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Key Factors of Successful Innovation Management

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A. The Problem

Today, hardly anyone still denies the enormous importance of technological innovations for both national economics and business administration. Their influence on the development of the general economic objectives of economic growth, employment, productivity, and international competitiveness has been thoroughly analyzed and confirmed empirically. Likewise, it is crucial for a firm to protect and consolidate its competitiveness for the long term by improving its production technologies as well as opening up new markets and producing new products and processes. Certainly, nobody disputes the paradigm according to which innovations take place within a contextual frame. Innovation management can adapt to contextual influences reactively, or try to shape them actively according to its own objectives. Therefore, it is imperative for innovation management to know the context-related key factors, because only if they are known the management activities can be oriented appropriately.

The aim of this paper is to systematically work out key factors of innovation management from empirical studies. Expanding from this basis, an empirical analysis will show whether the large number of key factors, which are certainly not free from overlap, can be condensed to a small number of independent main influencing factors. Finally, the relevance of the extracted key factors of innovation management to success will be examined. The aim is to find out in which key spheres, above all, successful innovation management must be active. For this purpose, we refer to an empirical study in which we examined 88 firms whose innovation projects were subsidized by the Federal Ministry of Economics within the frame of its "First Innovations Program". The sample of firms interviewed is dominated by medium-sized mechanical and electrical engineering firms.

B. Key factors of innovation management - an analysis of empirical surveys

Since the end of the 60's there has been scientific literature dealing with possible contextual factors influencing innovations.[1)] There are many different approaches to analyzing the way in which innovations are influenced. It is not only the innovation per se that is seen as a dependent variable, but also the various aspects of its characteristic features. For example, the influence of an innovation on economic as well as technical success is a variable which is often examined. Organizational problems and the capability to generate innovative ideas also receive considerable attention.

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1) See literature surveys in Cooper (Success and Failure 1979) p. 95 and Rothwell (Successful Innovators 1977) p. 192.

Table 1 is a list of most of the empirical studies dealing with factors influencing innovation management in an general way. They are exclusively empirical studies. The aim is to generate a systematic framework of possible influencing factors. In the ensuing analysis we have further restricted the scope of studies taken into consideration: Our aim is to analyze the heterogeneous structure of an innovation's determinants. Consequently, we do not consider studies which deal exclusively with a single contextual factor. We will not consider studies which, for example, deal specifically with the influence of organizational structure[1] or of so-called key persons[2] on an innovation process.

The survey of literature has been arranged as follows. In the column beside the author's name the subject of the study is briefly described, the main stress being on the structure of the sample studied and on the objective of the analysis. We believe that this minimal information is necessary to enable the reader to judge the relevance of the empirical results. The main part of the table consists of the contextual factors that were extracted. For reasons of clarity, we have divided the results into five categories: technology, market, production, organization, and other influencing factors. The figures assigned to the categories correspond to the influencing factors originally determined. They are defined in the legend at the end of the table.

Table 1: Synopsis of empirically determined influencing factors of innovation management

Study	Subject of the Study	Influencing Factors				
		Technology	Market	Production	Organization	Others
Mansfield (Industrial Research 1968) p. 59	Reasons for success or failure of 55 innovation projects in a large electrical engineering firm.	4			20,27	
Myers/Marquis (Innovations 1969) p. 58 ff.	Innovation processes of the most important innovation projects in 121 firms belonging to 5 branches of industry.	1,2,3,4	14		21,24,26	
Arthur D. Little (Barriers 1973)	Overcoming of innovation barriers with the help of governmental research policy in 19 firms.		13		22,25	28,29,30

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1) See Burns/Stalker (Innovation 1961), Lawrence/Lorsch (Differentiation 1965), Wilson (Innovation 1966) p. 193, Becker/Stafford (Organizational Success 1967) p. 511, Evan/Black(Business Organization 1967) p. 519, Shepard (Organization 1967), Sapolsky (Innovation 1967), Zaltman/Duncan/Holbek (Innovations 1973), Becker/Whisler (Organisation 1976) and Vedin (Product Innovation 1980).

2) See Allen (Roles 1970), Frost/Whitley (Communication 1971), Chakrabarti (Champions 1974), Maidique (Champions 1982), Fischer/Rosen (Information Star 1982), Fischer et al. (Product Champion 1986) and Gemünden (Promotors 1986).

Studie	Untersuchungs-gegenstand	Einflußfaktoren				
		Techno-logie	Absatz-markt	Produk-tion	Organisa-tion	Sonstige
Globe/Levy/ Schwartz (Key Factors 1973) p. 11	Innovation success in 8 case studies in different branches of industry.	1,4	9,14,16		20,23	28,29,30 32
Roberts/Burke (New Products 1974) p. 22 ff.	6 successful innova-tion projects in in-vestment goods indu-stry.	1,4	14,16			
Rothwell et al. (SAPPHO-Updated 1974) p. 265	Comparison of 43 pairs of successful and unsuccessful in-novations in chemical and precision engi-neering industry.	1,3	13,14	18	20,24,25	
Scholz (Techno-logie und Inno-vation 1974) p. 135 ff.	Innovation process of diffusion of integra-ted wiring in 25 electrical enginee-ring firms.	4	9,14	17	24	28,30
Davidson (Consumer Brands 1976) p. 119 ff.	50 pairs of success-ful and unsuccessful new product introduc-tions in consumer goods industry.	4	12,15			
Gerstenfeld (Successful Pro-jects 1976) p. 117 ff.	Innovation success in 22 innovation pro-jects in 3 branches of industry.	4	14		24,26	30
Rubenstein et al. (Innovation Success 1976) p. 17 f.	Economic and techni-cal success of 103 innovation projects in 6 firms belonging to different branches of industry.	1,3	5,7,14 15,16		20,21,22, 24,25,26, 27	29,30
Utterback et al. (The Process of Innovation 1976) p. 6	Innovation success in 164 innovation pro-jects in 59 Japanese and European firms belonging to 5 bran-ches of industry.		13,14,15 16		20,24,26	28

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Studie	Untersuchungs-gegenstand	Einflußfaktoren				
		Techno-logie	Absatz-markt	Produk-tion	Organisa-tion	Sonstige
Grefermann/ Sprenger (Inno-vationspraxis 1977) p. 59 ff., 87 f.	Innovation processes in more than 1500 in-dustrial firms (Ifo-Study).	3	5,9,16	18		28,30
Kulvik (Success or Failure 1977) p. 87	3 random sample sur-veys: * 24 pairs of suc-cessful and unsuc-cessful innovation projects in various branches of indu-stry. * Innovation success in 58 innovation projects of 7 firms * Innovation success in 68 innovation projects in one firm.	1	10,13,14 16			
Myers/Sweezy (Innovations 1978) p. 41 f.	200 failed innovation projects.		9,11,14 16		26	29,31
Cohen/Keller/ Streeter (Trans-fer 1979) p. 11	Success and Failure in 18 IBM innovation projects.	1,3,4	5,9		20	30
Cooper (Success and Failure 1979) p. 99, Cooper (New Product 1979) p. 127 ff.	102 successful and 93 unsuccessful new pro-duct introductions in 103 firms.	1,4	5,9,10, 12,13,14, 15,16	18		
Dillon/Calantone/ Worthing (Pro-duct Failures 1979) p. 1195	Success of innovation projects in 109 firms.	3	9,11,12, 13	17,18		
Koschorke/ Schilling (Stra-tegien 1979) p. 41	Innovation barriers in 169 workshops.	3	13			28,29
Mensch (Innova-tionsverhalten 1979) p. 74 ff.	64 innovation proces-ses in small- and medium-sized firms.	1	14,16		20,24	29

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Studie	Untersuchungs-gegenstand	Einflußfaktoren				
		Techno-logie	Absatz-markt	Produk-tion	Organisa-tion	Sonstige
Fernelius/Waldo (Industrial Innovation 1980) p. 37	Economic and technical cussess in 78 innovation projects of 50 firms.	1,3,4	5,14,16		20,21,24	30
Biehl (Innovationsbereitschaft 1981) p. 140 ff.	Success of innovation projects in 101 medium-sized mechanical engineering firms.	3	5,9,12	18	22,26	32
Hopkins (New-Product 1981) p. 12 ff.	Success of new product introductions in 148 firms in consumer and investment goods industry.	4	9,10,14, 16	17	20,22,26	
Gürtler/Schmalenholz (Innovationsaktivitäten 1982) p. 21	Innovation processes in more than 600 firms participating in the 1980 IFO innovation test.		5		20	29
Marquis (Successful Innovations 1982) p. 46 ff.	Innovation success in more than 500 innovation projects in 121 industrial firms.	3,4	14,16		20	
Nyström/Edvardson (Product Innovation 1982) p. 68	Technical and economic success in 121 innovation projects in 20 firms.	1,4	10		24	
Cooper (Strategies 1983) p. 255, Cooper (Product 1984) p. 16	Innovation success in 122 firms in investment goods industry.	4	5,10,13, 16			
Maidique/Hayes (Management 1984) p. 18 ff.	Innovation processes in 100 firms in electrical engineering industry.	2,4	10		21,24,25, 26	
Maidique/ Zirger (Product Innovation 1984) p. 198	59 pairs of successful/unsuccessful innovations in electronics industry.	4	10,12,13 14,16		20,25,26	

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Studie	Untersuchungs-gegenstand	Einflußfaktoren				
		Techno-logie	Absatz-markt	Produk-tion	Organisa-tion	Sonstige
Schmalholz/ Scholz (Innovationsschwächen 1984) p. 25	Innovation problems in firms (of various branches of industry) having participated in the 1982 IFO innovation test.	4	5	17	20,21,22	29
Scholz/ Schmalholz (Patentschutz 1984) p. 205	Innovation projects in 400 firms in the 1979 IFO test and innovation projects in 600 firms in the 1980 IFO test.		5,9,14		20	28,29,30 31
Smith et al. (Innovation 1984) p. 12 ff.	Innovation processes of 10 projects in a chemical industry firm.		10		20,24,25	
Voss (Technology Push 1984) p. 149	Innovation impulses in 63 innovation projects in user software industry.	4	14			
Ackermann/ Harrop (Technical Innovation 1985) p. 215	Innovation problems in 19 British and 12 Swiss mechanical engineering firms.	1,3,4	5,14,16		20,24	29
Fritz (Produktinnovationsstrategie 1985) p. 13 f.	Innovation output of 43 electrical firms.		9		20	31
Robinson/Fornell (Pioneer Advantages 1985) p. 312 ff.	Market success according to PIMS data for 371 firms in consumer goods industry.		10,11,12, 13			
Töpfer (Innovationsmanagement 1985) p. 405 f.	Innovation processes in 77 product groups of 20 firms.	2	13	17	24,25,27	28,29
Albach (Innovation und Imitation 1986) p. 55 ff.	31 successful and unsuccessful medium-sized mechanical engineering firms.	1,4	12,14	17		

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Studie	Untersuchungs-gegenstand	Einflußfaktoren				
		Techno-logie	Absatz-markt	Produk-tion	Organisa-tion	Sonstige
Cooper/Klein-schmidt (Success Factors 1987) p. 219 ff.	Innovation success of 203 product innova-tions in 125 firms.	1	5,8,10, 11,12,14 15	17,18		27
Gedenk (Imita-tionswettbewerb 1987) p. 216	Competitive imitation in 33 pharmaceutical firms.		5,8,15		21	
Perillieux Zeitfaktor 1987) p. 215	151 successful and 80 unsuccessful mechani-cal engineering firms.	1	5,6,7,10, 14,15	19		28
Glismann/Horn (Performance 1988) p. 1186	Invention success in 41 branches of indu-stry in 6 countries.					28,29,30, 32
Utterback et al. (Technology 1988) p. 18 ff.	Economic success of innovation projects in 60 firms.		11		21	28,29
de Brentani (Success 1989) p. 248	Innovation success in 276 innovation pro-jects in 115 firms.	3	10,14,16	18	24	29
Pinto/Slevin (Success Factors 1989) p. 31 ff.	Innovation success of 159 innovation pro-jects in computer industry.	1,4	14		20,21,24, 26,27	

Legend:

1: Technology experience
2: Dynamics of technological change
3: Complexity of technology, degree of innovativeness
4: Technological competitiveness
5: Market growth, market volume
6: Structure of customer potential
7: Diffusion speed
8: Customers' re-orientation
9: Intensity of competition
10: Relation to product program
11: Distribution net
12: Pricing policy
13: Marketing activities
14: Understanding of customers' needs
15: Relative advantageousness of the innovation
16: Knowledge of the market
17: Manufacturing know-how
18: Quality, "teething troubles"
19: Degree of standadization, series production
20: Project direction
21: Firm philosophy
22: Organizational structure
23: Project volume
24: Internal/external communication
25: Interfunctional cooperation
26: Degree of planning, process organization
27: Changes of goals, goal clarity
28: Protection of industrial property
29: Financial resources
30: Governmental activities
31: Branch influence
32: Influence of economic situation

One problem occuring in all synopses of this kind is certainly whether the results of the various studies can be compared at all; this problem naturally also occurs in this case. For example, there are often differences in the way the dependent variables are operationalized, in the way the statistical instruments of analysis are applied and in the way the units examined are selected.[1] Furthermore, it has to be taken into consideration that the dependent variables selected by the authors are not identical in the studies. It is true that most of the authors examine the influence of various factors on innovation success, but "success" is operationalized in quite different ways.[2] Perillieux, for example, uses success-determining criteria which describe innovation success from different perspectives.[3] The firms interviewed were asked to judge the following indicators of success on a 5-point-scale: turnover, market share, coverage of development and market introduction costs by sales revenues, proneness to break down and maintenance needs, number of resupply orders and customers' complaints. Maidique/Zirger[4], on the other hand, determine innovation success exclusively by means of financial break even analysis. In some of the studies, innovation success is not operationalized at all. It is mostly replaced by the variable "innovation process", in the sense of a more or less specified endogenous variable.[5] However, in nearly all of the empirical studies listed, an evaluation of success is at least implicitly given.

The synopsis of literature has been compiled in spite of these shortcomings in order to give a survey of the influencing factors which might be important for our own analysis. The following table illustrates the results of the analysis of these 44 studies: (table 2)

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1) See the detailed criticism of many of the studies mentioned above in Brockhoff (Probleme 1984) p. 345.
2) See also the criticism in Hauschildt (Innovationserfolg 1991) p. 464.
3) See Perillieux (Zeitfaktor 1987) p. 199.
4) See Maidique/Zirger (Product Innovation 1984) p. 194.
5) See for example Myers/Marquis (Innovations 1969) p. 58, Koschorke/Schilling (Strategien 1979) p. 41, Mensch (Innovationsverhalten 1979) p. 74, Gürtler/Schmalenholz (Innovationsaktivitäten 1982) p. 21, Smith et al. (Innovation 1984) p. 12 and Ackermann/Harrop (Technical Innovation 1985) p. 215.

Table 2: Frequency of reference to key factors of innovation management in empirical studies

Influencing factor	Frequency of reference to		
Market:			
- Market growth, market volume	14	11,4 %	4,7 %
- Structure of customer potential	1	0,7 %	0,3 %
- Diffusion speed	2	1,5 %	0,6 %
- Customers' re-orientation	2	1,5 %	0,6 %
- Intensity of competition	11	8,9 %	3,7 %
- Relation to product program	12	9,8 %	4,0 %
- Distribution net	15	12,2 %	5,0 %
- Pricing policy	8	6,5 %	2,7 %
- Marketing activities	11	8,9 %	3,7 %
- Understanding of customers' needs	24	19,5 %	8,0 %
- Relative advantageousness of the Innovation	7	5,7 %	2,4 %
- Knowledge of the market	16	13,0 %	5,3 %
Total:	123	100,0 %	41,0 %
Organization:			
- Project direction	18	26,1 %	6,0 %
- Firm philosophy	8	11,6 %	2,7 %
- Organizational structure	5	7,3 %	1,7 %
- Project volume	1	1,4 %	0,3 %
- Internal/external communication	15	21,7 %	5,0 %
- Interfunctional cooperation	7	10,1 %	2,4 %
- Degree of planning, process organization	10	14,5 %	3,3 %
- Changes of goals, goal clarity	5	7,3 %	1,7 %
Total:	69	100,0 %	23,0 %
Technology:			
- Technology experience	16	30,8 %	5,3 %
- Dynamics of technological change	3	5,8 %	1,0 %
- Complexity of technology, degree of innovativeness	12	23,0 %	4,0 %
- Technological competitiveness	21	40,4 %	7,0 %
Total:	52	100,0 %	17,3 %
Production:			
- Manufacturing know-how	7	46,7 %	2,4 %
- Quality, "teething troubles"	7	46,7 %	2,4 %
- Degree of standardization, series production	1	6,6 %	0,3 %
Total:	15	100,0 %	5,0 %
Others:			
- Protection of industrial property	11	26,8 %	3,7 %
- Financial resources	14	34,1 %	4,7 %
- Governmental activities	10	24,4 %	3,3 %
- Branch influence	3	7,3 %	1,0 %
- Influence of economic situation	3	7,3 %	1,0 %
Total:	41	100,0 %	13,7 %
Total:	300	100,0 %	100,0 %

Most of the studies identify the area of marketing as a key factor of innovation management. This applies to the number of items referred to as well as to the frequency of reference to the individual items. However, the frequency count clearly shows the predominance of the demand-pull argument and the great importance attributed to it in innovation research. [1]

The production area is seen as a relatively unimportant factor influencing innovation management. It is here that the lowest frequency rates are found. But this does not necessarily lead to the conclusion that the area of production hardly influences innovation management. Another possible interpretation is that this area has not yet been given much attention by empirical research.

A detailed analysis of all influencing factors leads to the following results regarding individual areas influencing innovation management:

In the technological area, the influencing factors reflect above all the firm's capability of handling the innovation's technological complexity, which is determined to a high degree by the efficiency of its R&D activities (regarding the personnel as well as the material aspect) and by the existing potential of technological experience.

The influence exerted by the market is analyzed in many different ways. Characteristics of the market as well as the innovator's efficiency in opening up markets are of decisive importance. In addition the competitive situation is seen as an important factor. It is implied (by the high number of possible activity parameters mentioned in this context) that the firm's own marketing potential must be regarded as a deciding factor of innovation success.

The influencing factor, "production" is analyzed in a few studies only. In this context, manufacturing know-how, quality of the goods produced and "teething troubles" are mentioned as factors influencing innovation success.

Many aspects of the factor, "organization" are seen as determinants. Elements of structure, process and personnel are of decisive importance in this context.

Among the "other" factors, the most important are:
- protection of industrial property,
- availability of financial resources, and
- governmental activities.

Given the multitude of factors possibly influencing innovation management, the question must be asked whether, on the one hand, these factors should be seen as independent in their influencing effect, or, on the other hand, whether it is more useful to condense them down to a few central key factors of innovation management. These questions are at the basis of the following empirical analysis.

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1) For the "Demand-Pull/Technology-Push"-Discussion, see Brockhoff (Probleme 1984) p. 344.

C. An analysis of structural relations between key factors of innovation management

1. The empirical basis

The large number of influencing factors mentioned above are a guideline for empirical determination of the structural relations between the main factors of innovation management.

The data material forming the basis of this analysis acquired through an empirical study of 88 innovation projects which were subsidized by the Federal Ministry of Economic's "First Innovations Program". The products are durable consumer or investment goods. Furthermore, in all projects the aim was to market the products, and the finished products of the innovation projects were in all cases actually introduced on the market. Failed innovations or innovations that were used only producing by the firm, and which were also subsidized by the program, have consequently not been considered.

Table 3 lists the variables of the structural relation analysis and their respective measuring instructions.

Table 3: Measuring instruction of the analyzed variables

Variable	Measuring instructions
Marketing system	Ability of the marketing system to reach the relevant customers.
Production capacity	Existence of sufficient production capacities.
Customers	To be familar with the relevant customers.
Easiness of application	The importance of easiness of application of the innovation.
Product novelty	Whether there is a similar product on the market at the time the innovation was introduced.
Demand situation	The importance of conformity of the innovation to demand.
Batch size	Size of the production series of the innovation.
Changeover costs	The amount of possible changeover costs for the user of the innovation.
Distribution channels	The existence of a fixed system of distribution channels.
Producer's reputation	The importance of the producer's reputation.
Cost situation	The importance of the fact that the user of the innovation could improve his cost situation.
Profitability of the production	The importance of the fact that the user of the innovation can make his production more profitable.
Development costs	The amount of the development costs.
Development time	The length of the development period.
Technical problems	The existence of possible technical problems of the innovation.
Degree of novelty	The degree of novelty of the innovation.
Frequency of innovations	The frequency of carryng out innovative projects.
External experts	Consulting of external experts.
New machines/materials	The impulse for the innovation steming from new machines/materials
Protextion of industrial property	Degree of use of patent law options by the innovator

Our means of analysis is factor analysis. One problem connected with this approach might be the varying scale levels. For our analyis, we interpret all ordinal variables as having the same intervals between the ranks, and the dichotomous measurements as simplified measurements of an attribute with interval scales, so that we can use Pearson's correlation matrix as the initial matrix of our factor analysis.[1)]

Table 4 shows the charge pattern of our relational analysis of the attributes.

1) See Arminger (Faktorenanalyse 1979) p. 157, who emphasize the explicit reliability of factor analysis for alternative features.

Table 4: Rotated factor charge matrix of the influencing variables

Variable	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI	Factor VII	Komm.
Marketing system	.80		.13			.19		.70
Production capacity	.65		-.21	.17	.10			.52
Customers	.64			-.22	-.29	-.21		.60
Easiness of application	-.11	.73	.12				.18	.60
Product novelty	-.30	-.65	.16	-.33		-.34	.12	.78
Demand situation		.65	.15	-.29	-.19			.58
Batch size	-.22	.37	.68					.65
Changeover costs			-.67				.16	.48
Distribution channels		-.25	.59		-.20	.14	.38	.61
Producer's reputation		-.14	-.50	-.13		.41	-.14	.47
Cost situation				.86			.18	.79
Profitability of the production		-.13		.83	-.12	-.26		.80
Development costs	-.20	-.11			.76		-.15	.66
Development time		-.15	-.22		.70	-.10	-.16	.61
Technical problems	.17	.15	-.33	-.37	.49		.29	.63
Degree of novelty	-.15	-.35	.29		.43	.20	.31	.55
Frequency of innovations	.12	.30			.20	.79		.78
External experts		.15	.11	.18	.32	-.76		.75
New machines/materials	-.11					.17	-.76	.64
Protection of industrial property	-.51	.15			-.12	.11	.62	.71

2. Interpretation of the extracted factors

a) Factor I: High "transfer efficiency"

This factor is characterized by the factsthat

- the innovator's marketing system is suitable for reaching relevant customers,
- there is free production capacity for the innovation,
- the potential customers of the innovative product belong to a familiar group of customers,
- possible ways of protecting industrial property are hardly used at all.

In addition to the interpretation of Factor I, the average negative charge of the variable "product novelty" may be used (saying that at the time of product introduction there were already similar products on the market). Hence, these variables describe innovations of which the technological attributes are not very complex. The firm did not apply for protective rights. Besides these aspects of comparatively low technological orientation of the innovation, Factor I also describes strong points of the innovator, namely those which gain in importance after the development stage terminates. For example, there is free production capacity and an efficient marketing system in order to service relevant customers. As the main charge is observed for variables describing activities which follow the development stage, we call this factor **"transfer efficiency"**. We use this term in order to clarify that it is characterized by activities relating to the transfer of innovations from the development to the marketing stage.

b) Factor II: "Demand orientation and easiness of application" of innovation projects

Factor II relates mainly to the fact that it is to an innovation's great advantage
- if it is more easily applicable than competing products, and
- if it is better adapted to the demand situation.

It is irrelevant whether there are similar products on the market or not. Furthermore, Factor II describes "routine" innovations which are produced as large-scale series and whose degree of novelty is comparatively low. Thus, Factor II may be interpreted as "**demand orientation**" of the innovation. When developing a new product, the innovator's aim is not to produce a technologically complex and new product, but to rigorously adapt to demand trends in order to reach a large number of customers (large-scale production).

c) Factor III: Innovation projects produced as "large-scale series"

The variables considered here describe innovations
- which are only produced as large-scale series,
- which do not cause high changeover costs for the user,
- for which there is already a system of distribution channels, and
- for which the marketing producer's reputation is of no importance. Finally, there are seldom technical problems in connection with these innovations.

Consequently, we call Factor III "**orientation towards large-scale production**". This factor describes attributes of the innovation which aim at reaching as soon as possible a high sales volume of a technologically faultless product. An established distribution system and large-scale series production are used to achieve this. Additionally, users' changeover costs are very limited, in other words, the innovation is characterized by a high degree of compatibility. It is probably for this reason that producer's reputation does not play an important role in its marketing.

d) Factor IV: "Cost orientation" of innovation projects

This factor describes an innovation's attributes which result above all in a cost advantage for the customer. The innovations are competing with similar products. Cost advantages may for example result from the fact that there are no technical problems ("teething troubles"), so that the customer can use the innovation from the beginning without there being any functional deficiencies. For this reason, Factor IV is called "**cost orientation**", a term referring to the use the customer makes of the innovation.

e) Factor V: "Technological orientation" of innovation projects

This factor describes above all the innovation's technological complexity:
- A long period of time is needed to terminate the development stage. Thus, development costs are considerable.
- This is underlined by a relatively high degree of novelty of the innovation.The consequence is that often, external experts are consulted in order to reduce the innovation's technological complexity. Also, there are often technical problems during the initial phase of the innovation's usage.

In the following, Factor V is called "**technological orientation**"; with the help of this factor, the technological complexity of the projects analyzed is described.

f) Faktor VI: "Innovation experience"

This factor describes attributes which refer mainly to the producer:

- Innovative projects have often been carried through. The innovative function has been routinized. The consequence is often that the producer prefers to frequently introduce products on the market with relatively low degrees of innovativeness, than to only occasionally introduce high-innovation products. By this means it is ascertained that the innovation remains manageable technologically and that it thus appears as an innovative-competent product to the potential customer.
- One effect of the innovative function being routinized and the degree of innovativeness being relatively low is that development activities remain within the firm and external experts do not have to be consulted.

We will call Factor VI "**innovation experience**". The phenomenon described is that increasing innovation activities lead to a routinization of development activities, which may then be taken care of completely by the firm itself.

g) Faktor VII: "Orientation towards improvement" of innovation projects

Factor VII describes innovations whose degree of novelty is not exceptionally high, but high enough to apply for property rights. It is consistent regarding this attribute that new machines or new materials are not the impulse for innovation. The innovation is based on familiar techniques, which, in connection with the fact that the innovator applied for protective rights and that the degree of novelty is relatively high, makes it reasonable to conclude that the innovator tries to improve existing products or techniques. However, this improvement must be a substantial modification, because protective rights would otherwise not be granted. The picture is completed by the existence of a system of distribution channels. It is possible for the innovator to use the "precursory innovation's distribution system" for the improved innovation.

Consequently, we will call Factor VI "**orientation towards improvement**".

3. Key factors of innovation management

There is no essential divergence between the extracted factor charge pattern and the numerous key factors of innovation management mentioned in the relevant literature. It is possible to condense a multitude of influencing factors to a few central factors. It should be noted that the result of this procedure cannot be limited to the confines of the functional system initially used.

If the extracted factors are considered with respect to the primary direction of their effects, they can be divided into two groups. The factors, "transfer efficiency" and "innovation experience" refer above all to characteristics of the innovating firm, while the factors, "demand orientation", "large-scale series", "cost orientation", "technological orientation", and "orientation towards improvement" refer to attributes of the innovative product. Thus, the factors can be systematized in the following way:

The following factors are **firm-related factors**:
- transfer efficiency and
- innovation experience.

The following factors are **innovation-related factors**:
- demand orientation,
- large-scale series,
- cost orientation,

- technological orientation, and
- orientation towards improvement.

The result of our analysis is therefore that an analysis of key factors of innovation management must not be restricted to parameters related to the individual innovation project, but has to take into account general characteristics of the innovative firm. Such an distinct separation is not explicitly mentioned in most of the studies considered. It can only be concluded implicitly from the material. Furthermore, only occasionally do the authors consider influencing factors which do not refer to attributes of the innovative projects but to attributes of the innovating firm. [1)]

When examining the relevance to success of these key factors the question has to be asked whether innovation success is determined largely by attributes of the innovating firm or by parameters of the innovation itself.

D. The relevance to success of the key factors extracted

Before taking a closer look at the extracted key factors, it is necessary to briefly present our operationalization of innovation success.

1. Measuring innovation success

With reference to Gzuk[2)] we define innovation success as the degree to which the goal is attained in an individual innovation process, seen from the point of view of the respective innovator. The innovators we interviewed were therefore forced

- to reveal the goals set in connection with the innovation project, and
- to evaluate the degree to which their aims were realized.

When using this method there arises risk that the degree of goal attainment depends very much on how the goal is defined.

However, our analysis shows that the factor dominating the goal definition is long-term turnover protection: 88.6% of the firms interviewed regard this as the goal set for the innovation project subsidized. The consequence of the outstanding importance of this goal is that the way in which goals are defined does not significantly influence the degree of goal attainment.

The following table shows the degree of goal attainment in the projects studied.

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1) See Table 1.

2) See Gzuk (Effizienz 1975) p. 40 and, based on Gzuk Gemünden (Innovationsmarketing 1981) p. 166 See also the criticism in Grabatin (Effizienz 1981) p. 19.

Table 5: Distribution of the variable "innovation success"

Innovation success	Frequency	
	absolute	relative
not satisfactory	33	37,5 %
moderately satisfactory	9	10,2 %
satisfactory	19	21,6 %
very satisfactory	19	21,6 %
extremely satisfactory	8	9,1 %

2. The influence of the extracted key factors on innovation success: results of regression analysis

We are now going to examine the relevance of the key factors to success with the help of a regression analysis approach. The results are given in the following table.

Table 6: Results of the regression analysis model for examining the influence of the extracted key factors on innovation success

Contextual factor	Effect on the innovation success			
	Beta	p	95 % confidence interval	
Firm related factors:				
Transfer efficiency	.27	.005	.08	.45
Innovation experience	.28	.004	.09	.46
Innovation related factors:				
Demand orientation	.04	n.s.	-.14	.23
Large-scale series	.26	.007	.07	.44
Cost orientation	.11	n.s.	-.07	.30
Technological orientation	-.28	.003	-.47	-.10
Orientation towards improvement	-.06	n.s.	-.25	.12
Certainty measure R^2: 0,31 with p < 0,001				

What is most striking about this result is that only 4 out of 7 contextual factors exert a measurable influence on innovation success. Out of these, the factors "transfer efficiency", "innovation experience", and "large-scale series" show a significantly positive charge, while only the regression coefficient of the factor "technological orientation" is negative. For all other factors, no significant influence was measured.

The significant influencing factors' regression coefficients are quite similar. The regression coefficient of the factor "transfer efficiency" is 0.27. This is to say that if an innovator is able to transfer his product from the development stage to the marketing stage (e. g., if there is an efficient marketing system or sufficient production capacity), then this has a positive effect on innovation success. This result is in keeping with corresponding empirical findings published. Albach, for example, stresses the high relevance to success of transfer efficiency at the time of transfer from prototype to marketable product.[1] Similar results may be found in Myers/Sweezy, Cooper, Dillon/Calantone/Worthing, and in Hopkins.[2] We can thus record that innovation success depends decisively on the innovator's efficiency in transferring the innovative project from the development stage to the marketing stage.

The contextual factor "innovation experience" is also significant in its relevance for success. Here, too, the regression coefficient is positive (0.28). The frequency with which firms carry through innovative projects has a positive effect on innovation success. Routinization of innovation processes has as yet only rarely been examined with regard to its influence on success. But, Freeman, as well as Perillieux, have published results pointing to the positive effect that familiarity with innovative projects has on innovation success.[3] A positive effect can also be found if the firm regards innovative functions as a permanent task.[4] The firm is then capable of continually presenting on the market new products, if not necessarily always innovations.

The remarkable thing about the significant influence of the factors "tranfer efficiency" and "innovation experience" on success is that both contextual factors describe attributes of the firm and not attributes of the innovative project. Consequently, out of the five contextual factors which describe an innovation project, only two have a significant effect on success. Innovation success seems to be determined primarily by firm attributes, not by attributes which only characterize an individual innovation project.

Out of the factors characterizing the innovation project, "large-scale series" and "technological orientation" are significantly related to success. "Orientation towards large-scale production" has a positive regression coefficient of 0.26. The innovator tries to attain a high sales volume with the help of high production capacity and an established distribution system. These results, too, are confirmed in the available literature. Perillieux[5] underlines that a high series size is relevant to success. Cooper[6] likewise regards it as important for innovation success that the firm does not address small customer groups only but that it tries to open up a large market for the innovation. The prospects for success of an innovation increase if the possibilities of its use and application are oriented towards the needs of a large number of customers instead of individualized customer needs.

The factor "technological orientation" has a negative regression coefficient (-0.28). Technologically complex projects are threatened by failure more than projects whose technology is less complex. If this result is compared with other studies, a very heterogeneous picture emerges. For example, Flaherty's[7] conclusion is that technologically complex innovations are

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1) See Albach (Innovation und Imitation 1986) p. 57.
2) See Myers/Sweezy (Innovations 1978) p. 41, Cooper (Success and Failure 1979) p. 99, Dillon/ Calantone/Worthing (Product Failures 1979) p. 1195 and Hopkins (New-Product 1981) p. 13.
3) See Freeman (Industrial Innovation 1974) p. 274 and Perillieux (Zeitfaktor 1987) p. 215.
4) See also Hauschildt (Innovationsstrategien 1989) p. 259.
5) See Perillieux (Zeitfaktor 1987) p. 215.
6) See Cooper (Product 1984) p. 16.
7) See Flaherty (Technology Leadership 1983) p. 99.

most apt to secure an innovation's success. Cooper[1], too, underlines the positive correlation between "technological orientation" and "innovation success", although he argues elsewhere that a technologically complex product is successful only if it was also in some way designed according to market needs.[2] Still a different result is also given by Rubenstein et al.[3] They say that technological complexity of an innovation project significantly contributes to the economic success of the innovation, but that the correlation between technological complexity and technical success is not significant. Our results correspond more or less to those of Fernelius/Waldo[4] pointing to the fact that successful innovations do not aim at realizing a great leap forward but rather try to improve existing products by small and not too complex innovative steps.[5] The results presented by Biehl[6] make it clear that a high degree of innovativeness does not necessarily lead to innovation success. Ackermann/Harrop[7] regard technological complexity of an innovation as one of the main problems in connection with the development of new products.

Finally, some remarks must be made on the factors which our regression analysis has shown to be insignificant with regard to innovation success. The most surprising result is that the factors "demand orientation" and "cost orientation"[8] belong to this category. In many empirical studies the authors emphasize that a good understanding of demand trends is a guarantee of innovation success.[9] The same applies to the factor "cost orientation": the relevance for success of this factor is confirmed in many empirical studies. Dillon/Calantone/Worthing[10] present cost and price advantages of an innovation as an important factor influencing later success of the innovation. Davidson, Rubenstein et al., Utterback et al. and Cooper[11] argue in a similar way in their studies. The question is how to explain this discrepancy between the results. First of all, it is certainly at least possible that the varying analysis approaches lead to heterogeneous results. Another possible explanation is that in our study, these attributes are not seen primarily as characteristics of the innovative projects, but of the innovating firm. Especially the factor "transfer efficiency" refers to influencing factors aiming at demand stimulation. The existence of an efficient marketing system and knowledge of the relevant customer groups, for example, are demand aspects which ascertain innovation success. Thus,

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1) See Cooper (Strategies 1983) p. 255 and Dillon/Calantone/Worthing (Product Failures 1979) p. 1195.
2) See Cooper (Strategies 1984) p. 161, and similarly Rothwell et al. (SAPPHO-Updated 1974) p. 265.
3) See Rubenstein et al. (Innovation Success 1976) p. 18.
4) See Fernelius/Waldo (Industrial Innovation 1980) p. 38.
5) See also the considerations on the optimal degree of novelty of innovations in Brockhoff (Schnittstellenmanagement 1989) p. 71.
6) See Biehl (Innovationsbereitschaft 1981) p. 139.
7) See Ackermann/Harrop (Technical Innovation 1985) p. 215.
8) We do not regard the non-significant relevance for success of the factor, "orientation towards improvement" as problematic for our regression analysis approach, because this factor is very similar to the factor "technological orientation", which is significant. The negativ correlation found there makes it clear that projects having a low degree of innovativeness, that is those which are more like improvement innovations, are more often successful than others. See also Albach (Kreativität 1986) p. 20, who argues that the products introduced on the market by successful innovators are rather improvement innovations. A similar line of argumentation is found in Katz/Shapiro (R&D Rivalry 1987) p. 418.
9) See Globe/Levy/Schwartz (Key Factors 1973) p. 11, Roberts/Burke (New Products 1974) p. 22, Scholz (Technologie und Innovation 1974) p. 135, Gerstenfeld (Successful Projects 1976) p. 6, Kulvik (Success or Failure 1977) p. 87, Myers/Sweezy (Innovations 1978) p. 41, Mensch (Innovationsverhalten 1979) p. 74, Hopkins (New-Product 1981) p. 12, Scholz/Schmalholz (Patentschutz 1984) p. 205, Perillieux (Zeitfaktor 1987) p. 215 and Pinto/Slevin (Success Factors 1989) p. 31.
10) See Dillon/Calantone/Worthing (Product Failures 1979) p. 1195, who found that price and cost advantages are the third important factor in a discriminatory function of 10 factors..
11) See Davidson (Consumer Brands 1976) p. 119, Rubenstein et al. (Innovation Success 1976) p. 17, Utterback et al. (The Process of Innovation 1976) p. 6 and Cooper (Success and Failure 1979) p. 99.

the initial discrepancy between our results and those of other empirical studies is strongly relativized.

E. Conclusions regarding the management of innovations

The analysis of numerous empirical studies on key factors of successful innovation management has made it clear that there is a network of interdependent influencing factors. Its complexity and the sometimes still doubtful relevance to success of some of the factors make it seem unsuitable for deciving concrete advice for management. This made it necessary to condense the influencing factors in order to obtain a few central factors.

Our empirical analysis shows that innovation management is not only influenced by factors directly related to the innovative project, but also, and in a decisive way, by attributes of the innovating firm. It is implied by this result that management of innovations must not be conceived to serve a single innovation project, but that the firm must generally be oriented towards innovative activities. This becomes clear especially if we regard the factor "innovation experience". It implies experience in innovating that a firm has gained by carrying through many innovative projects. The same applies to characteristics based on an efficient marketing system or efficient production capacity, neither of which are limited to a single project.

The significance of the distinction between key factors related to the firm and to the innovation is made even more evident by our analysis of the contribution of both groups to success. The influencing factors related to the firm - this is certainly the result of this study which is most important for practical management - decisively influence innovation success. Without the whole firm being adapted to innovation activities, it is very difficult to make a single innovation project become a success.

Furthermore, successful innovation management has to pay special attention to the factors "technological orientation" and "large-scale series", which are related to the innovation itself. Our analysis shows that the degree of an innovation's technological complexity must not increase too much in comparison with other products already existing on the market, if the innovation is to be successful. A high degree of technological complexity will perhaps make it possible to hold the position of technological leader, but not that of a successful innovator. This becomes even more clear if the high relevance to success of the factor, "large-scale series" is considered: an innovation can only be successful if it is successfully transfered from small-lot production to large-scale production and if a correspondingly high customer potential is simultaneously reached. This can hardly be imagined for application to innovations characterized by a relatively high degree of complexity.

The result of our study is that innovation management should not be limited to the direction of individual innovation projects. It should also try to organize the firm as a whole in such a way that innovation activities are favoured. However, the individual innovation must not be altogether be neglected, because a too high a degree of technological complexity can influence innovation success in a negative way.

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