environment. Of course, most transactions are of an in-between nature which

requires according to Williamson so-called hybrid forms of organization. Networks would be an example of such a hybrid form. Consequently the project tried to measure the involvement of firms and companies in various forms of cooperation and networking. The degree of outsourcing production represents another indicator which tries to capture the efforts undertaken by firms in making their transactions more efficient.

3. Project documentation and studies undertaken to date

Extensive documentation on the project is available on a CD which is included in a recent book publication edited by the author of this report.[2] The CD contains information on the history of the project, its theoretical foundations, the methods employed and reports key results in four areas: production technology, work organization, firm organization and cooperation with other firms. In addition basic data on the mechanical engineering industry are provided. Publications and cooperations with other projects are also documented. Finally the CD displays all questionnaires used by the project and includes reprints of the free of charge periodical "Mitteilungen für den Maschinenbau" which was designed to guarantee feedback of results to the respondents resp. the potential respondents. 21 editions of this periodical have been produced. In our view, the CD represents an encompassing and comprehensive documentation of the project. However, it does not contain the data base itself which is available through other media. I will come back to that question shortly.

The project has produced several books. The last book (which contains the CD) includes articles of members of the project team presenting central findings as well as contributions by scientists and experts external to the project. The basic idea was to broaden the analytical perspective beyond the focus of the panel project. Consequently also representatives from interest organizations (employer associations, unions) and consulting firms have been asked to contribute chapters. In general terms the message of the book is that restructuring processes in the mechanical engineering industry during the last decade produced rather moderate outcomes in comparison with other industries. This slower pace has to do with the prevailing production technology, the specific market conditions and the small size of firms which characterize this particular industry. Another problem is ownership. Roughly 80% of the firms and companies are owned by private persons. Personal owners of smaller firms – in most cases also the top managers – tend to be more "conservative" with respect to reorganizing their business pro-

[2] Ulrich Widmaier (Hrsg.): Der deutsche Maschinenbau in den neunziger Jahren. Kontinuität und Wandel einer Branche, Campus Verlag, Ffm 2000.

cesses and are less inclined to engage in stable cooperations and networks with other firms. Obviously they are afraid of giving up the relative autonomy they are still enjoying.

The panel data have also been used quite extensively by scientists working at other institutions (see project documentation on CD for a complete list). I will briefly mention three examples. Manfred Fleischer (1997) from the Science Center Berlin looked at a subset of the data: the machine tool industry. His analysis demonstrates that German machine tool manufacturers have a high risk to be caught in an inefficiency trap. Very special products (machines) for a small market segment with only a few customers require labour intensive production which tentatively increases the prize of products because economies of scale cannot be realized. This in turn could limit the number of customers even further thereby ending in a vicious circle.

Less pessimistic are the results of an analysis of the panel data undertaken by Michael Kleinaltenkamp (2000). He finds that there is considerable leeway for standardizing products and processes. But since the German mechanical engineering industry is extremely customer oriented such efforts cannot neglect individual needs of customers. The optimal mix between standardization and individualization varies from company to company and is due to changing technology and market conditions which are not stable over time.

A project undertaken by the Akademie für Technikfolgenabschätzung in Baden-Württemberg (Kerst / Steffensen, 1995) demonstrates the potential of the panel for regional analyses. The authors have been interested in the specific features of the mechanical engineering industry in Baden-Württemberg. Their initial hypothesis was that the firms and companies in Baden-Württemberg would be ahead of those in the rest of Germany with respect to cooperations, modern production technology and "lean" forms of work and business organization. This general hypothesis was not supported by the data. The industry in Baden-Württemberg does not differ significantly from the firms in the rest of Germany. However, the authors were able to identify one significant factor: the higher degree of involvement in modernization programs supported by public funds. This result suggests that the state is an important actor in that particular region. At the same time it also demonstrates that the effectiveness of these programs in promoting modernization processes is limited.

4. Data access

The complete data set is available to the scientific community through the Zentralarchiv für Empirische Sozialforschung (Archives for Empirical Social Research) at the University of Cologne. Address and other details can again be found on the CD. Regulations for acquiring the data including codebooks from the Archives are listed on its web-site www.za.uni-koeln.de. All variables except regional / local identification (postal code) are available in their original code. No recoding or sampling of cases was applied. Because data are converted into an SPSS (Statistical Package for the Social Sciences) system file format variable definitions and other information are included in the data-set itself.

5. Using the data for research and teaching

There are in principal two ways to analyze the data. From a cross-sectional perspective each wave can be treated separately which allows, for example, to compute percentages or means for different years on the basis of a relatively large sample in order to look at developments over time. This strategy would rest on the assumption that each cross-section is a representative sample of the underlying population. In other words parameters which are computed on the basis of the sample are an unbiased estimator of the true value in the population. However, such assumptions can only be made for actual random samples. The cross-sectional samples of the NIFA panel are generated by a process of self-selection which is not random in a strict sense. Even when known parameters of the population are relatively well matched by the sample (e.g. distribution of firm size) this does not guarantee that there is no bias in the sample and – more important – that it will be the same for all cross-sections. Analyzing the data as time-series allows to look at the development of individual firms over time and compute aggregate statistics on that basis. The disadvantage of this strategy is that the number of cases availabe for statistical analysis drops substantially depending on how many time points one wants to include (to 250 when all 8 waves are included). This restricts the options for multivariate analysis and increases the bias of the sample. The sample is more biased because a panel survey with specific topics like ours produces a positive selection process over time in the sense that firms which have restructured their organization and modernized their technology will find it more rewarding to fill in the questionnaire compared to those which have not.

Since the NIFA data are available for analysis to the public through the Zentralarchiv there are also no restrictions in using them for teaching pur-

poses. However, in order to fully benefit from working with the data-set students have to be familiar or make themselves familiar both with the relevant literature in industrial sociology, organizational theory, institutional economics and the statistical techniques to analyze primarily categorical panel data. The techniques included in the Statistical Package for the Social Sciences (SPSS) provide sufficient options at least for beginners. With respect to theory, the reading available on the CD-ROM and the book referenced in footnote 2 should supply students with more than just introductory information.

6. An invitation to the scientific community

Aside from the modest user fees charged by the Zentralarchiv to scientific users there are virtually no other restrictions in employing the NIFA dataset for studies to be undertaken by the scientific community except a lack of interest in the conceptual topics covered by the panel and / or the methodological instruments necessary to analyze the data. Those who think that a genuine interest in the German mechanical engineering industry is a precondition for considering the data as a research tool should be told that the analytical value of the data stretches substantially beyond its empirical focus on that particular industry and country. The German mechanical engineering industry with its predominantly medium and small sized firms represents the core of the investment goods industry where the substantial technological and organizational challenges firms and companies face in the process of globalization can be studied in a nutshell. Therefore the dataset provided by the NIFA Panel should be attractive to all colleagues and scholars interested in the technological change and the organizational restructuring which occured in the last ten years in firms and enterprises. The specific features of the mechanical engineering industry with respect to production technology and market structures should make such a project even more interesting. In that sense, I would like to invite everybody interested in such exciting research questions to order the data and start to look at them. For further questions on the project and the data-set do not hesitate to contact me at **uw@pw2. ruhr-uni-bochum.de.**

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