

Evaluation of product development process from technological innovation: a study in the segment of agricultural machinery and equipment

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Abstract: The objective of this work was to characterize companies of the agricultural equipment and machinery segment focusing on their effort into technological innovations related to the product development. Hence, some information was collected from IBGE (Brazilian Institute of Geography and Statistics), institution responsible for the PINTECs (Survey on Technological Innovation), between 1998 and 2005 and published in 2002, 2005 and 2007 including, respectively, 221, 294 and 485 important national companies in this segment. The results indicated that the development of new products focused on the improvement of existing products with low technological innovation incorporation. Most innovations in products were characterized as innovations for the company, but they were already known in the market. The 2000 and 2003 PINTECs presented small variation in the searched period, but the PINTEC2005 showed a great tendency towards the segment in relation to the incorporation of technological innovations in product development process (PDP).

Keywords: product development process, technological innovations, agricultural machinery and equipment industry, PINTEC.

1. Introduction

The PDP represents a business process that propels the companies to innovate and put competitive products in the market aiming at guaranteeing financial return.

In order to develop products that meet the real necessity of the consumers, the product development must be supported by technological innovations that can differentiate them from other products in the market. The more intense is the incorporation of the technological innovation in the product, the higher its chance of success if compared those with little differentiation and do not incorporate innovations.

Companies can differentiate themselves from others through the technological innovations applied to their products and can acquire the necessary competitiveness to consolidate their market and explore new ones.

The incorporation of technology to PDP has changed the products, its manufacturing, and its relations with the market. The technological innovations represent a critical instrument to the competitiveness of the organizations since it propels the launching of new products and promotes the improvement of the current products.

The success of a new product will be easily achieved when the differences between them are significant. Different products promote the competitiveness in the market, which stimulates the development of new and better products in a short period of time. The companies that are in this

kind of competitiveness market are classified by Overholt (2000), as flexible organizations with continuous capacity for adaptation and creation of a stable environment for changes. Among the strategies suggested by the author for the development of this capacity, the technological strategy stands out.

Nevertheless, the information released by the IBGE (2006) indicates that national companies innovate a little, and when do innovate, the transfer of technology to products has been targeted, mainly, to promote the improvement of the existing products by adapting them to the local market, to the structure of the suppliers, and to the production processes available.

In the segment of agricultural industries and machines the situation is not different from other industry segments. In this segment, the technological innovation is particularly important due to the need to update on the modernization of the other segments of agroindustrial production chains. At the same time, it is the starting point to meet the productivity demands necessary for the growth of Brazilian agribusiness.

In the period from the late 80's to the beginning of the 90's, the characteristics of PDP in the companies of the segment of agricultural industries and machines changed a little since the companies remained focused on the

development of projects that involve few adaptations in the existing products investing modestly in research.

Romano (2003) indicated the main characteristics of the PDP in this segment highlighting the lack of a formal model in SMEs (small and medium enterprises). In these companies, the PDP is carried out sequentially and informally according to the experiences of those who are responsible for it. On the other hand, in large companies, the PDP is based on formal procedures and occurs in a sequential way depending on the company and the project. Besides these characteristics, the author highlights the lack of knowledge about the projects and methodologies and models of management, regardless of the size of the companies.

Generally speaking, the segment of agricultural industries and machines presents particularities that justify this situation: factors such as the high seasonal demand and peculiar characteristics such as the fact that the companies are popular or in transition can contribute to it (ABIMAQ, 2006).

Even with such difficulties, the segment of agricultural industries and machines, which occupies the tenth position in the international ranking, has maintained steady growth with values greater than the GDP (gross domestic product), despite the oscillation of the national economy, with investments in production, technological development, and an increase in the level of employment.

For Romano (2003), one of the ways to reduce those difficulties and to allow the companies to achieve sustainable competitiveness in the long term is to concentrate efforts into the technological innovation aiming at the development of new products.

For these reasons, it is important to evaluate the performance of the PDP focusing on the main difficulties, mainly those related to the incorporation of technology in the PDP. Rozenfeld et al. (2006) highlighted some performance indicators of the process of product development related to technological innovation. The major ones are the total number of patents registered, quantities of products launched by year with some degree of technological innovation, and the return of the investment in innovations among others.

In this context, the main objective of this work is to characterize the business segment of agricultural machinery and equipment in relation to the effort into technological innovation focusing on new products development. Specifically, this study aims to identify how the companies have developed technological innovations, the degree of novelty of the innovation of its main product, and the primary reason for the development. This study also focused on investigating the participation of national companies in each of the innovative activities in accordance with the categories used by the IBGE during the PINTEC.

To meet those goals, information was collected from the IBGE, which allowed a specific characterization and analysis of companies in the segment studied. One of the major advantages of this kind of survey is quantification since the data can be grouped into tables and the variables in the study can be quantified, allowing the use of correlations.

The national scope and PINTECs indicated the evolution of technological innovation in this segment from 1998 to 2005. The publications occurred in 2000, 2003, and 2005, with a total of, respectively, 221, 294, and 485 domestic companies engaged in the segment.

Nevertheless, the information collected in the survey from IBGE was aggregated to other industries making it impossible to conduct an analysis and comparison of the three periods surveyed by the IBGE, specifically for the segment studied.

For the development of this research, information on the three PINTECs related to the segment of agricultural equipment was collected from IBGE, according to the CNAE (National Classification of Economic Activities). The segment of agricultural machinery and equipment is in section C, division 28, group 28.3.

2. Segment of agricultural machinery and equipment

The segment of agricultural equipment and machinery is characterized by a highly heterogeneous market structure including companies with different sizes and carrying and origin of capital. Another characteristic is the necessity of the companies to follow the modernization of the agricultural segment, situation that requires constant changes in the characteristics of the products.

According to Pasqual and Pedrozo (2007), it is a very productive segment with a permanent momentum of technological innovation characterized by the launch of new products, whose goal is to reduce the costs of agricultural activity and increase the productivity of operations.

The performance of the agricultural equipment segment, in general, accompanies the agribusiness and both depend on the volume and availability of agricultural credit for expenses and investments.

From the middle of the 90's, with the retraction of the economy and the lack of a consistent policy of agricultural credit, the industry has weakened, showing significant reductions in the productive activity. But at the end of that decade, it started up a new cycle of growth as a result of two main situations: the creation of the MODERFROTA (Fleet Modernization Program of Agricultural Tractors and Equipment Associates), and a worldwide rise in commodity prices.

The evolution of the industry's internal billing and value of exports indicated in Table 1 shows the industry reaction in 2000, which doubled the internal billing and more than quadrupled the value of exports.

Table 1. Internal billing and domestic exports of machinery and agricultural equipment.

Economic indicators	2000	2004
Turnover internal (U.S. \$ billion)	1,1	2,2
Value of exports (U.S. \$ billion)	125	536

Source: ABIMAQ, 2005.

The deployment of MODERFROTA in early 2000, whose result was the increase in production and sales, provided the renovation of more than 1/3 of the fleet of agricultural machinery and equipment in the country, besides giving greater technological content for equipment.

The growth registered at the beginning of the decade was interrupted in 2006, with a significant reduction in the production of agricultural equipment, as a result of the breach of national harvest of grains in 2005 lowering the prices of commodities in the international market, especially soybeans, and the enhancement of exchange. In 2007, this scenario changed again with the prices' recovery, mainly sugar cane, soy, and corn. The performance of production and export of machinery and agricultural equipment from 2005 to 2007 is showed in Figure 1.

With regards to exports, despite the intense exchange recovery, there was significant recovery in the transactions conducted in 2007 in relation to 2006. This performance confirms that industry, agricultural machinery and equipment reached a level of technological maturity able to maintain its international competitiveness even in an unfavorable business environment.

The number of companies working in the segment followed this development. In the 70's, there were about 275 companies in Brazil. At the end of the 80's the number of companies rose to 600, and in 2006 there were already 800 companies (ANFAVEA, 2008).

This shows a potential growing market for the agricultural machinery and equipment companies in Brazil. Thus, it is extremely important for domestic firms to acquire a world-class productivity to compete in those markets.

However, the industry has issues that must be overcome to monitor the development of Brazilian agribusiness. Among the difficulties, it is the adoption of technological innovations, a factor that is considered essential for companies to gain national competitiveness, especially in the international market. The process of technological innovation has become increasingly important for the integration and maintenance of companies, both in the domestic and foreign market. This process is more effective if the technologies are the latest.

According to Romano (2003), despite all the growth in the segment of agricultural machinery and equipment in Brazil, since the end of the 90's, the PDP and their

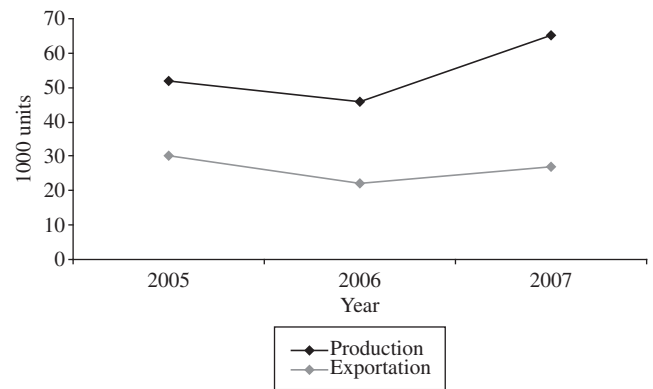


Figure 1. Production and export of agricultural machinery and equipment. Source: ANFAVEA, 2008.

management have been poor, especially in small and medium companies. This occurs because the PDP in these companies is carried out informally without the use of tools and methods of support.

The main focus of the companies has been the development of products' project with incremental innovations, so the new product will be new only for the company since it is already known in the market. There are a few companies that develop really new products, those that are considered a novelty and contribute significantly to the improvement of competitiveness of the company.

3. Product development process

It is clearly that companies need to develop products that meet the needs of the segment and could face competition. When the product incorporates new technologies developed and is different from the others, the chances of being successful increases considerably.

The incorporation of technology into the product can occur at various levels, from an incremental change to radical changes, which culminates with the development of a completely new product.

The literature reports many concepts of new products, however, it seems appropriate to consider that a new product should be categorized based on how it differs from those which already exist in the market. This classification considers the product to be new for the company and the market.

Under the viewpoint of the company, a new product is the one that is not part of its traditional line, or the product is new to it, even if it has already been marketed by other companies. The new product in the market is unknown by the public, and it is not available for consumption (IBGE, 2005).

Another concept was introduced by Toledo et al. (2002), and it is called follow-source. This concept can be applied

to the case of agricultural machinery and equipment, in multinational companies, and in projects developed by the company headquarters or in another unit of the group and that are sent to local units, which then are responsible for adapting them to local reality and produce them.

In the national companies, the innovations are still aimed at the improvement of products. This process is called project by development and is characterized by relatively few changes following the demands of the market. However, with the increase of competition among companies, the adoption of projects by innovation using solutions from new concepts with higher technology has increased.

The differentiation of products from its competitors is an essential ingredient for business success. However, it is very difficult to introduce products in the market with greater degree of innovation because consumers are conservative, particularly among rural producers.

The industry of agricultural machinery and equipment often uses extension projects of the traditional line of products, which are outdated and hardly meet the needs of the consumers. This category of products does not require changes in production lines or new equipment purchase.

3.1. PDP in companies of agricultural machinery and equipment

The design of a new product or improvement of an existing one involves practically all departments of the company and includes technological, economic, and environmental factors among others. What varies from one project to another is the relative importance of these factors. The variable technology grows in importance as the product under development needs to be more innovative differentiating from those in the market.

Nantes (2006) reports that technology is a key factor in the development of products; however, the author confirms that at the same time technology opens new prospects of development enabling the company to act in new highly competitive markets, but the products can become obsolete or outdated very quickly forcing companies to seek new alternatives. Hence, the segment of agricultural machinery and equipment presents a different feature from other industries. According to Pasqual and Pedrozo (2007), the degree of obsolescence of products is low because the life cycle is longer, around 10 to 15 years.

Although the segment of agricultural machinery and equipment in Brazil has advanced significantly in recent years, according to the growth of agribusiness and technological changes, the industry had weaknesses related to PDP.

Among the main difficulties reported by Simões (2007), there is a lack of alignment between the needs of the market

and the technological possibilities available to firms. This occurs because the strategic planning, including portfolio management, is weak or simply does not exist. This fact is more common in small size companies.

The strategic plan involves the definition of projects to be developed from the competitive strategies of the company, especially considering restrictions of capital and technology. The choice of projects that are better suited to the company, is part of the management of the portfolio, whose goal is to select among the ideas generated by different areas of business those that are aligned with the previously established strategic planning.

In the decision making process of the portfolio a set of projects of projects can be seen, comparing them with each other, making go/stop decisions. Considering businesses run predominantly by family members, which is typical of SMEs in the segment of agricultural equipment, this process is seriously compromised, so the owners have to decide on various aspects related to PDP.

Besides the lack of the management of the portfolio of projects, companies in the industry need a marketing strategy that could identify the needs of the customer. The number of rural producers is very large hindering the implementation of market research.

4. Presentation and analysis of results

The data presented in this item was obtained from the surveys conducted during PINTECs of 2000 (2002), 2003 (2005), and 2005 (2007), respectively, for a total of 221, 294, and 485 national companies. The number of companies with national and international capital, their market, and dependence of the group are shown in Table 2.

It can be observed in Table 2, that the segment of agricultural machinery and equipment is comprised primarily of national companies, which are not part, in their great majority, of a business group, i.e., the company is independent. There are few companies that do not fall into this category exercising the function of controlling the group.

Regarding to the market, it can be seen that the segment operates more intensely in the state market, followed by national and regional market. The participation of companies in the international market is unexpressive, and when they do, they most often export to Mercosul countries and the United States.

This information is important since the export orientation in general gives companies greater ability to innovate. Generally, it is observed that for the three parameters considered, the situation changed very little from 1998 to 2005. In that period, companies implemented to a greater or lesser intensity some kind of technological innovation.

The majority product innovations were characterized as innovations only for the company (Table 3). These results

Table 2. Controlling capital, the main market, and dependence of the group.

PINTEC	Capital origin		Main market				Dependence	
	National	Abroad	State	Regional	National	Abroad	Independent	Group
2000	220	1	128	19	75	0	214	7
2003	280	5	182	16	96	0	291	3
2005	490	5	275	59	148	4	478	7

Source: IBGE, 2002, 2005 and 2007.

Table 3. New product for the company and for national market.

PINTEC	New product for the company		New product for national market	
	Enterprises	%	Enterprises	%
2000	22	9,95	4	1,80
2003	25	8,50	3	1,02
2005	65	13,40	45	9,27

Source: IBGE, 2002, 2005 and 2007.

were expected since the national industry traditionally innovates very little to the market. However, it was observed by the PINTEC2005 (2007) a major concern of firms to promote innovations in the segment of the product to the market too. The participation of companies that innovate for the market rose from 1,80% in 2000 to 9,27% PINTEC (2005).

The increased participation of enterprises in innovative activities indicated by PINTEC2005 (2007) was probably caused by the implementation of the program MODERFROTA in early 2000. This line of credit changed the market for machinery and equipment from that period and led companies to invest in the development of new products.

According to ABIMAQ (2006), the segment of agricultural machinery and equipment investments have remained constant in the recent years focused on the technological development. The applied rates grew 80% in 2002 compared to 2001. There was a small decrease of 5% in 2003, compared with the previous year's high; however, it increased again expressively in 2004, around 44%.

There are optimistic projections are for the industry. Simões (2007) indicates that the segment of agricultural machinery and equipment tends to increase the adoption of technological innovations in products, expanding the ability of companies to develop their products and as a consequence, an increase in frequency of launching new products is expected.

Investments in technology in the industry are dependent on other segments of agroindustrial production chains and hence the performance of agribusiness. Moreover, the

macroeconomic guidelines of the institutional environment such as lines of credit, interest rates, and currency exchange among others, strongly influence the investments.

In addition to measuring the technological innovation, the survey indicated the degree of innovation of the company's main product. The number of national companies that have implemented innovations already known by the market and novelty products is shown in Table 4.

With regards to innovation in product, there are a larger number of companies developing new products for the company, but which are already in the national market, incorporating therefore little or no technology. In general, these developments are motivated by the loss of market, owing to the advancement of competition typical of innovation.

Innovations considered as improvement of existing products prevailed, but PINTEC2005 (2007) identified 8 companies that developed novelty products, but these innovations were new only for the company.

As expected, the innovations considered entirely new to the world market, did not occur in the two periods analyzed. This fact is understood by the greater need for training of businesses and the low introduction of national companies in international markets. The export orientation, very little in the national firms, is a very significant factor for the development of internal training favorable to innovation.

It is worth mentioning that the number of companies that have developed new products for the national market by improving the current ones in the world market. These companies were not identified by PINTEC2003 (2005), but totaled 45 PINTEC in 2005 showing that national firms are participating more actively in international events and internalizing knowledge.

The responsibility for the innovation in products lies, most of the times, with the company benefited by the innovation, but those companies are likely to seek partnerships with other companies, suppliers, and research institutions, aiming to introduce innovations into their line of products. The number of national companies responsible for the development and those that sought to establish partnerships with other companies or institutions can be found in Table 5.

Table 4. Degree of novelty of the main product innovation.

PINTEC*	New for the company and in the national market		New for the national market and in the worldwide market	
	Product improvement	Original	Product improvement	Original
2003	14	0	0	0
2005	57	8	45	0

*The information from PINTEC2000 (2002) were not available by IBGE. Source: IBGE, 2005 e 2007.

Table 5. Main responsible for the product development.

PINTEC	The company itself	Another company of the group	The company in cooperation with other companies	Another companies or institutes
2000	19	0	3	4
2003	26	2	0	0
2005	86	0	4	20

Source: IBGE, 2002, 2005 and 2007.

In the PINTECs of 2000 (2002) and 2003 (2005), practically all of the national companies developed their own products. The other alternatives investigated by this study, such as the development of another company, cooperation with other companies or institutes, and by other companies and institutes only were very few.

In the period researched by PINTEC2005 (2007), the participation of other companies and institutes in the development of new products occurred in a more pronounced way. The point that needs to be stressed is that companies need to broaden their base of knowledge to develop more innovative products, and cooperation enables a more efficient transfer of technology between organizations.

The cooperation for technological innovation with other companies or institutes had already been discussed by Nantes et al. (2006). The authors reported that this is a form of cooperation still rarely used by companies: only 11% of national firms have some form of collaboration with other organizations seeking to innovate their products and only 3.4% of innovative Brazilian research institutes cooperate with research institutes and universities.

Another issue concerns the ownership rights of the product. The number of patent applications in a segment represents an important indicator of the PDP. The methods of protection used by companies that had implemented innovations were written in the form of patent applications and registration of trademarks.

PINTEC2003 (2005) indicated only one company that had placed the patent application and five others that had registered their trademarks. In PINTEC2005 (2007), that number rose to five patent applications and fourteen registration of trademarks. Information of the PINTEC of 2000 related to the methods of protection used by companies

that have implemented innovations was not released by IBGE.

The registration of the mark and the filing of the patent application, although slow and bureaucratic processes, have the preference of companies due to the security offered. The written form of defense, represented by the submission of applications for trademarks and patents was used by 80% of companies. Other less bureaucratic ways, although less secure, called strategic including the complexity in the design, the industrial secret, and the time of leadership over the competitors, were also used by businesses, but less frequently.

The methodology of the survey conducted by IBGE classified the innovative activities in 7 major categories assigning each one-degree of importance as high, medium, and low. Table 6 shows a number of national companies that participated in innovative activities, according to the categories used by PINTEC.

PINTECs 2003 (2005) and 2005 (2007) indicated that the internal activities of R&D in general, have low importance or were not carried out. In companies of smaller size, the internal activities of R&D are usually informal; the officials responsible for these activities are not exclusive, dividing the time devoted to innovative activities with other functions. Furthermore, the innovative activities in general are not accompanied by formalized procedures.

The research performed by IBGE indicated significant influence of the size of company in the rate of innovation. Medium-sized industrial companies, from 100 to 499 employees registered the highest increase in indicators of the rate of innovation between 2001 and 2005, and they continue growing with the increasing size of companies with the general rate of innovation ranging from 28,9%, for those that hire between 10 and 49 people, and 79,2% for companies with 500 or more employees.

Table 6. Participation in innovative activities and their importance degrees.

Innovative activities	PINTEC 2000			PINTEC 2003			PINTEC 2005		
	Importance degree			Importance degree			Importance degree		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Internal activity from R&D	37	0	21	11	6	75	14	27	143
External acquisition from R&D	0	0	58	0	0	72	3	1	179
Acquisition of others external knowledge	1	2	55	3	3	85	1	6	177
Acquisition of machines and equipments	39	1	18	71	4	16	81	56	47
Training	16	0	42	68	0	24	31	40	113
Introduction of technological innovations in the market	8	2	48	27	3	61	61	28	95
Industrial project and technical preparations	7	1	50	12	3	77	76	47	61

Source: IBGE, 2002, 2005 and 2007.

This applies perfectly to the segment of agricultural equipment, which is linked to medium-high-technology presenting in the period considered the rate of 39,3%, higher than the national average for the industry, 33,4%.

Concerning the acquisition of foreign R&D, practically all companies said that their importance is low or they do not perform this activity indicating a trend towards the achievement of internal activities of R&D in such firms. This occurred for the three periods analyzed.

The activities of the acquisition of machinery and equipment are of high importance for most companies that have implemented innovations, and this result can be explained by the growth rates of innovation in companies of smaller size and particularly in segment that tend to have greater access to technological knowledge. The training activities were considered of high importance only by the companies surveyed in PINTEC2003 (2005), while the introduction of technological innovations in the market was low or most companies attributed no importance in the three periods surveyed.

The implementation of industrial projects and other technical preparations were reported as activities of low importance for most companies in the first two surveys; it became of high importance in PINTEC2005 (2007). It is worth mentioning that, within the innovative dynamics of the company, the activity of industrial design and other technical preparations are not performed continuously since it is associated with specific projects that results in changes in the production process or the final registration of new products.

5. Conclusions

The level of competitiveness of the company is increasingly dependent on its ability to innovate products in response to market needs and positioning of competition. Technology is one of the critical factors in this process. Technological advances offer better competitive conditions

to the companies that update their products obtaining better quality at a lower cost.

In the case of the Brazilian industry of agricultural equipment, mainly focused on the national market, most businesses do not present innovative initiatives by upgrading their range of products through the enhancement of existing products. However, there is a small number of companies, especially those of larger size using cutting-edge technology and that can be considered 100% nationals since they were created and patented in the country.

It is very difficult to introduce products in the market with a high degree of innovation because besides the development costs involved, the market barriers must be overcome because the rural producers are generally conservative. This is the main justification given by the firms for the non-fulfillment of innovative activities. The contrast is that the most innovative products have more chance of success when compared to those who have little differentiation.

It can be said that the low use of universities and research institutes as partners for product development indicate that the process of technological innovation is specific to the company and based on incremental innovations. PINTEC2005 (2007) indicated growth in partnerships in relation to previous years. However, the establishment of partnerships with other companies probably will not occur due to a strategic issue, but it is motivated by the lack of internal expertise for product development. Partnerships occur mainly with suppliers of raw materials and with end customers. In fact, companies use the end users of its products as partners, aiming to test the prototype developed in actual field conditions.

It is important that national companies identify what is happening with the various technological alternatives that are emerging. The monitoring of technology offers has a key role in this situation since the capacity for innovation is a critical factor for the competitiveness of companies.

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