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INTRODUCTION

Factor analysis of innovations can be made for different purposes. We know many such sources in literature, for example the study by Sumner Myers and Donald G. Marquis (NSF 1969), the project Sappho (1973), "The Flow of the Industrial Innovation Process" on the example of 218 cases by L. Uhlmann (1978) and others.

The Myers/Marquis study gave an overview to factors affecting innovations and their proportions in several branches. Project Sappho was an investigation comparing pairs of successful and unsuccessful innovations. The statistical results indicated that innovations which had achieved commercial success could be distinguished from failures by a superior performance in five major areas. They are

-- strength of management and characteristics of managers;
-- understanding user needs;
-- marketing and sales performance;
-- efficiency of development;

-- effectiveness of communications.

The Uhlmann study tried to identify main types of innovations which can be distinguished from each other by various kinds of factor combinations.

All these studies were made for the specific purposes of market economies, but they included not only market activities of corporations and enterprises, but also the impact of governmental policy on innovation

INVESTIGATION OF 32 FIRMS IN THE CONSUMER GOODS INDUSTRY

Central management and planning plays an important role in planned economies, but this does not mean that we can ignore the activity of enterprises towards the market. Therefore we chose another topic for factor analysis. Our question was: how strong is the influence of innovation process inhibiting factors on the level of state-owned enterprises? And also: how strong is the influence of a firm's own ideas and measures in overcoming bottlenecks and barriers in innovation process.

We formulated the following 26 variables:

1. Insufficient supply of the supplier industry,
2. Technical difficulties,
3. Stress by other production tasks,
4. Insufficient supply of machines and means of rationalization,
5. Failures in development, not yet abandoned,
6. Inability to master the process after handing over by development group,
7. Lack of R & D personnel,
8. Failures of management, insufficient engagement of the manager.

9. Long coordination time of superposed management,
10. Differences between managers and experts,
11. Failures in preparation of production,
12. Delay in construction activities,
13. Planned economy not reached. High costs,
14. Insufficient technological and qualitative level,
15. Conservative and obsolete views,
16. Inexact and changing objectives,
17. Delay in recognition of problems. Failures in information,
18. Changing demand,
19. State orders limit the project,
20. Insufficient know how transfer with other branches,
21. Saving measures,
22. Unfavourable price relations,
23. Insufficient special knowledge,
24. Uncoordinated development in several branches,
25. Better solutions from competitors,
26. New solutions overcome the initial project.

We asked managers from 15 state-owned enterprises using an initial list of 20 variables which we then increased to 26 variables. Then we randomly chose 32 successful innovations (9 products, 9 processes, 7 materials, 7 manufacturing processes) in 32 enterprises, and asked the managers responsible the following questions:

1. What degree of influence, p, had the 26 blocking variables on your innovation?
2. What degree of influence, q, had the firm's own measures in reducing blocking variables?

The degree of influence was measured by the scale:
0 = no importance, 1 = little importance, 2 = medium importance, 3 = high importance, 4 = very high importance.

Our aim was to identify the capacity of the firm to overcome barriers and bottlenecks in the innovation process. We expected that the activity of a firm, q, might somehow be correlated with the intensity of blocking variables, p. What were the results of this investigation?

RESULTS OF ENQUIRY CONCERNING 26 VARIABLES AFFECTING INNOVATION PROCESS

The correlation coefficient between q and p was 68.82% over 32 innovations and 79.22% over 26 variables. Both are statistically significant at an error level of less than 0.1%. It was necessary to investigate more deeply the specific patterns of influence for certain combinations of variables. Table 1 shows the number of statistically significant correlations between the variables.

According to this and to the average values of p and q we obtained the following results (Table 2).

The five most important inhibiting variables in the case of the 32 firms were:

-- Inability to master the process after handing over by the development group (6),
-- Insufficient supply of machines and means of rationalization (4),
-- Differences between managers and experts (10),
-- Failures in development stages (5), and
-- Failure of the management. Insufficient engagement of responsible managers (8).

Table 1. Number of statistically significant correlations between 26 variables for p and q.

No.	Variables
1	Insufficient supply of the supplier industry
2	Technical difficulties
3	Stress by other production tasks
4	Insufficient supply of machines & means of rationalization
5	Failures in development, not yet abandoned
6	Inability to master the process after handing over by the development group
7	Lack of R & D personnel
8	Failures of management. Insufficient engagement of managers
9	Long coordination to of superposed management
10	Differences between managers and experts
11	Failures in preparation of production
12	Delay in construction activities
13	High costs. Planned economy not reached
14	Insufficient technological and qualitative level
15	Conservative and obsolete views
16	Inexact and changing objectives
17	Delay in recognition of problems. Failures in information
18	Changing demand
19	State orders limit the project
20	Insufficient know how transfer with other branches
21	Saving measures
22	Unfavourable price relations
23	Insufficient special knowledge
24	Uncoordinated development in several branches
25	Better solutions from competitors
26	New solutions overcome the initial project

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Number of significant relations for p	6	3	4	3	2	2	6	3	0	11	3	6	0	1	9	2	5	7	5	2	1	1	1	9	7	8
Number of significant relations for q	6	3	8	3	1	1	3	4	3	6	4	3	3	2	10	7	11	7	10	12	5	8	3	7	3	6
Sum of significant relations for p and q	12	6	12	6	3	3	9	7	3	17	7	9	3	3	19	9	16	14	15	14	6	9	4	16	10	14

◢ correlation for p ◤ correlation for q ■ complementary correlation for p and q

Table 2. Rank order of variables by various measures.

No.	variables	Average p	Average q	Σpq q	Relations between p	q	Sum
1	Insufficient supply of the supplier industry	19	18	22	8	11	9.5
2	Technical difficulties	10	6	15	14.8	19.5	19
3	Stress by other production tasks	12	9	4	12	5.5	9.5
4	Insufficient supply of machines & means of rationalization	2	2.5	7	14.5	19.5	19
5	Failures in development, not yet abandoned	4	2.5	3	18.5	25.5	24
6	Inability to master the process after handing over by the development group	1	10.5	19	18.5	25.5	24
7	Lack of R & D personnel	24	23	1	8	19.5	13.5
8	Failures in management. Insufficient engagements of managers	5	4.5	9.5	14.5	14.5	16
9	Long coordination time of superposed management	7	1	2	25.5	19.5	24
10	Differences between managers and experts	3	14	8	1	11	2
11	Failures in preparation of production	25	25	25	14.5	14.5	17
12	Delay in construction activities	17	19.5	17	8	19.5	13.5
13	High costs. Planned economy not reached	8	7	12	25.5	19.5	24
14	Insufficient technological and qualitative level	11	4.5	5	22.5	24	24
15	Conservative and obsolete views	18	16	16	2.5	3.5	1
16	Inexact and changing objectives	13	22	20	18.5	8	13.5
17	Delay in recognition of problems. Failures in information	21	19.5	18	10.5	2	3.5
18	Changing demand	26	24	21	5.5	8	7
19	State orders limit the project	22	21	23	10.5	3.5	5
20	Insufficient know how transfer with other branches	23	26	26	18.5	1	7
21	Saving measures	15	12.5	6	22.5	13	19
22	Unfavourable price relations	16	8	13.5	22.5	5.5	13.5
23	Insufficient special knowledge	6	17	24	22.5	19.5	21
24	Uncoordinated development in several branches	14	12.5	9.5	2.5	8	3.5
25	Better solutions from competitors	9	10.5	13.5	5.5	19.5	11
26	New solutions overcome the initial project	20	15	11	4	11	7

The most interlinked blocking variables were:

-- Differences between managers and experts (10),
-- Conservative and obsolete views (15),
-- Uncoordinated development in social branches (24),
-- New own solutions, overcoming the initial project (26), and
-- Changing demand.

Most important promoting variables were:

-- Better coordination with superposed management (9),
-- Own production of rationalization means (4),
-- Reduction of failures in development stages (5),
-- Improvements in management (8),
-- Improvements in technological and qualitative level (14),

The most interlinked promoting variables were:

-- Better know how transfer with other branches (20),
-- Faster recognition of problems and improvement in information (17),
-- Better adaptation to new state orders and laws (19),
-- Positive changes in views and approaches (15),
-- Reducing stress by other production tasks (3).

AN APPROACH FOR FINDING THE MAIN FACTORS INHIBITING OR PROMOTING INNOVATIONS

In our discussions with managers we clarified that the ability to master the innovation process is a very complex phenomenon. Some specialists stress the importance of creative or innovative potential, but on the other side, if this potential is not used in the right direction, the results will not be sufficient. Therefore a second major point is firm's strategy and long-term orientation. Having a considerable innovation potential

and also an appropriate strategy, the whole thing could be ruined through stress by other production tasks. Capability of mastering ongoing processes is therefore the third factor. The innovation process is a very complex process touching the whole network of supplier and buyer relations. Therefore a fourth factor is cooperation and coordination

These four determinants are more or less related to the main stages of the innovation process and therefore we came to the following analytical scheme (Table 3).

Table 3. Determinants and stages of the innovation process and their measurement through the variables

Determinants for innovations	R & D	Prediction	Marketing	Management in all stages
Innovation potential I	2,5,7, 11,14, 26	2,6,13	14	6,8,10 15,23
Strategic orientation S	1,7,14 17	22	18	9,10,15 16,17
Capacity for ongoing processes O	3,7	3,13,21	18	8,9,10
Cooperation and coordination C	1,4,24	1,4,20	20,25	1,9,10 17,19

We adjusted the 26 variables to the four determinants I,S, O,C, over the four stages R & D, Production, Marketing and Management, by our assumptions of their dependencies. To prove this we used the multivariate factor analysis. Multivariate factor analysis gives us the opportunity to identify the main factors among many variables by investigating their laten intercorrelation. As a criterion we used here the so-called factor loading of a variable at a level of at least ±0.40. We could identify 7 factors in the case of inhibiting variables (Table 4) and also 7 factors in the case of promoting variable (Table 5). If we try to adjust

Table 4. Inhibiting variables and their factor configuration.

	Factors			
	1	2	3	4
VARIABLES	11 Failures in preparation of production 0.81	18 Changing demand 0.74	24 Uncoordinated development in several branches 0.66	22 Unfavourable price relations 0.75
	7 Lack of R & D personnel 0.69	16 Inexact and changing objectives 0.70	21 Saving measures 0.64	3 Stress by other production tasks 0.74
	15 Conservative and obsolete views 0.63	1 Insufficient supply of the supplier industry 0.66	4 Insufficient supply of machines 0.61	19 State orders limit the project 0.46
	25 Better solutions from competitors 0.62	17 Delay in recognition of problems 0.55	26 New solutions overcome the initial project 0.55	
	19 State order limit the project 0.41	12 Delay in construction activities 0.52	12 Delay in construction activities 0.41	
	5	6	7	
	6 Inability to master the process after development 0.72	13 High costs. Planned economy not reached 0.62	8 Failures of management 0.67	
	2 Technical difficulties 0.60	21 Saving measures 0.42	10 Differences between managers & experts 0.58	
	23 Insufficient special knowledge 0.42	19 State orders limit the project 0.41	5 Failures in development 0.54	

Table 5. Promoting variables and their factor configuration (factor loadings).

	Factors			
VARIABLES	1	2	3	4
	17 Delay in recognition of problems 0.87	25 Better solutions from competitors 0.71	23 Insufficient special knowledge 0.74	4 Insufficient supply of machines 0.83
	20 Insufficient know-how transfer 0.84	24 Uncoordinated development in several branches 0.67	16 Inexact and changing objectives 0.68	21 Saving measures 0.62
	12 Delay in construction activities 0.64	26 New solutions overcome initial project 0.67	10 Differences between managers & experts 0.66	1 Insufficient supply of the supplier industry 0.41
	11 Failures in preparation of production 0.59	22 Unfavourable price relations 0.66	7 Lack of R & D personnel 0.63	13 High costs 0.41
	15 Conservative and obsolete views 0.42	15 Conservative and obsolete views 0.65	18 Changing demand 0.50	
	1 Insufficient supply of the supplier industry 0.40	14 Insufficient technological and qualitative level 0.57	14 Insufficient technological level 0.45	
	5	6	7	
	3 Stress by other production tasks 0.63	6 Inability to master the process after development 0.73	9 Long coordination time of superposed management 0.68	
	10 Differences between managers and experts 0.50	4 Insufficient supply of machines 0.58	8 Failures of management 0.44	
	14 Insufficient technological level 0.45	13 High costs 0.50		
	19 State orders limit the project 0.43			
	8 Failures of management 0.42			

these factors to determinants and stages of the innovation process we get the following results:

1. Inhibiting variables:

Factors	Determinant	Stage
1.	Innovation potential I	R & D
2.	Strategic orientation S	Management in all stages
3.	Cooperation and coordination	R & D
4.	Economic mechanism	Management in all stages
5.	Know how factor	Management in all stages
6.	Cost factor	Management in all stages
7.	--	Management in all stages

2. Promoting variables:

Factors	Determinant	Stage
1.	Strategic orientation	R & D
2.	Cooperation and coordination	R & D
3.	Strategic orientation	Management in all stages
4.	Cooperation and coordination	Management in all stages
5.	Capacity for ongoing processes	Management in all stages
6.	Innovation potential	Production
7.	--	Management in all stages

It is interesting to note that innovation potential, strategic orientation, cooperation, and coordination, are the main determinants, connected to the strongest inhibiting variables. Conversely the development of innovation potential does not play such an important role on the side of promoting variables. We could identify three other determinants which are also important:

-- Economic mechanism, including price relations, planning mechanisms and other incentives,

-- Know how factor, and

-- Cost factor.

And so we arrived at an improved scheme for factor analysis (Table 6). This gives us an impression of the practical complexity of innovation management.

Table 6. Determinants, stages, and factors of the innovation process, measured by 26 variables

Determinants \ Stages		R & D	Production	Marketing	Management of the whole process
1 Innovation potential	I	p 11,7,15, 25,24,19 (1)	6,13,23	14	8,10,15
		q	6,14,13 (6)		
2 Strategic orientation	S	p 7,14,17	16,20,24	18	18,16,1,17,12 (2)
		q 17,20,12, 11,15,1 (1)			23,16,10,7,18 14 (3)
3 Cooperation and coordination	C	p 24,21,4, 26,12 (3)			4,21,1,13 (4)
		q 25,24,26, 22,15,14 (2)			4,21,1,13 (4)
4 Capacity for ongoing processes	O	p 3,7	3,13,21	18,23	13,21,19 (6)
		q			3,10,14,19,8 (5)
5 Economic mechanism	E	p			22,3,19 (4)
		q			
6 Know how factor	K	p 5,12,20, 23	6,20,23	14,18	6,2,23,20 (5)
		q			
All together		p			8,10,5 (7)
		q			9,8 (7)

() Factor number p = inhibiting variables q = promoting variables

The figures in the factor fields are the variables from the multivariate factor analysis. The underlined figures show the variables appropriate also from a more qualitative judgement.

FACTOR PROFILES FOR COMPARISON OF ENTERPRISES

The number of innovations analyzed is too small for stronger judgements. But it became clear that in these instances the systematic development of innovation potential is not organized enough. The influence of inhibiting factors in a given firm and also the influence of promoting factors can be described by a profile. We also discovered that the objective factor configuration is far more unified than the specific behaviour of firms. This means we should recognize more effectively the objective factor configuration of the innovation process according to industries and the national economy, and also according to basic innovations and improvement innovations.

On the other hand we should analyze the individual behaviour of the firms and compare it with the objective factor configuration on industry or societal level. This could give us some indication about the management of the firm as well as for national innovation policy.

The consequences of an inadquate policy for innovation in an industrial firm are not always immediately apparent. It may also take a long time to develop and to use creative potential. Main attention should be given to the human factor and to the right combination between the main factors of the innovation process.

We would propose investigating this problem by a specific profile, showing the strength of inhibiting factors as well as the strength of a firm's own ideas and measures, over the stages of the innovation process. Figure 1 presents such a profile for the whole sample of 32 innovations in the sectors of the consumer goods industry investigated.

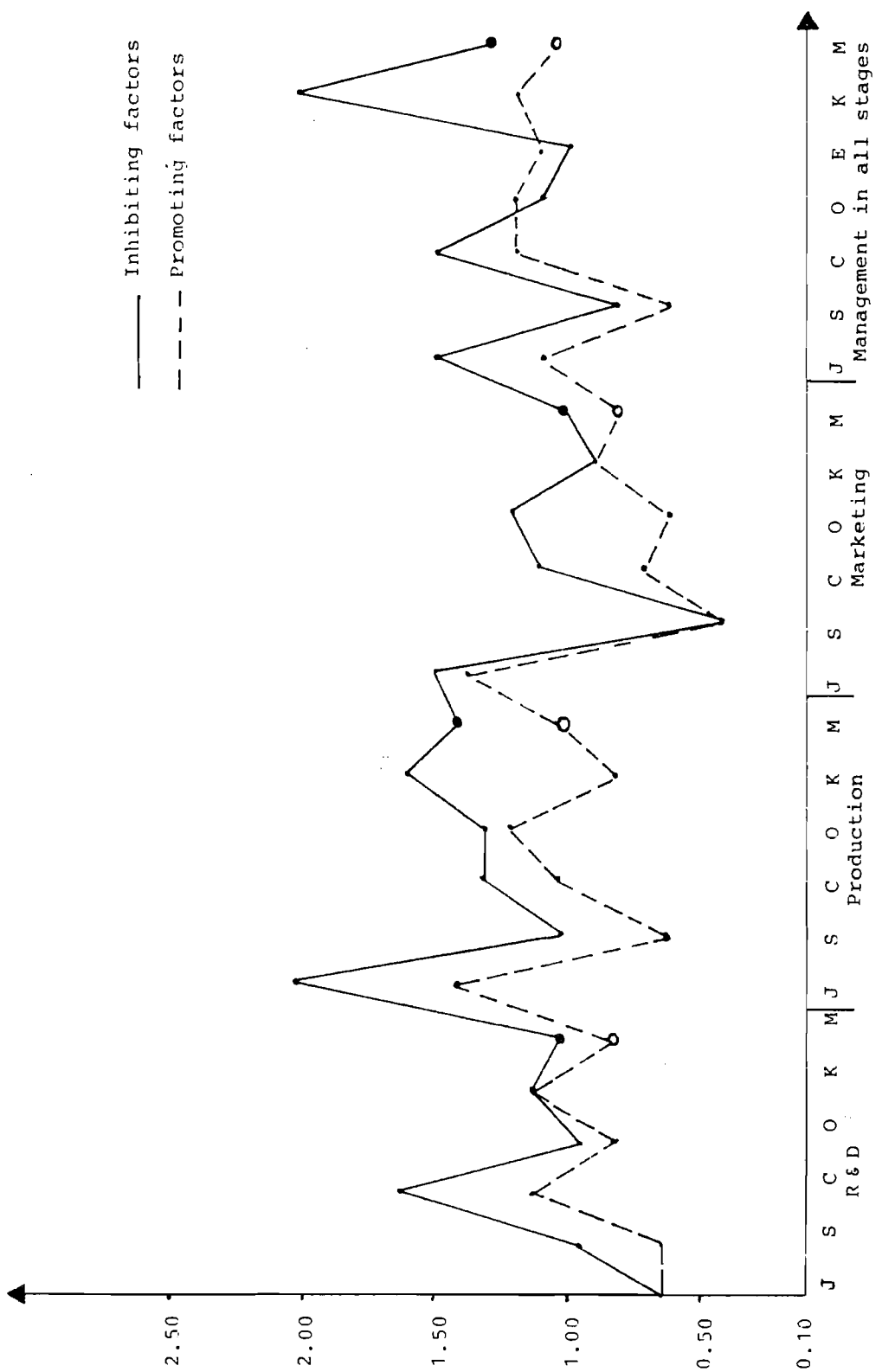

Figure 1. Profile of the strength of inhibiting factors and promoting factors of innovation process for 32 firms on average.

According to this picture we find the greatest differences between the strength of inhibiting factors and the strength of the firm's own capabilities in the following determinants and stages:

-- Cooperation and coordination - R & D

-- Innovation potential - Production

-- Know how factor - Production

-- Capacity for ongoing processes - Marketing.

Therefore a long-term development programme for the given industry should include measures for improving R & D--organization as well as the necessary increase of qualification level in production. We can state that the present organizational changes in GDR industry have the explicit goal of mastering the complexity of the innovation process and enabling firms to implement their new products and processes without bureaucratic delays. In this process exchange of experience between enterprises plays an important role.

Comparison of enterprises (Betriebsvergleich) is a remarkable tool for recognizing bottlenecks as well as opportunities. For example in Figure 2 a single firm's profile is compared with the average of the investigated sample. This shows that this firm might have good experience in marketing, useful for other enterprises. Further, in former times, comparison of enterprises was mainly oriented towards technical and economic indicators. Comparison of determinants of innovation process, innovation potential, and know how factor could be a useful addition to a traditional tool of management.

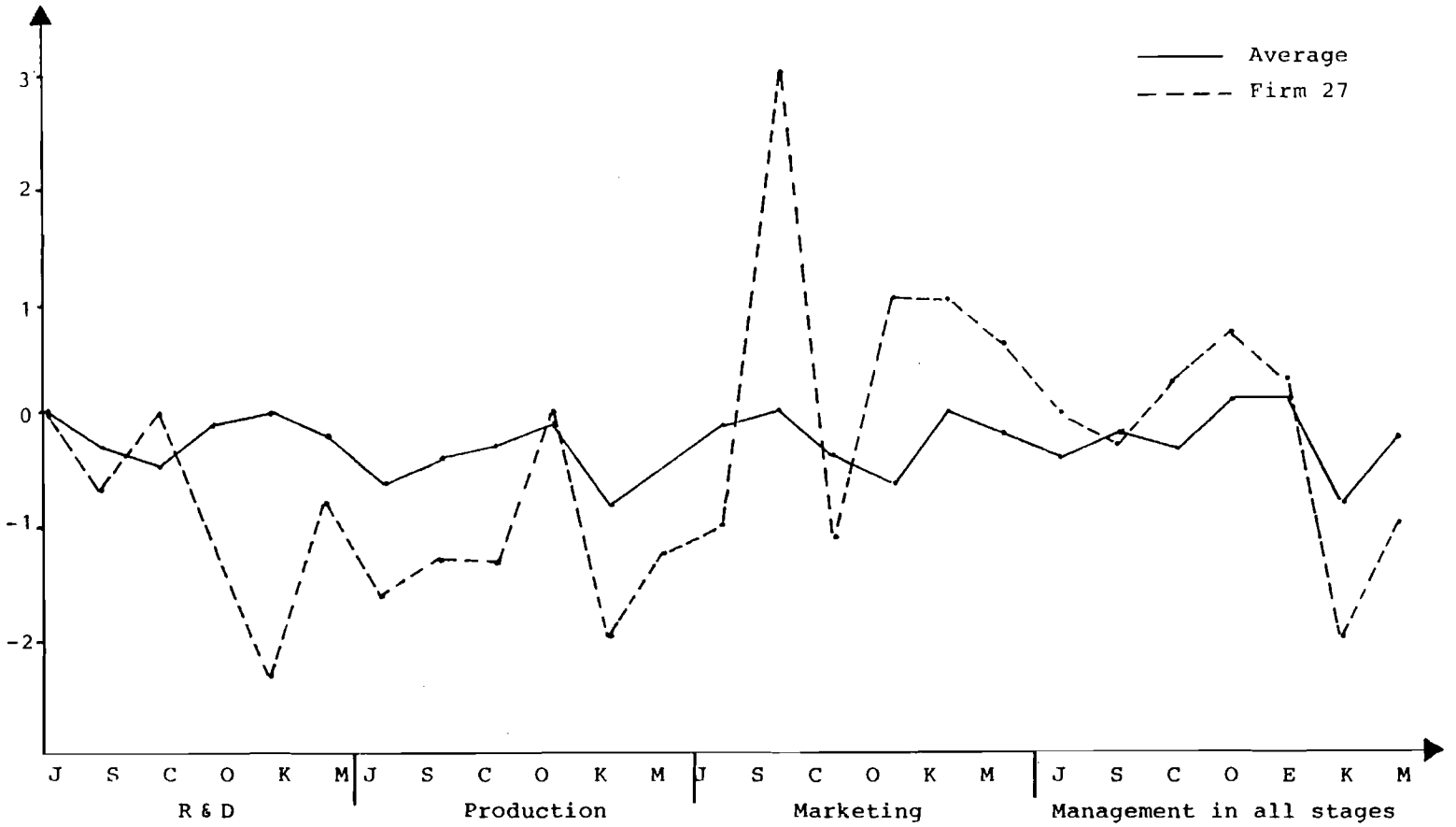

Figure 2. Difference between strength of promoting factors and inhibiting factors of innovation process for 32 firms and for a single firm.

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