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Incentives for employed inventors: An empirical analysis with special emphasis on the German law for employees' inventions

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No. 345

*Incentives for Employed Inventors:
An Empirical Analysis with Special Emphasis on the
German Law for Employees' Inventions*

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I. Introduction

In a rapidly changing environment, companies have to meet an steadily increasing demand on their inventive capacity. Inventive and innovative potential of a company are largely determined by its R&D activities. R&D is defined here as systematic creative activities, aimed at generating new scientific knowledge or new applications for products and processes.¹ The output of industrial R&D significantly depends on the creative potential of its R&D personnel. This may be enhanced by particular motivation. Badawy (1988) states that "technical professionals are not only an R&D organization's greatest asset but its most expensive one"². Therefore, it is essential to build an effective system for the use of these human resources in order to achieve and secure inventiveness in an technical organization. One key element of effective human resource management is the establishment of an incentive system, which activates and supports the full potential of the R&D staff. The management challenge is the creation of conditions conducive to meeting the corporate goal of productivity and profitability, as well as R&D personnel's needs for satisfaction and motivation. In some countries special legal provisions were taken to support this management task by securing the employed inventor a share in the proceeds that the firm earns from the invention.³ This study investigates the role of the German Employees' Inventions Law, enacted in order to encourage inventiveness and to enhance motivation of employed inventors, which should result in higher R&D performance. In the second part of the study, an experimental design is presented that helps to measure the individual preferences of R&D professionals with respect to certain incentive variables. Especially, the motivation potential of monetary versus non-monetary incentives will be tested, since the literature on this topic presents somewhat conflicting results.⁴ The paper will close with managerial implications and some concluding remarks.

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- 1 see Brockhoff, K., (1992): *Forschung und Entwicklung, Planung und Kontrolle*, 3rd ed., München/Wien.
 - 2 Badawy, M. K., (1988): *Managing Human Resources*, in: *Research Technology Management*, Vol. 31, p. 19.
 - 3 between 80 and 90% of all patented inventions in Germany are made by employed inventors; see German Patent Office, *Annual Report*, several years.
 - 4 see, e. g., Ellis, L. W., Honig-Haftel, S., (1992): *Reward Strategies for R&D*, in: *Research Technology Management*, Vol. 35, No. 2, pp. 16-20; Smayling, M. M., (1987): *Incentive Systems for Research and Development Scientists and Engineers*, Diss., University of Minnesota. For Germany, see, e. g., the results of Brockhoff, K. von Ghycsy, T. G. J., Wilhelm, W., (1988): *Die Triade im Test*, in: *Manager Magazin*, No. 11, pp. 218-229; Domsch, M., (1984): *Anreizsysteme für Industrieforscher*, in: Domsch, M., Jochum, E. (Hrsg.): *Personal-Management in der industriellen Forschung und Entwicklung (F&E)*, pp. 249-270.

II. Institutional Framework

II. 1. Compensation for Employed Inventors

The compensation of employed inventors over and above their regular salary is regulated differently in various countries. In Germany, for example, it is defined by law, whereas in other countries, such as the U. S., it is usually determined by employment contract. The following chapter gives a short overview of these legal guidelines as they exist in Germany and compares these with the situation in other countries.

II. 1. 1. Legal Framework in Germany

In Germany, the relations between employees and employers are regulated by law in the so-called Employees' Inventions Act, which dates from the year 1957.⁵ In its origins it goes back to a government decree of 1942. The Employees' Inventions Act contains more than 40 sections and gives guidelines as to what is considered adequate remuneration. Due to the complexity, only the most important provisions need to be discussed here.

The German Act is applicable to all enterprises under German law including German affiliates of foreign companies. Moreover, the Act also pertains to foreign nationals employed by a German company. The law is primarily concerned with inventions capable of being protected by Patent Law or by Utility Model Law (see § 2). The Act also applies to those improvement suggestions which are not patentable but give the employer a similar monopolistic position (see §§ 3 and 20). However, these suggestions have not gained practical importance and several patent attorneys in Germany recommend that these suggestions should be deleted.⁶ To summarize, the Act is concerned with legal and factual monopolies that arise from technical field inventions or improvements. It provides compensation for that to the originator, but not for other meritorious acts of the employee.

The German Employees' Invention Act distinguishes between two kinds of employees' inventions: the service invention, and the free invention (see § 4).

Service inventions are defined as inventions made during employment as a result of activities that are part of the usual contractual responsibilities of the

⁵ "Gesetz über Arbeitnehmererfindungen vom 25. Juli 1957", Bundesgesetzblatt I.

⁶ comp. K. J. Heimbach, (1992): Law and Practice of Employee Inventions in Germany, Paper presented at the WIPO Symposium on Employee Inventions, Bucharest, Romania, October 6 and 7, 1992, Geneva, 1993, p. 36.

employee in the enterprise. All other employees' inventions are free inventions. The employee is obliged to report any service invention to his employer without delay (see § 5). Within four month upon receipt of the invention report the employer may acquire all rights to the invention by an unrestricted claim made by a written declaration to the employee . By a restricted claim made within the same time period the employer can acquire a non-exclusive right to use the invention (see §§ 6 and 7). A service invention becomes a free invention if the employer releases it or does not claim it without restrictions in due time. As soon as the employer claims the unrestricted use of the invention, the employee is entitled to an adequate and reasonable compensation. For a claim of restrictive use, the employer is required to pay only in case of actual use. The following chapter gives more details of how "adequate remuneration" is to be interpreted.

II. 1. 2. Compensation Guidelines

Concerning the amount and calculation of the inventor's compensation the law simply states that it has to be reasonable, and to be based on the commercial exploitability of the service invention, the contractual duties and the position of the employee in the company, and the company's contribution to the invention. Detailed methods for the calculation are suggested in the "Guidelines for the Compensation of Employees' Inventions in Private Enterprises", issued by the Federal Minister of Labour and Social Order in 1959.⁷ These guidelines give indications when a compensation is considered as reasonable. However, the guidelines are not legally binding. According to German jurisdiction, an inventor's remuneration has to be paid for each patent granted, whether used or not, as long as it is in force, and for each patent application which is used.

Without going into details, a short description of how the inventor's compensation is calculated follows:

The most common method to calculate the inventor's compensation is the "license analogy" method. The focus of this method is to calculate the invention value through comparison with a license fee which would have to be paid to a free outside inventor under comparable circumstances. The invention value has now to be reduced by a certain amount that reflects the companies own contributions. This is achieved by the so-called sharing factor.

The sharing factor itself is determined by three aspects:

- a) the degree of involvement of the employee in the formulation of the problem to be solved by the invention,

⁷ "Richtlinien für die Vergütung von Arbeitnehmererfindungen im privaten Dienst vom 25. Juli. 1959", Bundesanzeiger Nr. 156.

- b) how the employee solved the problem,
- c) the responsibilities and the hierarchical position of the employee in the enterprise.

The more the normal responsibility involves inventions and the higher the position of the inventor is placed in the hierarchy, the smaller is his sharing factor. The calculation of the inventor's compensation seems to be quite simple but only at first sight. One important problem arises with the fact that inventions are often made jointly by several persons in a team project. It is then to determine the correct share of each inventor in the invention. Another problem is to estimate the share of a particular patent in a product that is based on several patents. Moreover, it is difficult to identify all the products covered by a certain patent. In cases where employed inventors and employers disagree on the sharing rules, disputes arise. They may be brought before a board of arbitrators, which was established at the German Patent Office.⁸ The arbitration board is not a tribunal that releases orders and passes decisions but its role is to propose agreements. If the arbitration is without success, the parties can go to court. Otherwise, in the absence of objections from the concerned parties, its suggestion becomes legally binding.

II. 1. 3. International Comparison

Many Western European nations have enacted statutes to protect the rights of employers and employees. These laws differ in several ways, but they all divide employees' inventions into two general categories: service inventions and free inventions (comp. II. 1. 1.). Germany's statute, however, is the most comprehensive of the Western European Employees Invention Laws. It covers not only inventions that are kept as trade secrets or that are actually patented but it also extends protection to technical improvement suggestions that are not eligible for patent filing. Furthermore, guidelines on adequate compensation for employee inventions were formulated. This chapter gives a comparative description of compensation practices in three other nations: the U.S. , Japan, and Great Britain.⁹

⁸ for a detailed report on the activities of the arbitration board, see German Patent Office, Annual Report, several years.

⁹ for a comparable study of Employees' Invention Laws in industrial countries, see for example Rebel, D., (1993): Handbuch Gewerbliche Schutzrechte: Übersichten und Strategien Europa-USA-Japan, Wiesbaden. For a detailed study of European Employed Inventors Acts, see also Steckelberg, W. R., (1979): Compensating Employed Inventors in Europe, in: Research Management, Vol. 22, No. 4, pp. 28-31; Kommission der Europäischen Gemeinschaft, (1978), Vergleichende Untersuchung über das Recht der Arbeitnehmererfindung in den Mitgliedsstaaten der Europäischen Gemeinschaft, Brüssel; U.S. Senate, Committee of the Judiciary, (1963): The Laws of Employed Inventors in Europe, Washington, D. C.

Whereas most industrial countries protect employees' patent rights by law, U.S. companies generally require pre-employment contracts that turn over the rights to these inventions to the employer. Furthermore, in the U.S. no special compensation is required for the assignment of an employee's invention to an employer. To encourage inventiveness, however, most American companies offer special rewards programs. These rewards programs usually offer financial rewards and rewards of a more ideal value to the employed inventor.¹⁰

In Great Britain, a new Patents Act came into force in 1978 (Patents Act 1977). It contained provisions on the compensation of employed inventors. They are entitled to a share of the benefits resulting from "outstanding" inventions for which they are responsible. The new legislation made no major changes in the conditions of ownership of inventions. The Act clearly specifies that an invention belongs to the employer when it was made as part of the employee's normal duties or when conditions of the employment were such that the employee could be expected to further the interests of the employer. A significant change, however, was made in the compensation of the employed inventor. In the case of an employee-owned invention, the companies may no longer remove the inventors' common law rights through employment contracts. In the case of an employer-owned invention, the employee is now entitled to a "fair" share of any outstanding benefits flowing from the patent. In this case, the Act also provides the guidelines for calculating this share. One major problem of the present Patent Act is the definition of what is understood by an "outstanding benefit to the employer".¹¹ Littler and Pearson (1979) conducted a questionnaire survey among a sample of *The Times* Top 1000 companies in order to examine industry's opinion on this problem and the reactions to the Act.¹² They found that the reactions in industry were generally unfavorable. Among the concerns expressed were, for example, that the Act would encourage secrecy among R&D professionals and that it singles out only one group of individuals, namely the inventors to the exclusion of others working in an inventive capacity. Most companies had problems in taking adequate steps to meet the requirements of the new law. They had to consider how they intent to interpret the "fair share" and "outstanding benefit" clauses.

¹⁰ a survey of compensation practices for employees' inventions in the US is given by Savitsky, T. R., (1991): Compensation Practices for Employee Inventions, in: *Journal of the Patent and Trademark Office Society*, 9/91, pp. 645-679.

¹¹ for more details, see Orkin, N., (1984): Rewarding Employee Invention: Time for Change, in: *Harvard Business Review*, Vol. 62, No. 1, pp. 56-57.

¹² comp. Littler, D. A., Pearson, A. W., (1979): Rewarding the Employee Inventor and the Patents Act (1977), in: *R&D Management*, Vol. 10, No. 1, pp. 29-32.

Japan's Patent Compensation Statute, enacted in 1959 as § 35 of the Japanese Patent Law, contains provisions quite similar to those in Western European countries. Compliance is voluntary, unlike in Europe, where it is mandatory. Most Japanese companies have adopted service-invention regulations proposed by the Japanese Patent Office, others have their own rules for compensating employee-inventors. Compared to European and American standards, the amount of compensation involved is rather small. "Nevertheless, in conjunction with employment practices that also reward innovative contributions, they (compensation guidelines) have had a noticeable effect on Japanese inventiveness. Within ten years of the law's enactment, the number of patent applications from Japanese citizens had more than tripled to well over 100,000 a year."¹³ However, it is questionable whether this mono-variable explanation should be taken at face value.

II. 2. Intentions of the German Law and their Evaluation

The Intentions followed by the German Law can be separated in two major aspects:

- a legalistic aspect to bridge the gap between two legal approaches,
- an economical aspect to encourage inventive activities.

The German Employees' Inventions Act was created as a social balance between the employer and the employee. On the one hand, the general German labor law assumes that the owner of a business is considered the owner of the product of that business, and that every employee owes a duty of fidelity to his employer. On the other hand, the law states that an invention originates with the inventor, who thus has the right to receive patent or utility model protection for the invention. The German Employees' Invention Act tries to bridge this legal conflict between patent and labor law in case of employee inventions.¹⁴

Additionally, when the German Employee's Inventions Act was introduced in 1957, two major economic objectives were targeted. First, the law was established to encourage inventiveness and to increase the rate of invention in the economy. Secondly, the compensation guidelines were expected to motivate inventors, which should lead to an increased work performance that in

¹³ Orkin, N., (1984): Rewarding Employee Invention: Time for Change, in: HBR, Vol. 62, No. 1, p. 57. See also Rebel, D., (1993): Handbuch Gewerbliche Schutzrechte: Übersichten und Strategien Europa-USA-Japan, Wiesbaden, p. 288.

¹⁴ comp. Hoffmann, F., Bühner, R., (1979): Die Vergütung von Arbeitnehmererfindungen aus betriebswirtschaftlicher Sicht, in: Die Betriebswirtschaft, Vol. 39, No. 4, p. 574.

turn should result in higher scientific output.¹⁵ To analyse the first objective of the German Act, i. e. to increase inventiveness in Germany, it is useful to evaluate patent data as a way of measuring inventiveness.¹⁶ By comparing German and US patent applications from the 1950's to the late 1970's, Manly (1978) states that the data does not support the assumption that legislation for compensating inventors, such as that in Germany, stimulates inventions, although rival influences on comparative activities are not studied in detail.¹⁷

The use of the Employee's Inventors Act as a motivational tool and its influence on the performance of the R&D personnel is evaluated in this empirical study. The investigation was performed in two steps: an exploratory sequence of interviews was followed by a questionnaire survey with an integrated experiment. First, 20 interviews were held with R&D personnel of various hierarchical positions, i. e. from junior researchers to R&D directors. Additionally, members of labor unions, directors of patent departments in different industries in Germany as well as independent patent attorneys were interviewed in order to analyse their opinions about the pros and cons of the German legislation concerning the compensation of employed inventors. The perception of the Act and its motivational potential was generally rated quite negative. To put this evaluation on a broader basis, a questionnaire was mailed to 390 R&D professionals in three different industries in Germany.¹⁸ 116 responses were received, which results in a response rate of 29,7%. The second part of the questionnaire contained an experiment which was designed to measure the preference of R&D personnel for different incentives, monetary and non-monetary incentives in particular. This experiment was conducted to test the hypothesis that the motivational potential of the law is low because R&D

¹⁵ comp., for example, Volmer, B., (1964): *Richtlinien über Vergütungen für Arbeitnehmererfindungen und Prämien für Verbesserungsvorschläge*, Beck'sche Kommentare zum Arbeitsrecht, München/Berlin; Volmer, B., (1958): *Arbeitnehmererfindungsgesetz*, Beck'sche Kommentare zum Arbeitsrecht, München/Berlin; Bartenbach, K., Volz, F.-E., (1991): *Gesetz über Arbeitnehmererfindungen*, Kommentar, 2nd ed., Köln et al.

¹⁶ Schmookler was among the first to use patent data to evaluate inventive activities, comp. Schmookler, J., (1966): *Invention and Economic Growth*, Harvard University Press, Cambridge, Mass. For a detailed discussion of the pros and cons of patent data as an output measure for R&D, see Basberg, B. L., (1987): *Patents and the Measurement of Technological Change: A Survey of the Literature*, in: *Research Policy*, Vol. 16, pp. 131-141; Griliches, Z., (1990): *Patent Statistics as Economic Indicators: A Survey*, in: *Journal of Economic Literature*, Vol. 28, pp. 1661-1707.

¹⁷ Manly, D. G., (1978): *Inventors, Innovators, Compensation and the Law*, in: *Research Management*, Vol. 21, No. 2, pp. 29-32.

¹⁸ the empirical study included the mechanical engineering, the electronic and the chemical, incl. the pharmaceutical industry. More than 80% of all employee-inventors in Germany work in these three industries.

personnel is more intrinsically motivated such that monetary incentives have little influence.¹⁹

III. An Experiment to Measure the Preference of R&D Personnel for Incentive Variables

III. 1. Structure of the Analysis

Our experiment was designed as a conjoint measurement exercise. Possible combinations of incentives are described on stimuli-cards; the interviewees are asked to rank-order these cards according to their subjective preference. From this ranking information it is possible to estimate individual preference functions. The relative importance of the incentive variables is measured both on the individual and on an aggregate level. Conjoint measurement method is a decompositional approach that is widely used in marketing. Its advantages are the following:

- the experiment is especially suited for a restricted set of relevant factors,
- it is possible to evaluate individual variables and trade-offs between them,
- a decompositional approach fits real-life decision-making processes quite well.

1. Relevant Variables and their Levels

The variables used in the experiment need to meet the following requirements:

- they have to be relevant and discriminating. In this study, the empirical relevance of our variables was established by the interviews which were held prior to the experiment.
- the variables should be independent of each other in order to avoid redundancy effects.
- the set of variables must be sufficiently small. Green/Srinivasan (1978) recommend a set of five to six variables, otherwise the interviewees will be confronted with an "information overload".²⁰

For each variable two levels were chosen in order to further constrain the complexity of the experimental design. It is important to note that in order to

¹⁹ for a discussion of intrinsic vs. extrinsic motivation and their influence on the working satisfaction, see Herzberg, F. H., Mausner, B. M., Snyderman, B. B., (1959): *The Motivation to Work*, New York.

²⁰ comp. Green, P. E., Srinivasan, V., (1978): *Conjoint Analysis in Consumer Research: Issues and Outlook*, in: *Journal of Consumer Research*, Vol. 5, pp. 103-123.

receive reliable empirical results, the values of the levels should "be made larger than reality but not so large as to be unbelievable".²¹ Our set of variables and their levels is described in Table 1.

Table 1: Variables and Levels

VARIABLE	LEVEL A	LEVEL B
Income Structure Relationship of guaranteed fixed income to maximum variable bonus depending on the inventive performance)	100% fixed; 0% variable	90% fixed; up to 20% variable
Independence / Autonomy Proportion of contract working hours which can be freely devoted to own R&D interests (in %)	5%	15%
Participation in Training Programs Number of training events (in days per year)	1-4 days	5-8 days
Income Increase Increase of fixed salary (in % per year)	0%	10%
Responsibility (Number of subordinate employees)	constant	increased

The experiment was conducted by mail. The scenario-cards directed to R&D personnel were randomly ordered with a varying sequence of variables and levels. For an example of a scenario-card see Appendix 1. A detailed description of how to perform the experiment was included in the questionnaire (see Appendix 2). The subjects were asked to consider the following situation: The director of the R&D unit intends to develop an incentive system. Therefore, he is presenting 9 different combinations of incentive menus. The R&D professionals were first asked to classify the cases using two preference categories and, second, to rank all scenarios according to their individual preference within each category. Of the 116 responses 98 could be included in the following evaluations.

²¹ Green, P. E., Srinivasan, V., (1978): Conjoint Analysis in Consumer Research: Issues and Outlook, in: Journal of Consumer Research, Vol. 5, p. 109.

2. *Experimental Design*

A set of five variables with two levels each would produce a full factorial design of 32 scenarios. Such a large number of scenarios would overload the interviewees and reduce the reliability of the results. Therefore, it was necessary to reduce the number of scenarios. Assuming that there are only minor interaction effects between the variables, an orthogonal main-effect design was created.²² This fractional design consisted of 8 scenarios, through which all main effects can be evaluated. A sufficient number of degrees of freedom remain, which avoids a common deficiency of conjoint studies, that of having too few or no degrees of freedom.²³ One additional scenario has been included in the analysis as a hold-out. Hold-out cards are not used to estimate the utility function. Instead, they serve as a check for external validity in comparing their actual versus their predicted preference values. Consequently, a set of 9 scenario cards results.

3. *Estimating the Utility Function*

After completing the collection of data, a model must be generated that transforms ordinal preference judgements (rankings) into part-worths of each variable level. In this study the most common model in conjoint measurement is used, namely the additive compensatory model of main effects.²⁴ The preference functions are normalized so that the sum of the absolute values of the part-values equals 100%. The empirical findings of this study are presented in the following chapter.

III. 2. **Empirical Results**

The main results of a conjoint analysis are the relative importance of the variables used in the analysis part-worths of the variable levels and, as a measure

22 Hahn, G. J., Shapiro, S. S., (1966): A Catalog and Computer Program for the Design and Analysis of Orthogonal Symmetric and Asymmetric Fractional Factorial Experiments, in: mimeo, GE-Report 66-C-165, New York. For a survey of the pros and cons of including interaction effects in the analysis, see Green, P. E., Srinivasan, V., (1990): Conjoint Analysis in Marketing: New Developments with Implications for Research and Practice, in: *Journal of Marketing*, Oktober, pp. 4.

23 Green, P. E., Srinivasan, V., (1990): Conjoint Analysis in Marketing: New Developments with Implications for Research and Practice, in: *Journal of Marketing*, Oktober, p. 5.

24 in this study the Conjoint Analyser program of Bretton-Clark, USA, Version 3 was used to estimate the preference function.

of the validity of the analysis, the adjusted R-squares (adj. R^2).²⁵ Part-worths can be used to create different segments of the respondents.

III. 2. 1. Aggregate Data

An overview of the aggregated empirical data is given in Table 2, showing the group statistics. Based on 98 valid respondents, the estimated group utility function has reached an adjusted R-square of 0.917, which indicates that the model does an exceptional job of fitting the data. Aggregated over all respondents, the variable that measures "Income Increase" potential receives the highest relative importance with 31.89%, while the variable "Participation in Training Programs" is given the lowest weight (11.72% relative importance). "Independence", "Responsibility" and "Income structure" as incentive variables are found in between these extremes with a relative importance of 20.48%, 19.52% and 16.39%, respectively (in parentheses, the standard errors are given).

Table 2: Group Statistics of the Conjoint Analysis

Number of respondents = 98	
Average adjusted Rsquare = 0.917 (SE = 0.029)	
Income structure - Indiv. Rel. Imp. = 16.39 % (SE = 1.52)	
100% fix; 0% var.	90% fix; up to 20% var.
-0.457 (0.087)	0.457 (0.087)
Income Increase - Indiv. Rel. Imp. = 31.89 % (SE = 2.08)	
10%	0%
1.324 (0.089)	-1.324 (0.089)
Participation in Training Programs - Ind. Rel. Imp. = 11.72 % (SE = 1.27)	
5-8 days	1-4 days
0.393 (0.062)	-0.393 (0.062)
Independence / Autonomy- Indiv. Rel. Imp. = 20.48 % (SE = 1.77)	
15%	5%
0.809 (0.078)	-0.809 (0.078)
Responsibility - Indiv. Rel. Imp. = 19.52 % (SE = 1.68)	
increased	constant
0.582 (0.100)	-0.582 (0.100)

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R-square is a measure of how well the model of the utility function fits the respondent data, in other words, it measures how much of the variance in the original data is captured by the utility function. It varies between 1.0 for a perfect fit to 0.0 for no relation. The adjusted R-square corrects the data for the bias of conjoint studies of typically containing relatively few degrees of freedom.

Furthermore, the part-worths of all variable levels are shown in the group statistics. The results cause no doubts that the monetary compensation foreseen by the German Employees' Inventions Act could not activate the motivation potential of R&D professionals. Monetary incentives have quite a strong importance for R&D personnel in industry.

The "distribution of preferred levels" which provides a way of examining the degree of heterogeneity or segmentation in the sample is illustrated in Table 3. For each variable, the Table displays the percentage of respondents that prefer each of its levels. The sum of the percentages for each variable equals 100%. Thus, for the variable "Income Structure" 29.08% of the respondents preferred having a fixed income of 100%, whereas 70.92% preferred having a relationship of 90% fixed income to up to 20% variable bonus. To prefer one of the variable levels means that the respondent has a greater utility than for the other level of the feature.

Table 3: Distribution of Preferred Levels

Income structure	
100% fix; 0% var.	90% fix; up to 20% var.
29.08%	70.92%
Income Increase	
10%	0%
92.35%	7.65%
Participation in Training Programs	
5-8 days	1-4 days
72.96%	27.04%
Independence / Autonomy	
15%	5%
88.27%	11.73%
Responsibility	
increased	constant
78.06%	21.94%

The degree to which these percentages differ from 0% or 100% indicates the degree of heterogeneity for each variable. There is greatest variability for the variables "Income Structure" (29.08% vs. 70.92%), "Participation in Training Programs" (27.04% vs. 72.96%), and Responsibility (21.94% vs. 78.06%). If respondents are heterogeneous, like in this study, using the group statistics as a way to summarize the results of the study is to be considered with caution. Therefore, it is more appropriate to create different segments (clusters) of respondents with more homogeneous preference structures.

III. 2. 2. Segmentation of the Sample

In order to explore such preference structures, a clustering of the individual utility functions is performed. A cluster analysis was conducted with the part-worths of all individuals. Four clusters were derived using Ward's method with squared Euclidean distance as a measure of similarity. In a first step, outliers were excluded from the analysis by the single-linkage procedure (i.e. nearest-neighbour method). Thus, 88 respondents remain. The four individual clusters are sufficiently homogeneous. This is judged from the fact that only 2 out of 20 F-values are greater than 1.²⁶ The homogeneity is also stressed by the fact that the variance within the clusters is only 20%, compared to the variance between the clusters which is 80%. In a second step, the preference functions are reevaluated at the aggregated level of individual clusters. The different part-worths of the incentive variables within each cluster will be presented in Figure 1. The results reveal interesting preference differences regarding the incentive variables:

Cluster 1 (n=10) is characterized by the high relevance of the attribute level "variable income structure". The preference for a guaranteed fixed income of 90% plus a possible bonus up to 20% is dominant (part-worth of 2.188 / relative importance of 50.1%) in this segment of R&D personnel. Other incentive variables are less important with relative importances between 10% and 15%.

Members of **Cluster 2 (n=44)** focus on pay rises (part-worth of 2.199 / relative importance of 52.43%). This cluster represents half of all subjects included in this analysis and therefore stresses the importance of monetary incentives for R&D professionals

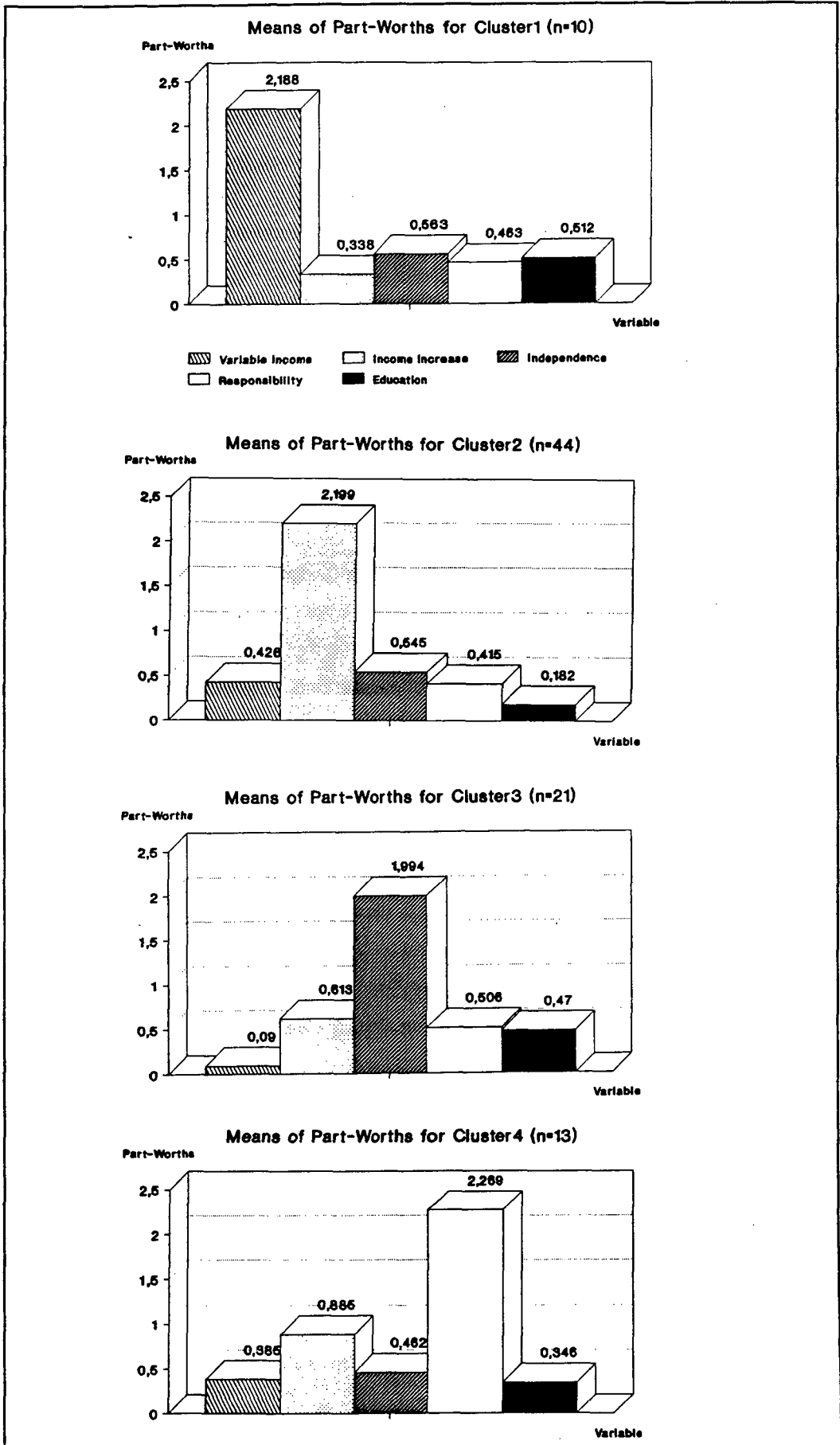
In **Cluster 3 (n=21)** the special emphasis lies on the variable level of increased independence to perform their own R&D interests (part-worth of 1.994 / relative importance of 47.78%). Monetary incentives almost play no role in this segment.

Finally, **Cluster 4 (n=13)** can be characterized by R&D researchers and scientists, who strongly prefer increased responsibility as their most favored incentive (part-worth of 2.269 / relative importance 49.94%). In this segment, some preference is also given to increased income.

As expected, the incentive variable "Participation in Training Programs" is of minor relevance in all 4 clusters (part-worths between 0.512 and 0.182). The segmentation does not reveal a "training-cluster", since this variable is the least favored one with only 11% relative importance over all respondents.

²⁶ Backhaus, K., Erichson, B., Plinke, W., Weiber, R., (1990): Multivariate Analysemethoden, Eine anwendungsorientierte Einführung, 6th ed., Berlin/Heidelberg, p. 149-150.

Figure 1: Segmentation of the Sample in four clusters



After completing the cluster analysis with the resulting four homogeneous clusters, it was asked to which degree the incentive preferences could be related to socio-economic variables. No correlation was found between the segments and age, hierarchical status, and income.

Our findings support the view that the stereotype of an R&D professional, who is mostly motivated by intrinsic incentives, does not exist.²⁷ Instead, there is a wide spectrum of R&D professionals with differing individual preferences. These preferences are not related to factors such as age, income or hierarchical level. Furthermore, the findings do not support the often postulated statement that needs for prestige or freedom become important only after a certain material base has been satisfied, here in the form of monetary rewards.²⁸ A hierarchical categorization of needs, where basic physical and social needs have primacy over needs for prestige and freedom, can not be supported by these empirical findings.

III. 2. 3. Quality of the Empirical Results

Reliability is a necessary, but not sufficient prerequisite for an empirical study.²⁹ Testing the reliability of a conjoint study can be performed in a variety of ways.³⁰ Here, a significance test is performed for the adjusted R-square to measure whether the results of this study differs significantly from the results of a study, based on random rank-orders. A second study was conducted evaluating 100 respondent, randomly ranking 9 scenario-cards. The distribution of the real adjusted R-squares was compared with the distribution of the random adjusted Rsquare values. A Kolmogoroff-Smirnoff Test was performed to test if the two distributions of R-square values differ significantly. On a highly significant level ($p=0.000$), the real adjusted Rsquare (0.917) values differ from the values of randomly ranking the scenario-cards (adj R-square = 0.269). This establishes the reliability of our study.

In the literature, several methods to test the validity of conjoint studies are presented in detail.³¹ In our case, the validity of the study is tested by evaluating

²⁷ Herzberg, F. H., Mausner, B. M., Snyderman, B. B., (1959): *The Motivation to work*, New York.

²⁸ Maslow, A. H., (1970): *Motivation and Personality*, 2nd ed., New York et al., pp. 35.

²⁹ see, Green, P. E., Tull, D. S., (1982): *Methoden und Techniken der Marketingforschung*, 4th ed., Stuttgart, p. 185.

³⁰ Weisenfeld, U., (1989): *Die Einflüsse von Verfahrensvariationen und der Art des Kaufentscheidungsprozesses auf die Reliabilität der Ergebnisse bei der Conjoint Analyse*, Berlin.

³¹ Müller-Hagedorn, L., Sewing, S., Toporowski, W., (1993): *Zur Validität von Conjoint-Analysen*, in: *Zeitschrift für betriebswirtschaftliche Forschung*, Vol. 45, No. 2, pp. 123-148.

the hold-out data. As mentioned before, one hold-out card was added to the experimental design. However, this card was not used to estimate the respondent's utility function. Instead, this data is "held out" of the main analysis in order to check how well the utility functions predict these hold-out evaluations. The correlation between the predicted and the actual hold-out data could range from 1.0 for perfect fit to 0.0 for a total lack of fit. Aggregating the hold-out data across all respondents, the analysis reaches a mean hold-out value of 0.76. Consequently, the analysis is considered to be valid.

III. 3. Managerial Implications

The empirical results obtained through this experiment clearly indicate that monetary incentives for R&D personnel are highly preferred over non-monetary incentives on an aggregate level. At first sight, this leads to the rejection of the hypothesis that the motivation potential of the German Employees' Inventions Law is low because of its emphasis on using only monetary rewards. Instead, monetary incentive variables have a high utility value for most respondents. An alternative conclusion would be that the application of the Inventors Act in the German industry is connected with substantial problems. Some of these problems concerning the law, are presented as the result of a first analysis of the empirical data collected in this study:

One major problem, as frequently stated by the respondents, is the lack of knowledge about the Law and the Guidelines for compensating inventors in Germany. 13% of all respondents had no knowledge about the law at all, 63.5% knew its contents at least partially and only 23.5% were familiar with it. 80.9% of the R&D personnel suggested that an office within the company to consult with inventors about the compensation guidelines would be necessary, but only 53% of the respondents knew about the existence of such a consulting office in their company. Consequently, if the Law and the Guidelines are not known by the inventors, they cannot serve their purposes. Interestingly, 13.9% of all respondents even stated that in their companies the Employed Inventors Law is not in use at all, although it is a legal act.

A severe problem with an extreme negative influence on the motivation potential of the inventor is the calculation of the award. Often, the time-span between the invention and its commercialization is extremely long. Also, it is difficult to estimate the total sales that arises from the invention which is the basis for the compensation. The present value of a compensation tends to be rather small. Payments are made several years after the actual creation of the idea. Interviewees in Germany point out that the cases where significant

payments were granted are quite rare. On the other hand, the cost of calculating and controlling the compensation is rather high. In the central patent department of Siemens AG, Germany, for example, 10% of the entire working hours of the patent attorneys is spent managing compensation problems.³²

Another significant problem arising with the German Act is the fact that only the inventor is rewarded with a monetary award. In interdisciplinary projects, this leaves team members from other functional areas who are supportive to the innovation but who are not inventors without an award. This reduces the interfunctional communication flow and causes tension. Additionally, since compensation is connected primarily with patentable inventions, it discriminates against all other inventive or creative technical work which cannot be patented, like for example in the soft-ware industry.

Furthermore, the compensation guidelines are individually oriented and not appropriate for use as a team compensation instrument. Thus, a significant problem arises from the lack of communication and exchange of experiences, as inventors try to make new inventions on their own to earn a higher share in the compensation.³³

IV. Conclusions

This study indicates that the application of the German Employees' Inventions Act in industry is connected with a wide spectrum of problems. The Act does not seem to meet the original expectations and intentions that were raised when the Law was enacted in 1957. This can not be attributed to a lack of interest of monetary incentives. As the results of our experiment clearly indicate, monetary awards are preferred by the respondents. Consequently, intrinsic motives which are often considered to be of high relevance in R&D are of minor importance than stressed in the literature.³⁴ Furthermore, the empirical results support the need for an individualization and more detailed differentiation of the granted rewards.

³² Körber, A., (1992): The Encouragement of Inventiveness in Enterprises, Paper presented at the WIPO Asian Regional Symposium on the Promotion of Invention and Innovation, New Delhi, India, February 5 to 7, 1992.

³³ for a detailed evaluation of the effectiveness of individual versus aggregate compensation, see Gomez-Mejia, L. R, Balkin, D. B., (1989): Effectiveness of Individual and Aggregate Compensation Strategies, in: *Industrial Relations*, Vol. 28, No. 3, pp. 431 - 445.

³⁴ this argument is supported by Staudt et al. (1991), comp. Staudt, E., et al., (1991): Incentive systems as an instrument of company innovation management: results of an empirical investigation in the R&D sector, in: *International Journal of Technology Management*, Special Issue on Manufacturing Strategy, Vol. 6, p. 406.

No stereotype inventor exists with a fixed preference structure. Instead, the introduction of a cafeteria-system³⁵ in industrial R&D, offering a menu of several incentive variables, from which the inventors can choose the most favored ones, would be a possible solution to meet the fundamental need of making existing incentive systems more flexible.

It should be stressed that our findings constitute interim results only. This research project is still in progress. We plan to present expanded conclusions in the near future. Special emphasis will be given to the question of whether highly motivated R&D professionals produce a higher R&D output than those who are less motivated.³⁶

Abstract:

This paper evaluates the use of incentive systems in R&D to stimulate the motivation potential of R&D personnel. Special emphasis is given to the German Employees' Inventions Act, enacted in 1957. It provides guidelines for a mandatory compensation of employed inventors. The major contents of the law, its advantages and disadvantages are presented and discussed in detail. It is shown that the general consensus in industry is not favorable to the German Act. A significant administrative effort of calculating the compensation, the problem of how to interpret an adequate compensation level, and the encouragement of secrecy among R&D professionals are only some of the drawbacks of this law. We also report on an experiment that measures the individual preferences of R&D personnel for monetary versus non-monetary incentive variables. Finally, some managerial implications taken from the empirical results will be highlighted.

³⁵ Wagner, D., (1986): Möglichkeiten und Grenzen des Cafeteria-Ansatzes in der Bundesrepublik Deutschland, in: ZfbF, Vol. 38, No. 1, pp. 16-27.

³⁶ see in this context the study of Honig-Haftel, S., Martin, L. R., (1993): The Effectiveness of Reward Systems on Innovative Output: An Empirical Analysis, in: Small Business Economics, Vol. 5, pp. 261-269.

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Appendix 1: Example of a scenario-card

Income Structure Relationship of guaranteed fixed income to maximum variable bonus depending on the inventive performance	100% fixed 0% variable
Independence / Autonomy Proportion of fixed working hours which can be freely devoted to own R&D interests (in %)	15%
Participation in Training Programs Number of training events (in days per year)	5-8 days
Income Increase Increase of fixed salary (in % per year)	10%
Responsibility Number of subordinate employees	increased

→ Please write down the ranking numbers in this field !

Appendix 2: Instructions for the experiment

INSTRUCTIONS for the Experiment

This experiment is to simulate decision-making situations.

Consider the following situation: The director of your R&D unit intends to develop an incentive system. Therefore, he is presenting you 9 different combinations of incentive menus, consisting of several incentive variables. You are asked to rank these cards, depending on your personal preference. The possible combinations are listed on the enclosed cards.

Step 1: Sorting all cards

Please look at one card at a time. Decide if you would favor the described incentive menus or not. Check all cards and sort them accordingly to the following two categories.

☐

yes

☐

not

→ First sort all 9 cards as described above. Then proceed with Step 2.

Step 2: Ranking all cards

- Rank cards within each of the two piles. The card on top should contain the menus which you favor most.
- Combine the two piles into one deck as shown. You obtain an entire ranking depending on your personal preference.
- Please check if you are satisfied with the entire sequence of the cards. Then, write down the ranking numbers on the index cards. The card which you favor most should receive the rank '1', the next one rank '2', etc.

→ Please put the ranking number of each card in this field

Scheme of Instructions