SZENT ISTVÁN UNIVERSITY

The innovation activities of Hungarian agricultural machinery manufacturers

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Árpád Bak

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Doctoral school

Name: **Technical Scientific Doctoral School**

Discipline: **Agricultural Engineering**

Head of School: **Prof. Dr. István Farkas**

professor, DSc

Szent István University,

Faculty of Mechanical Engineering,

Institute of Environmental Systems

Supervisor: **Prof. Dr. István Husti**

professor, DSc

Szent István University,

Faculty of Mechanical Engineering,

Institute of Engineering Management

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Approved by head of school   Approved by supervisor

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1. INTRODUCTION AND OBJECTIVES

The global social and economic changes that could be felt in the past decade forced the players of the public and private sector to base their decision making mechanisms on information of better quality while reacting to the challenges of the era. This need is more and more underpinned by recognising the economic role of innovation in the case of agricultural machinery manufacturers.

The basic objective of my dissertation is to survey the innovation activities of the national agricultural machinery manufacturers. My examinations are directed at exploring the innovation activities and results of the Hungarian agricultural machinery manufacturing enterprises. A thorough picture has been made about the forms, sources, influencing factors and main characteristics of novelties.

My further objective is to prepare and develop such a complex examination methodology which is suitable for collecting and evaluating primary data on the innovation activities of the Hungarian agricultural machinery manufacturers and organisations with a similar profile.

My research objectives are summarised in the points below.

1. Reviewing and evaluating the relevant national and international literature on the topic with special regards to the features of agricultural technological innovations.

2. Reviewing national and international macro-statistical data on innovation to interpret the results of the examinations on the performance within the industry.

3. Reviewing and evaluating the best practices of measuring innovation that serve as the basis for a sector specific examination methodology.

4. Preparing and improving a questionnaire and a method of examination that can be used to collect primary data on the innovation activities of agricultural machinery manufacturers.

5. Working out a complex innovation measuring methodology that is suitable for the complex evaluation of the innovation performance of the national agricultural machinery manufacturers with special regards to the special characteristics of the sector.

6. Preparing a thorough picture of the present situation and performance of agricultural machinery innovations as well as the direction of developments on the basis of the empiric research and methodology.

7. Exploring the implementations, national characteristics and internal relations of agricultural machinery innovations and development by analysing data.

2. MATERIAL AND METHOD

This chapter outlines the *concept* that led from drafting up questions through data collection and analysis to presenting the results.

2.1. Research questions in details

The questions of the research in details as well as the points of view deriving from the basic objectives of examination are the following:

1. What are the main indicators, decisive trends and narrow cross sections of the innovation performance of the national agricultural machinery manufacturers?
2. What components influence the technological development and innovation activities of enterprises and what are the assisting, hindering and motivation factors?
3. How can the effects of the global economic climate be felt by the enterprises with special regards to their innovation activities?
4. How can the general and innovation organisational characteristics of enterprises affect innovation results?
5. What is the cooperation activity of enterprises like, what are the characteristics of their social network and how can they affect innovation activities?
6. What internal correlations can be explored between the general organisational characteristics of enterprises that affect their innovation results/performance and their innovation (R&D) activities?
7. How can the relations between corporate strategy, marketing and innovation activities of the examined manufacturers be characterised?
8. What method can be applied to separate the sample and what are the unique features of the created groups like on the basis of their research and development, innovation and general organisational characters?

2.2. Hypotheses of the research

While formulating the *hypotheses of the research* the theoretical conclusions drawn from synthetizing the relevant professional literature and the initial questions raised during the research were considered. On the basis of them, seven hypotheses were drafted.

Hypothesis 1/a.: The probability of introducing new products and technologies increases in line with the revenue of agricultural machinery manufacturers.

Hypothesis 1/b.: The probability of introducing new products and technologies increases in line with the number of employees at agricultural machinery manufacturers.

Hypothesis 2.: More agricultural machinery manufacturers with research-development divisions introduce new products or/and technologies than those without such divisions.

Hypothesis 3.: The objectives and tasks of the innovation activities of the Hungarian agricultural machinery manufacturers derive from the concept of 'technological pressure'.

Hypothesis 4.: Mainly the agricultural machinery manufacturers with research-development divisions introducing new products or/and technologies take part in research-development cooperations.

Hypothesis 5.: Lack of deliberate innovation concept based on strategic approach basically prevents agricultural machinery producers from developing successful innovation activities.

Hypothesis 6.: The national agricultural machinery manufacturers subordinate their marketing activities to short term market objectives and marketing has a weak effect on innovation as well as R&D activities.

Hypothesis 7.: The national agricultural machinery producers can be classified on the basis of their corporate, organisational and innovation characteristics. The single divisions can be described by unique corporate and innovation features, which can influence their ability for a renewal.

2.3 The method and process of the research

Basically my research is based on *primary research* within the framework of which a questionnaire was compiled. When drafting the questions the results of my secondary research data on this industry were considered and also the 2005 edition of 'Oslo Handbook' was consulted that formulates OECD guidelines for collecting and interpreting technological innovation data. According to the general methodological requirements some pilot interviews were made a first and afterwards the questionnaire was finalised on the basis of my experience.

2.4. Issues of sample taking and reliability

In Hungary more than 100-150 enterprises deal with producing agricultural machinery and machine parts. Experts estimate that the number of companies engaged in agricultural machinery production as *the main profile* is approximately *forty*. The contact addresses of all the enterprises necessary for the questionnaire were gained through MEGOSZ.

The multi-channel approach was used when recording the data of the research whose main points are the following:
- 15 machine manufacturers were interviewed personally;
- Questionnaires were sent to 25 organisations by post asking them the send it back after filling in the questionnaire.
- The electronic version of our questionnaire was sent to organisations that were incorporated in the MEGOSZ database. Altogether 18 questionnaires were returned.

The same questionnaire was used in all three approaches so figures can be compared. Data were recorded between March 2010 and August 2010. Fifty eight organisations supplied data in the examination. An approach based on proportion estimate was selected to ensure the reliability and accuracy of the research. The accuracy level of the entire sample is ±7,7 per cent points with fixed 95 per cent reliability on the basis of the statistical calculations that were carried out. However, a positive feature is that mainly the senior management (chief executive officer, production or technical manager) provided the data. As a result, hands-on information was gained about the general situation, current plans and strategic way of thinking of the organisations concerned.

2.5. The Complex Innovation Index

The following part describes the novel concept and method by means of which the examined sample was divided and ranked based on the unique innovation and organisational characteristics.

Of the criteria defined for indicators the professional literature emphasizes specific nature, measurability, accessibility, reliability and its validity for a limited period in time. One of the main functions of indicators is data reduction, i.e. the requirement to reduce the amount of information which has to be considered for the decision makers.

The indicator to be established (termed as *Complex Innovation Index*) is based on incorporating several innovation characteristics. The negative values of the derived rank order suggest low innovation potential while the other end of the scale refers to high innovation potential. During the creation of the theoretical model, innovation indicators based on quantitative indicators and expressed in natural units as well as the qualitative innovation features expressing efficiency were included.

The information content of the Complex Innovation Index includes
- The quantitative figures describing innovation input and output that were incorporated in the so-called activity features. In the case of product and process innovations their novelty was considered, which added a weighed difference to the index.

- Qualitative features such as revenue related innovation and R&D expenditure or the number of researchers and developers as of the total number of employees were considered in the indicator of innovation efficiency. Innovation strategy and cooperation were also part of qualitative features during the analysis.
- The features of general corporate processes were summarised in corporate efficiency. The variables (though to a different extent) selected on the basis of the examinations carried out so far are in a significant relationship with innovation activity so their application is justified.

On the basis of the theoretical model presented by *Figure 1* the single (already standardised) variables were joined by principle component analysis and then the newly created variables were also subject to analysis. The relevant principle component score was assigned to the organisation, which, as an aggregated variable, includes the innovation features typical of the selected organisation. The system of 14 variables constructed to analyse the innovation of 58 enterprises was reduced to a principle component with suitable information content (above 70%). *Figure 1* summarises the model of the complex innovation indicator with the results of the calculated principal component analyses.
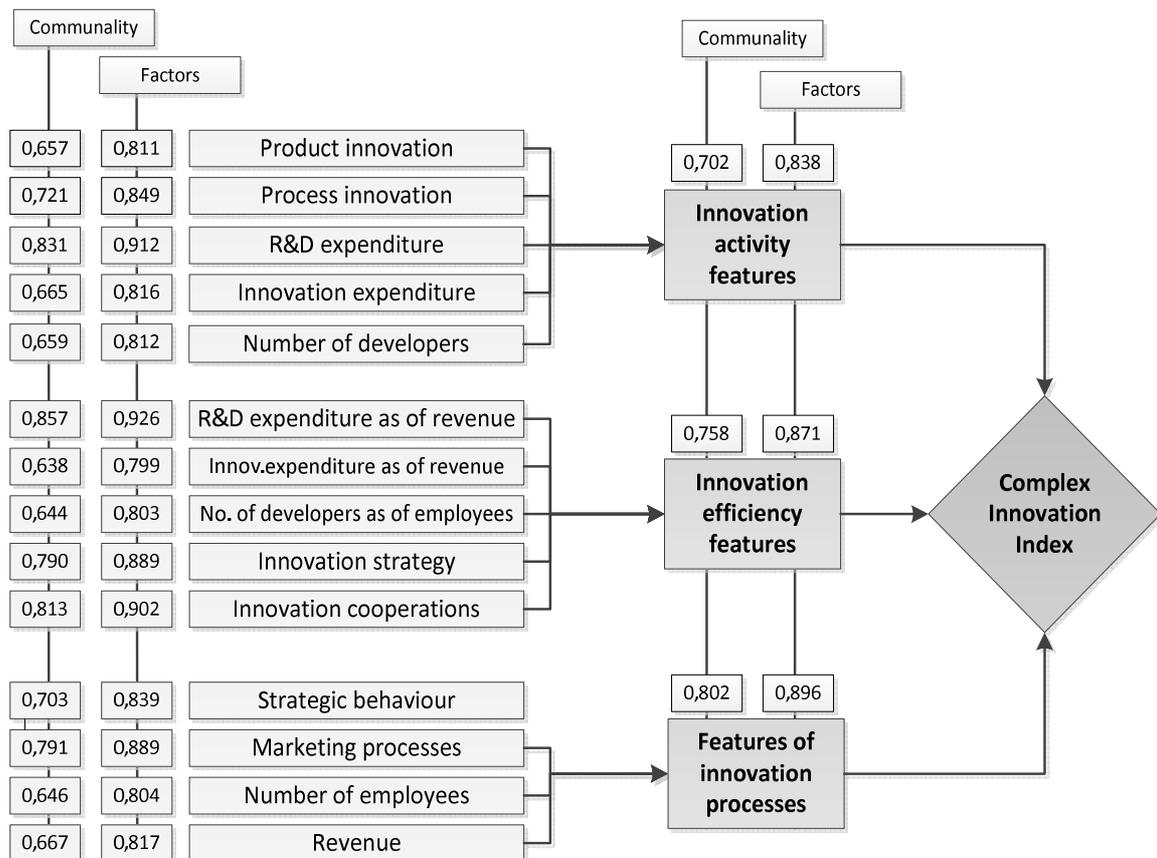

Figure 1: Summarising Complex Innovation Indicator by factor weight and communalities

3. RESULTS

3.1. Results of the characteristics of the research sample

Table 1 shows the aggregated revenue of the enterprises concerned. *Seventy five percent* of the revenue derives from *agricultural machinery manufacturing*. Seventy two percent of the examined organisations sell on the Hungarian market and in the past three years there was no significant change in this respect. The average revenue was approximately 1 billion Ft. Median helps formulate a clearer picture about the situation as a revenue of 700 million Ft is typical of the SME sector in Hungary.

Table 1: Correlations of revenue data (n=58)

Revenue (million HUF/year)	Periods		
	2007	2008	2009
Total revenue	5370	5920	5500
Average	1094,9	1285,7	1140,1
Median	692,5	708,6	665,2
Maximum	8273	9752	6101
Minimum	28	25	20
The size of the enterprises by revenue (%)	**2007**	**2008**	**2009**
Small enterprise(<700)	51,7	48,3	44,8
Medium enterp. (700-4000)	41,4	44,8	48,3
Large enterprise(4000<)	6,9	6,9	6,9

According to my examinations there is a significant connection between revenue and innovation activity (*Table 2*). By analysing the internal correlations it can be seen that a significant part of micro enterprises is inactive regarding those with revenue below 100 million Ft and also the number of employees. In this way *Hypothesis 1/a.* is proved by the statistical results.

Table 2: Correlations between revenue, product and procedure innovations

Revenue (million HUF)	Product inn. (%)		Total %	Procedure inn. (%)		Total %
	No	Yes		No	Yes	
1. 0-100	100,0	0,0	6,9	100,0	0.0	6.9
2. 101-450	56,3	43,8	27,6	62,5	37.5	27.6
3. 451-1200	23,1	76,9	44,8	15,4	84.6	44.8
4. over 1200	8,3	91,7	20,7	0,0	100.0	20.7
Total (%)	34,5	65,5	100,0	31,0	69.0	100.0
n (item)			58			58
Significance			0,018			0,007
Cramer V			0,417			0,459

According to my examinations there is a significant connection of medium strength between the number of employees and innovation activity (*Table 3*). Of the correlation analyses carried out one of the strongest one can be experienced in this area. In this way *Hypothesis 1/b.* is proved by the statistical results.

Table 3: Correlations between size by the number of employees, product and procedure innovations

Number of employees	Product inn. (%)		Total %	Procedure inn. (%)		Total %
	No	Yes		No	Yes	
Micro ent. (1-9)	100,0	0,0	6,9	100,0	0.0	6,9
Small ent. (10-49)	53,8	46,2	44,8	42,3	57.7	44,8
Medium (50-249)	9,1	90,9	37,9	13,6	86.4	37,9
Large ent. (250 <)	0,0	100,0	10,3	0,0	100.0	10,3
Total (%)	34,5	65,5	100,0	31,0	69.0	100,0
n (item)			58			58
Significance			0,016			0,003
Cramer V			0,423			0,491

3.2. The organisational features of the examined sample

Within the scope of time examined 34,5 percent of enterprises had a separate R&D division, which can be regarded as favourable when compared to the surveys in other industries. The assumption of *Hypothesis 2* according to which more agricultural machinery manufacturers with research-development divisions introduce new products or/and technologies than those without such divisions cannot be proved by the results obtained. Statistical trials did not justify the correlation on the entire sample.

Regarding organisational form, an interesting finding is that 48,2 percent of the enterprises operate in a linear while 37,9 percent of them in a simple organisational form, i.e. they do not have functionally separate organisational units while 13,8 percent have functional organisational forms.

3.3. Inputs of innovations

According to the results the examined enterprises realised the necessity of development and the figures show an increasing tendency in this respect. Enterprises tend to have spent more on innovation as of revenue (*Table 4).* When examining the median, again a clearer picture can be obtained. One-two percent of the revenue is spent on research and development while 3-4 percent is used for innovation.

Table 4: Innovation, R&D and marketing expenditure as of percentage of revenue (n=58)

Average (%)	2007	2008	2009
R&D expenditure	2,6	3,38	4,1
Innovation expenditure	3,0	4,3	5,3
Marketing expenditure	1,3	1,6	1,8
Median (%)	2007	2008	2009
R&D expenditure	0,9	1,7	2,1
Innovation expenditure	1,3	2,7	3,9
Marketing expenditure	0,7	0,9	1,4

One of *the widest spread innovation indicators* is the correlation between the research-development ratio as of revenue and the innovation results.

Table 5: The correlation between R&D ratio as of revenue and product-and procedure innovation

R&D expenditure of turnover	Product inn, (%)		Total %	Procedure inn, (%)		Total %
	No	Yes		No	Yes	
1, 0 (%)	100,0	0,0	13,8	87,5	12,5	13,8
2, 0,1 - 3 (%)	50,0	50,0	31,0	44,4	55,6	31,0
3, 3,1 - 6 (%)	12,5	87,5	41,4	12,5	87,5	41,4
4, 6,1 (%) <	0,0	100,0	13,8	0,0	100,0	13,8
Total (%)	34,5	65,5	100,0	31,0	69,0	100,0
n (item)			58			58
Significance			0,023			0,019
Cramer V			0,293			0,256

A smaller part of enterprises (13,8%) do not spend on R&D, their innovation activity is slight and some activity may only be experienced in terms of technological development. The enterprises that spend more (between 0,1 – 3%) have a better sign of innovation. The results of correlation examinations show that there is a significant relationship between product-and procedure innovation and R&D ratio although it is weak (Cramer-V: 0,293; 0,256).

In the following part I examine the role of the ratio of those employed in R&D play sin the development processes as an independent variable. The success of product-and procedure innovation is more likely in the case of companies with a higher number of development specialists so a positive significant correlation can be experienced.

3.4. Outputs of innovations

According to my examinations 65,6 percent of enterprises during the period of examination launched a new product to the market or modified some and 68.9

percent carried out technological innovation. Fifty nine percent started to be implementing an innovation project at the time of the survey. The development of a new product of global standard is, unfortunately, very limited (5,3 %). 34,2 percent of the implemented product developments by the enterprises can be regarded as a novelty under Hungarian circumstances. At the same time a significant part, namely 60,5 percent are only about innovations of modifying-developing nature. With respect to modernity, manufacturers seem to concentrate on rather technological development as 48,7 percent of the examined sample developed/introduced new technologies not applied so far in Hungary.

Another aspect of research-development and innovation activities consists of publications and patents. In this aspect the performance of Hungarian agricultural machinery manufacturers is rather weak. During the examined period regardless of one or two examples patents and publications were not typical of the enterprises in the industry.

3.5. Objectives of agricultural machinery innovations

Of the product innovations (*Figure 2*) improving the quality of the products (4,6) ranks *first*. Regarding the innovation objectives of enterprises the efforts of widening the market is the *second*.
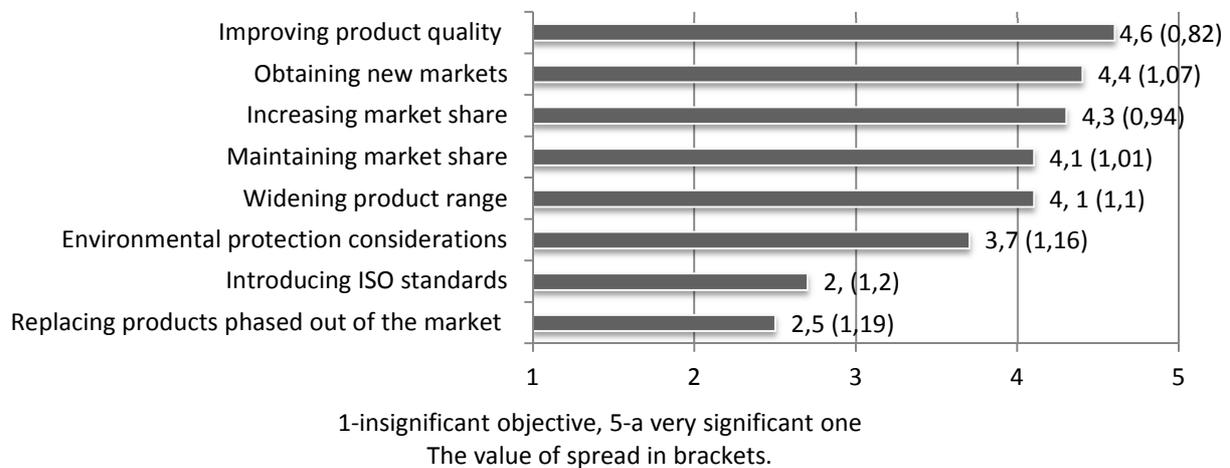

1-insignificant objective, 5-a very significant one
The value of spread in brackets.

Figure 2: Objectives of product innovations
(n=58, α=0,731)

In the last third of product innovation objectives we can find environmental considerations (3,7), introducing ISO standards (2,7) and replacing products phased out of the market (2,5).

A map of scaling was drafted (*Figure 3*) how manufacturers realise typical innovation objectives and R&D tasks. The typical groups are the following.

- *Preferred development and business objective:* improving the quality of product, maintaining market share.
- *Slightly preferred development and business objective:* increasing market share, widening product range, obtaining new markets, environmental protection.
- *Not preferred development and business objective:* introducing ISO standards, replacing products phased out of the market.
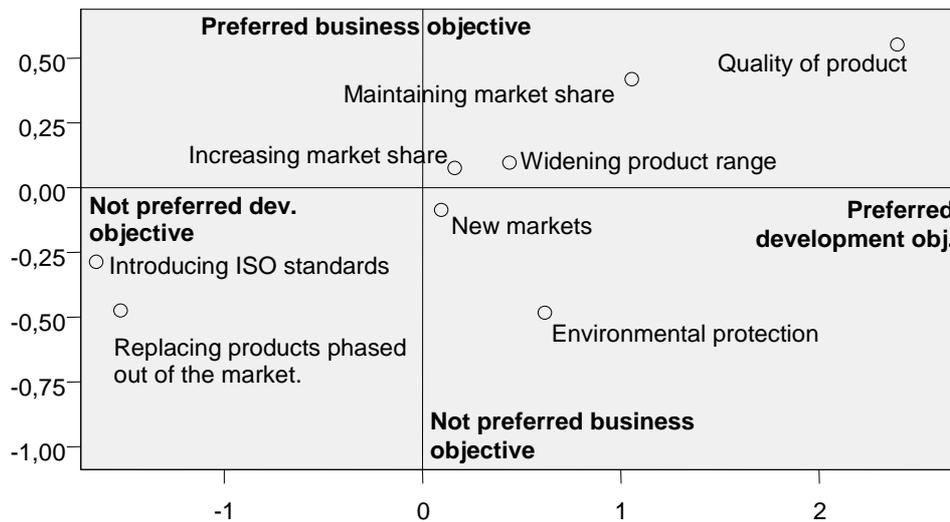

Figure 3: MDS map showing objectives of product innovations

MDS examinations were also carried out for technological innovations and the applied dimensions were the same as the previous ones. The fitting of the model is suitable this time, as well (RSQ = 0,81628) while quality is satisfactory (Stress = 0,12470).

Again, three groups can be observed.
- *Preferred development and business objective:* improving the quality of product, decreasing production costs, decreasing material and energy costs, decreasing units of wage.
- *Slightly preferred development and business objective:* decreasing environmental damage, increasing IT capacity, compliance with industrial standards, widening production and service capacity.
- *Not preferred development and business objective:* introducing ISO standards, decreasing costs of product planning.

Based on the results of the examinations carried out *Hypothesis 3 cannot be justified.* Analyses stress that the pulling power of market needs motivates the innovation activities of the national agricultural machinery manufacturers, of which improving quality, reliability and increasing safety are markedly highlighted.

3.6. Assisting and hindering factors of innovations

When examining the results it is not surprising that most of all it is the high cost of innovation (3,42) that prevents Hungarian agricultural machinery manufacturing companies from their innovation activities. Controlling innovation costs is rather problematic due to the uncertainties of the different sub-processes and their parts as unexpected costs can incur very frequently. Lack of state and project funds (3,08) is another significant hindering factor.

The separation of financial funds within the company (3,08) is a problem tightly linked to the previous one. A frequently made excuse is that the available funds are needed for other purposes so due to the necessity of ensuring everyday living uncertain developments are often sacrificed. High risk (2,81), taxation and its legal regulation (2,77) and the weakness of protecting intellectual property rights (2,28) are also seen as further obstacles.
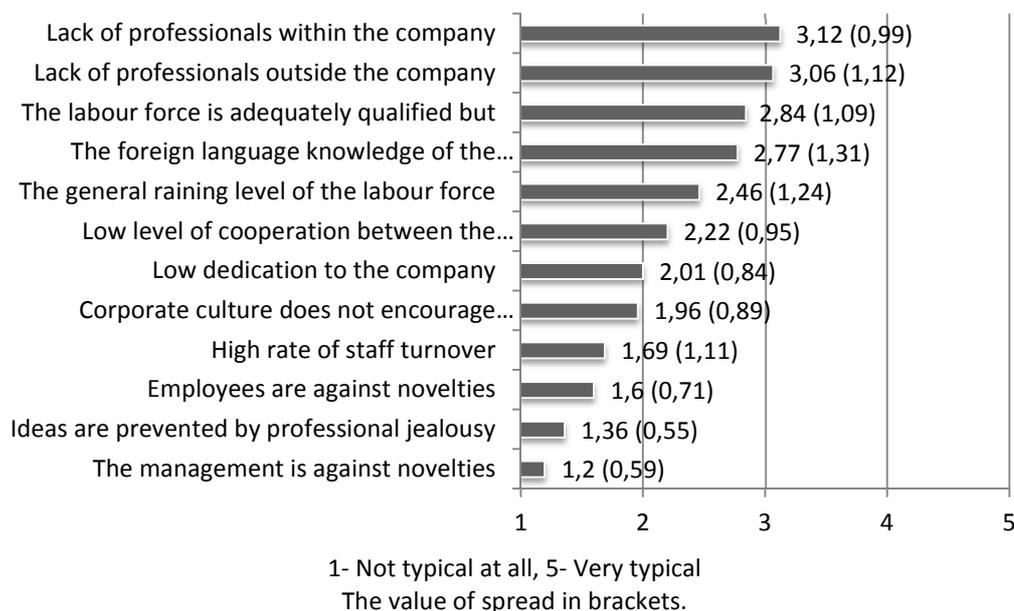

1- Not typical at all, 5- Very typical
The value of spread in brackets.

Figure 4: Human factors that hinder corporate innovation
(n=58, α=0,756)

I examined the human factors within the hindering factors of spreading innovation separately (*Figure 4*). The results are obvious as the factors in connection with *lack of professionals and training* are among the five most significant hindering ones. According to the chief executives the motivation of their subordinates and fluctuation do not hinder innovation processes. Interviews highlight that there was no resistance experienced among the employees (including the vocational staff of workshops), what is more, they are interested in a novelty, new developments and at several places new ideas are rewarded. The managerial approach against novelties (1,2) was ranked the lowest of the different hindering factors.

In my questionnaire the criteria of the success of innovation were also analysed (*Figure 5*). An answer was sought to the question what factors the companies regard as the most essential ones for their successful innovation activities. Unanimously participation in *professional exhibitions* (4,32) was selected as the most significant success factor of implementing innovation. Manufacturers realised that machine exhibitions and fairs act as a complex marketing means, i.e. they are such communication channels where sellers and buyers can meet through time and space, At the same time, the professional standard of exhibitions is the economic and technological indicator of the industry concerned as observing competitors and getting to know the opinion of potential customers serve to orienteer in further developments.

1- Not important at all 5- Very important
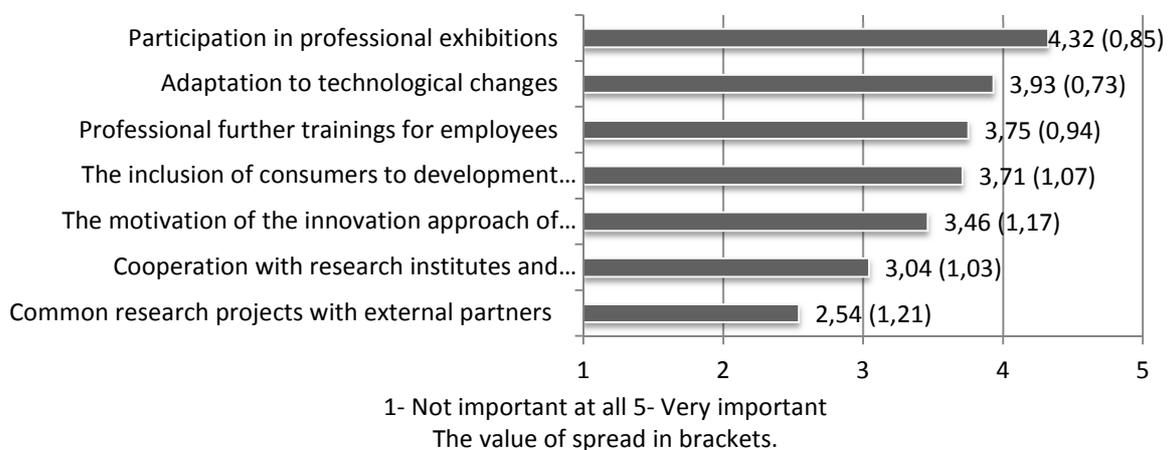The value of spread in brackets.

Figure 5: The success factors of innovation and R&D activity

The creation of common innovation projects with *universities and other research institutes* (3,04) regarded partially important in the system of success factors but, of course, satisfactory did not mean degradation as it is proved by the results of the innovation knowledge network to be described later.

3.7. The innovation knowledge networks of agricultural machinery manufacturers

According to my survey almost 87 percent of the companies concerned in research-development cooperation have already taken part in a form, which can be regarded a fairly good proportion.

Results show that for those who have never taken part in cooperation (although their proportion is slight, 6,9 %) the number of successful innovations is low. In this aspect the most active ones are who have always incorporated a partner in their innovation processes. A decisive part of the sample, i.e.79 percent occasionally participate in cooperations. In this case a significant difference can also be noticed as the ratio of the active ones is approximately 70 percent. There

is a *significant correlation* between product, process innovation and R&D cooperation and the strength is the correlation is close to satisfactory.

Table 6: Correlations between R&D cooperations and product- and process innovations

The proportion of R&D cooperation (%)	Product inn.(%)		Total %	Procedure inn. (%)		Total %
	No	Yes		No	Yes	
Never	75,0	25,0	13,8	100,0	0,0	13,8
Sometimes	34,8	65,2	79,3	30,4	69,6	79,3
Always	12,5	87,5	6,9	0,0	100,0	6,9
Total (%)	34,5	65,5	100,0	31,0	69,0	100,0
n (item)			58			58
Significance			0,016			0,008
Cramer V			0,377			0,406

The extent of R&D activity (Figure 6) reflects the most decisive directions of knowledge flow. These results illustrate the demand-driven nature of innovations in the agricultural machinery sector. Companies are trying to cooperate closely with their customers in order to know their needs. Sixty percent of the sample examined has already taken part in a common research-development project with a university research institute.
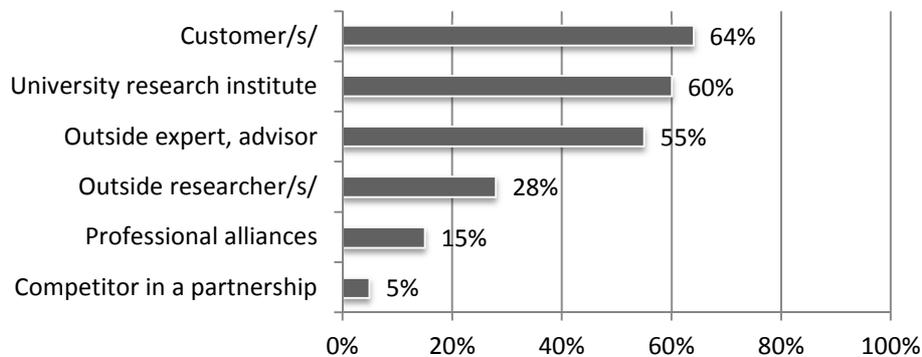

Figure 6: The proportion of R&D cooperation agreements of agricultural machinery manufacturing companies (Relative frequency, more than one answer could have been given)

In order to get to know the typical groups and alliances the information managing habits of enterprises were also considered in the multidimensional scaling. The fitting of the model is good   (RSQ = 0,95413) and the quality of solution can also be regarded good (Stress = 0,09959). When analysing the MDS map of information managing habits (Figure 7) we can find the typical groups that were described alongside two dimensions. The first dimension is the preferred-not preferred information on the horizontal axis while information (primary/secondary) is included on the vertical axis.

Typical groups:

- *Preferred primary information:* customers' needs, national and international machine exhibitions, and a further preferred source is the information of competitors and other machine manufacturers.
- *Slightly preferred information:* development experience of tool manufacturers, basic material manufacturers and of their own, information deriving from corporate R&D specialists and marketing experts.
- *Less preferred secondary information:* The use of national and international professional literature can be described as a less preferred secondary source. Another less preferred group is the one of counselling, technological transfer organisations and professional alliances.
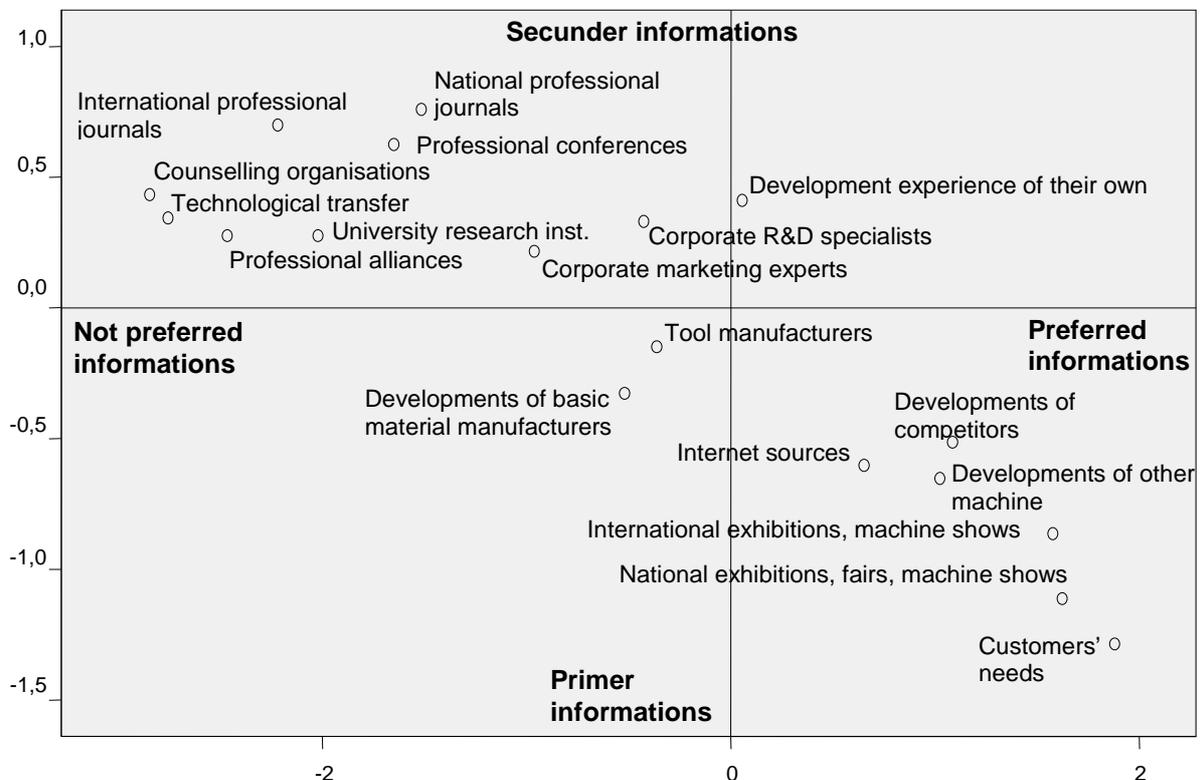

Figure 7: MDS map showing the information managing habits of enterprises

On the basis of the cross table and Chi-square analyses a positive connection can be observed between the two variables, i.e. different cooperations promote the innovation activities of agricultural machinery manufacturers in Hungary so *Hypothesis 4 can be justified.* According to the examination on the use of information sources we can state that of the information for their innovation activities enterprises prefer market like information sources most such as their customers and different professional exhibitions.

3.8. The role of strategic behaviour in innovation activity

At the time of the research almost 44,8 percent of the responding companies had a written corporate strategy and only 33 percent could present innovation strategy.

Table 8 reflects that a systematic innovation concept can positively influence the success of product and procedure innovations. The proportion of the innovative enterprises is 88,9 percent in the case of product innovation while 100 percent in procedure innovation, respectively. The correlation between the two variables is significant.

On the basis of the cross table analyses it can be stated that a systematic innovation concept based on a strategic approach is such a factor that can positively influence the product and procedure development activities of agricultural machinery manufacturers so *Hypothesis 5* is also justified.

Table 8: Correlation between corporate innovation strategy and product-and procedure innovations

Corporate innovation strategy	Product inn. (%)		Total %	Procedure inn. (%)		Total %
	No	Yes		No	Yes	
No	45,0	55,0	65,5	47,4	52.6	65.5
Yes	11,1	88,9	34,5	0,0	100.0	34.5
Total (%)	34,5	65,5	100,0	31,0	69.0	100.0
n (item)			58			58
Significance			0,021			0
Cramer V			0,467			0,665

At the same time, most enterprises have not been aware yet of the significance of the strategic approach. It is also proved by the fact that only 34.5 percent of them have an innovation strategy.

3.9. Connection between marketing approach and innovation

Hardly more than 1percent of the revenue is spent on marketing activities. Only 31 percent of the enterprises concerned have a separate marketing division where in most cases one person is employed or more typically, one person spends part of their working hours on marketing like tasks. While examining the entire sample I was unable to find a lot of agricultural machinery manufacturers running a marketing department that introduce new products and/or technologies. The statistical trials could not show a significant correlation between these two variables.

Table 9: Correlation between marketing departments and product-and procedure innovation

Proportion of marketing departments	Product inn. (%)		Total %	Procedure inn. (%)		Total %
	No	Yes		No	Yes	
No	35,0	65,0	69,0	30,0	70,0	69,0
Yes	33,3	66,7	31,0	33,3	66,7	31,0
Total (%)	34,5	65,5	100,0	31,0	69,0	100,0
n (item)			58			58
Significance			0,501			0,699
Cramer V			-			-

Regarding product innovation a higher proportion (76,5 percent) of the enterprises carrying out regular marketing activities (*Table 10*) is active and there is a weak correlation (Cramer V 0,181) between the two variables.

Table 10: Correlations between regular marketing and product-and procedure innovations

Proportion of market research	Product inn. (%)		Total %	Procedure inn. (%)		Total %
	No	Yes		No	Yes	
No	50,0	50,0	68,6	41,7	58,3	68,6
Yes	23,5	76,5	31,4	23,5	76,5	31,4
Total (%)	34,5	65,5	100,0	31,0	69,0	100,0
n (item)			58			58
Significance			0,036			0,14
Cramer V			0,181			-

It has been justified that the short term approach subordinates marketing processes to actual market objectives and marketing has a weak effect on innovation and R&D activity so *Hypothesis 6 is justified*.

3.10. Separating the sample and characteristics of groups

With the help of the generated Complex Innovation Index the principal component value of each organisation was calculated and assigned to the organisation in question. As a result, every enterprise can be characterised by complex values of innovation activity, efficiency and corporate efficiency. By putting the values of generated principal components in order a sector specific innovation (competitiveness) rank could be created (*Figure 8*).

The principal component values of the calculated Complex Innovation Index range from *-2,03 to 1,04* and their spread is on the left sliding in the negative direction of the histogram. Three groups were created on the basis of the axis and histogram of the complex innovation index.
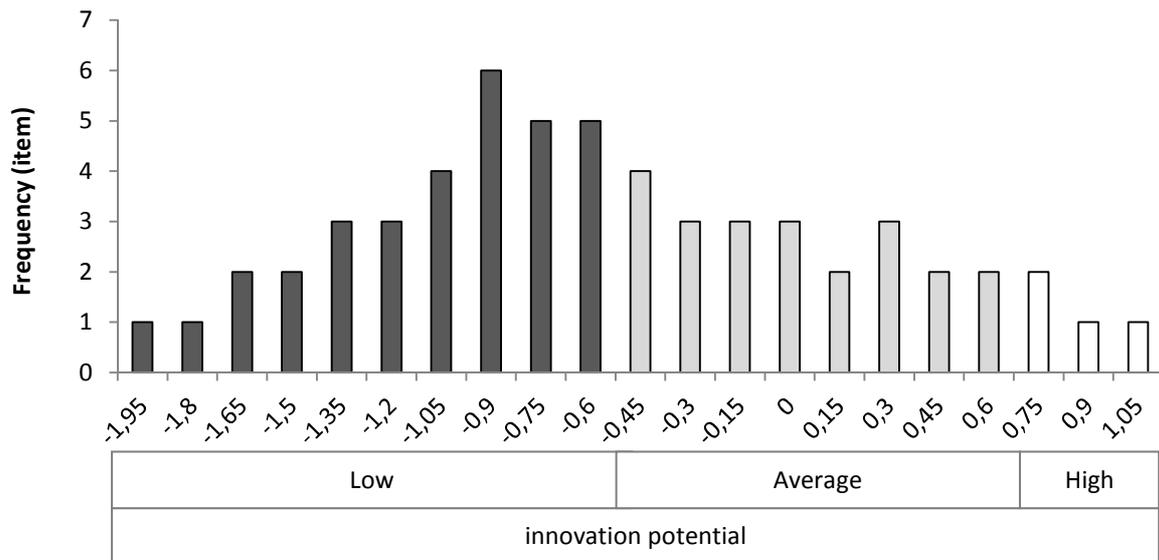
Figure 8: Corporate ranking based on the values of the Complex Innovation Index (n=58)

- *Top performers*: have higher values (above 0,5) and their ratio in the sample is 10,3 percent.
- *Those who catch up* can be described by average values (-0,5 and 0,5) and their ratio is significant in the sample, almost 34,5%.
- *Those who lag behind* comprise a group with low values below -0,5 and comprise more than half of the pattern (55,2%).

3.11. Summary of the characteristics of corporate groups

The following part summarises the characteristics of the single corporate groups established on the basis of the Complex Innovation Index.

The ratio of *top performers* in the sample is 10,3 percent. This group possesses the characteristics of big corporations with significant market and operating experience and an independent market presence. Their innovation activity can be described by high qualitative and quantitative numbers resulting from high level R&D knowledge integration. Their operation is characterised by effective organisational communication and a high standard of communication between the functions. They have realised the importance of innovation and their long term development plans are integrated into their corporate strategies. They have enough financial and human resources to perform innovation and R&&D tasks and they are directed at cooperation in innovation processes. They employ high standard technologies in their production which affects the high quality of their products as well as the efficiency of production. The members of the group have good chances in an international competition which is reflected by the fact that the ratio of export intensity is one-third of their revenue.

The ratio of *those who catch up in* the sample reaches 34,5 percent. On the basis of revenue and the number of employees SME like enterprises comprise this group. Their innovation activity is high in quantity although its novelty is only satisfactory. Their attention is directed at technological renewal whose objective is to improve the efficiency of the indicators in production processes. Their organisation is less favourable in terms of innovation activities. On the basis of my examinations it is possible that the knowledge integration which is necessary for technical developments prevails on the level of human resources in their case rather than in separate organisational units. Their financial means for performing innovation tasks are more limited and less sensitive to the external opportunities of technical knowledge. Marketing activities are controlled by cost savings as a result of the global economic crisis which has a weak impact on corporate and innovation cooperation.

By giving more than half (55,2 percent) of the sample, *those who lag behind* also show the characteristics of SMEs. At the same time, regarding spread rather small enterprises dominate. Their innovation activity can be best described by low qualitative and quantitative indicators. Financial and economic resources for innovation are scarce and for them innovation and R&D expenditure as of revenue is the lowest together with the ratio of developing specialists. Only 40 percent of the group show innovation activity that can be regarded new on a corporate level. Their development activities are directed at decreasing the production costs of existing products. They are closed in their development processes and the role of universities and professional organisations is rather limited in their operation. Organisational efficiency is low and unfavourable conditions hinder innovation processes. For them in order to increase innovation a shift in attitude is at least as important as in developing corporate culture as ensuring sources for development.

By employing the Complex Innovation Index that aggregates corporate and innovation process characteristics the examined sample can be broken down into clusters. Regarding the conditions for innovation significant differences can be experienced between the groups established on the basis of my examinations so *Hypothesis 7 can be justified*.

4. NEW SCIENTIFIC RESULTS

My new scientific results during my research work on the innovation activity of the Hungarian agricultural machinery manufacturers are the following [1]:

Thesis 1:

Such a complex method of examination and measurement has been worked out that is suitable for collecting and evaluating primary data on the innovation processes of agricultural machinery producers. I have established the concept of an industry-specific complex index that comprises innovation activity, efficiency and general organisational characteristics. The system of 14 variables with suitable information content (above 70 percent) was reduced into a principal component. In addition to evaluating innovation potential on corporate level, the method is also suitable for working out such a one dimensional scaling technique that results in a rank of capability for innovation in the industry. On the basis of the sensor axis spread by the index I pointed out that during the examined period the sample can be described by values between -2.03 and 1.04.

Moreover, by using the method I divided the national agricultural machinery manufacturers into three groups: top performers (10,3%), those who catch up (34,5%) and those who lag behind (55,2%). My further examinations reflected the unique characteristics of the single groups that influence innovation activity and proved that regarding innovation activity the industry cannot be considered unified.

Thesis 2:

My other examinations pointed out the input and output characteristics of the innovation performance of the agricultural machinery manufacturers in Hungary. The R&D expenditure of enterprises takes up 3 percent of their revenue (median 1,5%), which showed an increasing tendency during the examined period. Innovation costs also tend to rise as 4,2 percent of revenue (median 2,6%) was spent on such activity. The number of R&D employees reaches 3,5 percent of total workforce (median 2,1%) that stagnated during the examined period. I showed the results of R&D and innovation activities. During the period of examination 65.6 percent of agricultural machinery manufacturers launched a new product onto the market or modified a product and 68,9 percent carried out technological innovation. By examining the novelty of the developed products and technologies I pointed out that the range of new products of global

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[1] Legend:

Sig_1 = significance level of product innovation

Sig_2 = significance level of procedure innovation

$CramerV_1$ = strength of correlation in product innovation

$CramerV_2$ = strength of correlation in procedure innovation

standard is 5,3 percent, 34,2 percent can be regarded new under Hungarian circumstances and 60,5 percent is only about modifying-developing innovations. Furthermore, I explored that the other aspect of innovation results, i.e. patent and publication indicators show a low value for the Hungarian agricultural machinery manufacturers.

Thesis 3:

My examinations explored the internal correlations between the general and innovation organisational features that are important with regard to novelty and innovation activity. I proved that in the case of national agricultural machinery manufacturers a significant correlation of medium strength can be noticed between innovation activity and company size. The probability of successful innovations rise with revenue ($Sig_1=0,018$; $Sig_2=0,007$ and $CramerV_1=0,417$; $CramerV_2=0,459$) and the number of employees ($Sig_1=0,016$; $Sig_2=0,003$ and $CramerV_1=0.423$; $CramerV_2=0.491$). I also concluded that of the innovation organisational characteristics that are important regarding novelty the revenue related R&D expenditure ($Sig_1=0,023$; 0.019 and $CramerV_1=0,239$; $CramerV_2=0,256$) and the number of R&D employees ($Sig_1=0,021$; $Sig_2=0,033$ and $CramerV_1=0,239$; $CramerV_2=0,277$) show a significant, slightly positive correlation with innovation activity.

Thesis 4:

My multidimensional examinations proved that the innovation activity of the national agricultural machinery manufacturers is motivated by the pulling force of market needs. With the help of a multidimensional map I concluded that the objectives of agricultural machinery manufacturers related to product ($RSQ=0,99208$; $Stress=0,052533$) and procedure innovation ($RSQ=0,81628$; $Stress=0,12470$) can be described by three groups along two dimensions: preferred, slightly preferred and not preferred development and business plan. I stated that of the innovation used for innovation activity the national agricultural machinery manufacturers mostly prefer primary like sources. With the help of a multidimensional map ($RSQ=0,95413$; $Stress=0,09959$) information managing habits connected to innovation activities were divided into three groups along two dimensions: preferred primary like, slightly preferred and less preferred secondary information. I proved that for the Hungarian agricultural machinery manufacturers there is a positive significant ($Sig_1=0,016$; $Sig_2=0,008$) correlation of medium strength between innovation activity and cooperation ($CramerV_1=0,377$; $CramerV_2=0,406$). My further examinations explored that in innovation cooperation it is typically the customers (64 percent) and university research institutes (60 percent) who are the preferred partners.

Thesis 5:

My examinations proved that the corporate integration of R&D and marketing can decisively influence the success of innovation processes. Regarding organisational form 48.2 percent of the examined organisations have a linear and 37,9 percent of them a simple organisational structure, i.e. thy do not have separate units/divisions and 13,9 parent of them operate in a functional organisational form. I also pointed out that there is a positive significant correlation (Sig_1=0,013; Sig_2=0,01 and $CramerV_1$=0,501; $CramerV_2$=0,561) of medium strength between the quality of organisational form and innovation activity. I stressed that approximately one third of the examined enterprises have an independent R&D division (34,5%) and marketing (31%) department. My further examinations explored that the efficiency of these R&D and marketing divisions and ultimately the qualitative and quantitative success of innovation activities are decisively influenced by the organisational form and the quality of organisational connections. The agricultural machinery manufacturers that have an R&D and marketing department and operate in a continuously coordinated functional organisational form can be described by high innovation activity.

Thesis 6:

My examinations proved that of the factors influencing innovation the systematic innovation concept based on strategic aspects is such a factor that channelled the product (Sig_1= 0,021; $CramerV_1$=0,467) and procedure innovation (Sig_2=0,000; $CramerV_2$=0,665) activities of the national agricultural machinery manufacturers into a positive direction. I pointed out that most enterprises are still unaware of the importance of a strategic concept in innovation activity, which is proved by the fact that only 34,5 percent of them have an innovation strategy. My other examinations reflected that the Hungarian agricultural machinery manufacturers prioritise short term objectives and efforts instantly justified by the market in the fight for improving efficiency and productivity indicators.

5. CONCLUSIONS AND SUGGESTIONS

During my research I gained a lot of experience in connection with the industry that has both theoretical and practical implications. The topicality of the research can be stressed because as far as I know during the past twenty years there has not been an agricultural machinery manufacturing survey of such nature and depth in Hungary. The examination has resulted in several new research results that could be used in practice by the experts in my opinion.

On the basis of the conclusions drawn from the research results I suggest working out cluster specific instruments and action plans of the methods encouraging innovation and I also outline a possible way of becoming a top performer, i.e. technical knowledge, the quality of corporate processes and the harmony between the different organisational functions are given a greater and greater role in the innovation ability of agricultural machinery manufacturers. Manufacturers must show a greater interest in exploring and applying the new knowledge accumulated outside their organisational boundaries. In order to keep pace with market and technological changes as well as integrate new scientific results cooperation with professional alliances and specialist universities must be prioritised in their innovation processes. I would also highlight the role of strategic behaviour in the success of innovation processes. The management has to make decisions on investment and development on the basis of a strategic approach in line with systematic innovation objectives.

The methodological obstacles of the research: the methodology of the examination, the questionnaire and the Complex Innovation Index (in line with the objectives of the dissertation) has been worked out by considering the characteristics of the industry. The questionnaire was compiled with regard to OECD guidelines and the measured and published data for this industry are suitable for being compared even with international data. The established index is an indicator that pays special attention to the specific features of the industry so its values cannot be generalised for other industries although as a method it can be used cautiously knowing primary data.

The possibility of improving the research definitely lies in the further application of the established Complex Innovation Index. One option is automating data collection and increasing the speed of processing. One of my plans is to work out a more modern and flexible system of surveying on the Internet, which makes the annual monitoring cycle possible in this topic.

A *direction of research in the future* can be testing the Complex Innovation Index in other industries. By utilising the experience gained in this way the theoretical improvement of the methodology would be possible. *The other direction of the research in the far future* is expanding the examination to another European county and carrying out comparative analyses.

6. SUMMARY

In my research the definitions for innovation which could be found in literature were interpreted first in my thesis. I concluded that the most relevant statements of the Schumpeter evolutionary theory on technical development and innovation served as the theoretical background of my research. All experts agree about the importance of measuring and evaluating R&D and innovation. However, there is no unified practice regarding methodology. Literature review concludes with the presentation of the tendencies of international and national macro-statistical innovation and agricultural machinery manufacturing data.

The third chapter of my thesis points out the questions to be examined in the research. By considering them the methodology of the empiric research was worked out and the reliability and punctuality of the examination were defined. The next part provides details about the structure of the questionnaire used in the research, the process of data recording and the methods of analysis as well as the hypotheses of the research were also introduced.

Chapter Four of my thesis contains the results of the research. Within the framework of primary research a questionnaire was used to ask 58 Hungarian agricultural machinery manufacturers. During the empirical study I presented the indicators of the innovation performance of the sector as well as the special features and motivations of its innovation processes. I was striving to define the variables that describe the correlations between the general organisational features that affect innovation, the characteristics of research and development and innovation features in the case of agricultural machinery manufacturing companies.

A *new, complex indicator* (termed as Complex Innovation Index) was established to evaluate agricultural machinery manufacturers, which integrates 14 variables. By applying this method the micro-level analysis of companies was carried out and also the ranking of companies by industry was compiled by aggregating the single results, which served as the basis for further research. In the order per sector three categories were identified on the basis of the typical values. They are the market leaders, those who are catching up and who lag behind. The typical features were concluded by comparing seven areas of the cluster groups. To conclude the chapter new and novel scientific results were drafted based on my examinations.

Chapter Five of the thesis summarises the conclusions that can be drawn from the research results, mentions the barriers of the research and recommendations were also made about the possibilities of further research.

7. MOST IMPORTANT PUBLICATIONS RELATED TO THE THESIS

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