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Technological Profile Analysis in Dairy Companies: A Case Study

Luz M. Barrera-Rojas[a], Jorge A. Obando-Bastidas[b], Juliana Puello-Mendez*[c]

[a]Agroindustrial Engineering Department, Universidad de Los Llanos, Villavicencio, Colombia
[b]Department of Education, Universidad Cooperativa de Colombia, Villavicencio, Colombia
[c]Chemical Engineering Department, Universidad de San Buenaventura, Cartagena, Colombia
jpuello@usbctg.edu.co; julianapuello@hotmail.com

This paper presents the application of a Technology Management Methodology (TMM) in the analysis of the four M's (Machine, Methods, Management and Money) in twelve dairy companies located in the Colombian region of Meta. The application of the methodology was performed for the assessment of the technological and innovation profiles of the dairy companies. Multivariate statistical techniques were used in the structural analysis in order to identify major technological and innovation gaps in each company. Low technology processes were observed in this case study; however, these gaps can be considered as opportunities to promote technological innovation in the dairy companies by formulating action plans that include goals, strategies, and projects that contribute to the development of this area in the region under study.

1. Introduction

The importance of the dairy industry in Latin America is related to the contribution from this industry to the product and the feeding, the territory that is destined to the activities of this industry and the employment generation, so that changes and innovation represent an important factor for the development in dairy companies, considering the FTA (free trade agreement) between Colombia and United States. This agreement started in May 2012, and covers the trading of liquid milk, milk powder, yogurt, butter, cheese, whey and processed dairy products. In Colombia, the daily production of milk reaches 17.2 million liters. 41% of this production is processed in dairy companies, and the other 59% is commercialized in the non-formal market of raw (non-pasteurized) milk. An important characteristic that distinguishes dairy production from many other agricultural products is that milk is a highly perishable product, which requires an installed industrial capacity to transform it into milk derivatives. Two exceptions are homemade processing models, which do not qualify as "industrial capacity", and the sale of raw milk, usually in small populated centers and in peri-urban areas, which are the core of what could be called the "informal dairy" in Latin America and the Caribbean, and which compete, albeit marginally, with processed products from established factories. In Latin America, an important share of the dairy processes is carried out in family-type farms (OECD, 2005). The U.S. Department of Agriculture reports that in 2011, the world production of milk reached 614.4 millions tonnes, which represents a 2.5% increase, compared to the production in 2010. In regard to innovation, according to the Oslo Manual (2005), the innovation is considered as the introduction of a new, or a significantly improved product (good or service), process, a new marketing method, a new organizational method in the practices of the company, the organization of the work place or the external relationships. It also stablishes four types of innovation: (1) product, (2) process, (3) marketing and (4) organization.
One of the innovations that has been developed in the dairy industry is the PCR (Polymerase Chain Reaction) technique, which is a biomedical technique that allows an improved detection and identification of bacteriophage of lactic acid bacteria, by a chain reaction of the multiple polymerase. Traditionally, this technique allows detecting and identifying different bacterial phages in yogurt; another technique is the ultrasound control of the microbiological quality of the packaged UHT milk, which detects contamination from the start of incubation. On the other hand, technological diffusion and lice cycle of products, follow a behavior that is similar to population growth, described by S-shaped curves, whose points of inflection indicate the time

for innovation, investment and performing strategies in negotiation and marketing (Walmsley et al., 2015). Another research in agroindustry is related to the innovation DNA. This considers that each company has a DNA with all the information about the processes, products, applications, procedures, services and structure, which allows building strategies for improvement, development or modification of factors that affect the innovation capabilities. This strategy is similar to the basic composition of DNA (phosphate, sugar and nitrogen bases) with the application of multivariable analysis, in order to determine the most important innovation variables, in order to support the decision making (Schimith et al., 2015). In Latin America, Mexico is one of the leading countries in innovation research about production processes in dairy industries. The technological innovation are represented in advances related to conservation, packaging, mass production, continuous production, and separation and isolation of milk components (defatting and lactose-removing). In Argentina, innovations in dairy industries have focused on process improvement like dehydration, ultra-pasteurization, modern cheese manufacturing, process automation and equipment for quality testing. In Costa Rica, two types of innovation have been developed: (1) closed innovation, related to process improvement and (2) open innovation, related to the rapid growth and intensive industries on information and communication technologies (Food and Agriculture Organization of the United Nations, Pan-American Dairy Federation, 2012). In this study, twelve dairy companies in the region of Meta (Colombia) were inspected, according to the Technological Management Methodology (TMM), and an absence of technology was perceived in all of the processes. The Technological Management Methodology consists in a sequence of questions and analysis that help stablishing goals, strategies and projects, required to close the technology and innovation gaps identified in the profiles. The components of this tool are: Technology inventory, technology profile, innovation profile and structural analysis with the MICMAC method (Matrix-based multiplication applied to a classification) (OECD, 2005). Said methodology includes the four M's (machine, methods, management, money), and it considers the relationships between the variables that are described next. Abbreviations for each variable are also indicated.

Technological change (Tech-chg): considered as an increase in the efficiency of a product or process that results in an increase output, without an increase in input. Technological change helps creating new products, increases the efficiency and lowers costs, and helps economies evolve.

Technological surveillance (Tech-surv): a methodology that helps to strategically address the processes of research and technological development (R&D) in different productive sectors; it is based on the fact that technology is a key factor in the competitiveness of enterprises. Therefore, knowledge of technological advances, in all of its components, is a sine qua non for progress with more certainty in the identification of gaps and challenges.

Know how (Know-how): any industrial information and technique that assists in the manufacture or processing of goods or materials. Know how includes tangible and intangible material which are not common knowledge, since it comprehends expert skill, information, or body knowledge that imparts an ability to cause a desired result.

Employees Training in technology (Trng-Tech): It is important to develop a program that trains all team members. To do this, it is necessary to understand the company culture, in order to provide a solution-oriented approach that helps integrating technology that meets employee needs for their day-to-day operations.

Investment in IT (Inv-IT): IT productivity considers IT capital as an economic input to production. As such, IT capital is treated as an independent variable, while the dependent variable takes the form of tangible outputs such as value added or sales growth (Kleis et al, 2012).

Contribution of the technology to increase the profitability (Transv-tech): whether the end costumers are consumers or businesses, their interest is to be involved in an environment based on the latest technologies. Manufacturers seek to add new technologies to their products as efficiently and quickly as possible, and get those products to their customers on time. New technologies can come in many forms, such as new materials, faster process units, faster processors, more energy-efficient designs, improved firmware and software features, among other.

Modalities of technical production (Tech-prod): A modality is a technological solution, for example, in dairy companies it can be a process control system that provides advanced engineering tools for dairy and cheese makers, which allows them to meet all technological requirements of the dairy process. This type of technology modality includes standard and specific functions ranging from raw material reception through finished products.

Technological strategy (Tech-Strat): is the overall plan which consists of objectives, principles and tactics relating to the use of the technologies within a particular organization. Is the task of building, maintaining and exploiting a company's technological assets.

Technology management in the strategic plan (Mgmt-Strat): considers the planning, direction, control and coordination of the development and implementation of the technological capabilities to formulate and reach the strategic and operational goals of the company.

Maintenance of equipment (Equip-Maint): involves keeping the equipment, their structure, machines, furniture and facilities in good repair and operating efficiently and safely.
Technology incorporated to the capital (Tech-Capital): this is the inherent technology of production goods. The transfer of technology consists of the purchase and sale of capital goods.
Software implementation/generation (Software): these are the systematically structured approaches to effectively integrate of develop a software based service or component into the workflow of the organizational structure.
Contribution of technology to sales growth (Tech-incr-sls): this is related to the use of digital, mobile and social media to improve the business-consumer interaction (Kleis et al., 2012).
Sales software (Soft-Sls): to allow companies to review sales reports.
Technology management (Mgmt-Tech): a set of management disciplines that allows organizations to manage their technological fundamentals to create competitive advantage, based on the understanding of the value of certain technology for the organization.
Contribution of the technology management to profitability (Mgmt-Tec-Prft): the adoption of technologies has an impact on the position of the companies, which seek to benefit from the trends (Kleis et al., 2012).
Technology acquisition (Acq-tech): this factor involves the match between technological capabilities and market opportunities, as well as the capability of the company to absorb and make good use of technologies that other firms are developing (Mortara and Ford, 2012).

2. Methods

This is a descriptive and non-experimental research. The field research was based on observation and polls. The research instruments consisted of a survey, a Likert scale and checklists. The poll was to verify the characteristics of the production costs related to investments in improving the quality of the existing products, and the development of new products in the region of Meta-Colombia. The Likert scale allowed the assessment of the techniques, equipment, and informatics programs used for production of goods and services, supply of inputs, support activities (i.e. purchases and accounting, among other); finally, checklists allowed for a direct and indirect observation of the technical processes and human resources. The instruments were applied to twelve dairy companies. Then, data were systematized with SPSS® and R® statistics software. A descriptive analysis and inference analysis were carried out by the construction of ANOVAs, to verify the significance of the crossing of variables. To analyze the Likert scale, multivariate data association techniques were used, in order to assess the significance of each question component.

3. Results

As a context, it is pertinent to consider that the structure of the dairy industry in Colombia is more heterogenous than in the countries of the Southern Cone (Argentina, Chile, Paraguay and Uruguay), with farms whose average size is much lower than that prevailing in the Southern Cone region, which means more farms, subtropical oriented production system and the coexistence of modern specialized systems and dual purpose systems. This case study covers twelve of the fifteen dairy companies that are officially registered in the region of Meta, Colombia. Each company will be named by a code (E1, E2, E3…E12), due to the confidentiality of the analysis and the findings related to the activities of some of the companies. In the region of Meta (Colombia) it is common to find dual purpose systems with family production schemes, which makes it difficult to measure the quantity of milk produced, because there is no measurable delivery to formal circuits, although an important part is destined for consumption within the property, either by the animals or the family, whether it is raw or processed. The so-called "double-purpose system" is generally characterized by small farms with undefined breeds which are oriented towards meat and milk production and therefore often have low levels of adoption of specific technologies, and show a weak integration with the more formal trade channels. On the other hand, in relation to business models, there exist two different forms of organization. A "family-based business model", in which the producer and his family are involved in the daily management of exploitation, especially at the level of decisions, and provide a significant but not a majority of the work of the establishment, and the "entrepreneurial business model", where the producer or his family adopt a managerial role, with labor almost exclusively contracted. There is also a very significant subgroup, in terms of quantity of producers, which has been termed "non-commercial family", i.e. producers who produce for subsistence and are not integrated with the market. Subsequently, the experiences of integration into the chain are very diverse, because the structure of primary production and the characteristics of the marketing and consumption channels are very heterogeneous in the volume of production and in the organization of the integration of the farm with the consumer. In some cases, the figures of the intermediary and the elaboration in farm are still very important, whereas in other companies the chain is more developed, with a direct relation between the

producer and the industry. Figure 1 establishes a reference for what was found and what would be expected in the later stages of the study, based on the preliminary observation. Figure 1 also shows evidence of the lack of technology perceived in the initial stage of the study. Three Zones were considered, regarding the surrounding factors in the company that are related to the technological development. The first zone (Zone 1) is constituted by the companies that are close to the capital of the country (companies E9, E10 and E11). These companies are the ones that aim for improvement in order to meet the needs imposed by the market. The company E9 shows a high development and strategy to implement technology for process automation and reinvestment of profits. This company has a Good Manufacturing Practice (GMP) certificate, and it is aiming for HACCP certification, ISO 22000 certification and origin certificates. This development is due to the financial support that this company has received from the government. The companies E10 and E11 have also received support from the government. Some of the elements that are referenced in the companies that are grouped in the Zone 1, consist in changes in the product presentation, selection processes of suppliers based on payment process, price, and continuous availability of the raw materials, as well as skilled labour and training. These companies also consider financial incentives and awards for their employees.

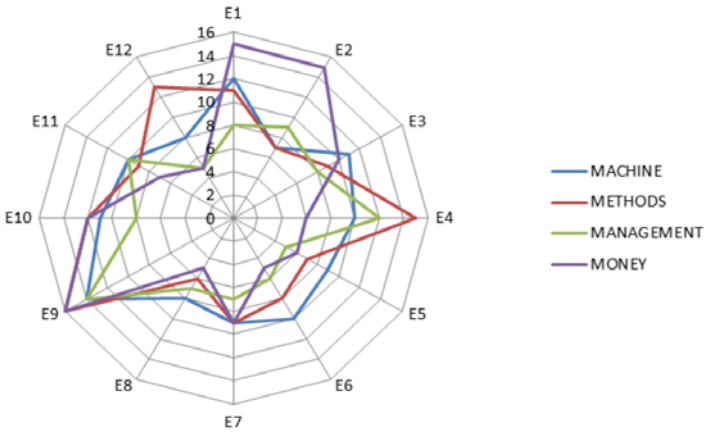

Figure 1: Dairy companies in the region of Meta, Colombia

On the other hand, eight companies are grouped in the Zone 2, where the milk production has become one of the most important economy activities that are carried out by big and small companies. Only two of these eight companies register a formal process for hiring skilled and experienced labour, according to their quality management system. In this zone (Zone 2), only a few innovation activities are identified in the production process, marketing, quality and product, through reinvestment of profits. Companies E2 and E4 work according to the standard and have destined financial resources in R&D for innovation. The results are evident in the development of the companies and their technology (industrial and semi industrial). These companies select their suppliers according to their production capabilities, the quality, the service and the payment process, and their training programs depend on the specific needs of each company. Two companies are located in the third zone (Zone 3), but the poll was only applied to one of the companies (E12). E12 is a small company (semi craft company) that produces cheese, with 13 years in the market. This company is only focused in the product manufacture and the marketing with their current costumers; there is no evidence of innovation or investment that aims for sales increase, to enter other markets, to motivate employees or to get a quality certificate. These descriptive results show the gap between what is expected and what was found. For example, in Figure 1, it is observed the company E9 is the only company in the whole group that has developed some innovation in regard of technology. This company also has evidence of elements associated with methods, management and money, showing that this is an organized company that invests in technology and innovation, which results in big sales. The company E2 is also highlighted in the implementation of technologies that drive innovation in its new products and in the way they assume the organizational processes; in contrast, the other companies are away from this reality, due to the lack of innovation in technological processes, as it is the case of the company E1. Figure 2 shows how the companies are associated between them, according to the lack or presence of technology.

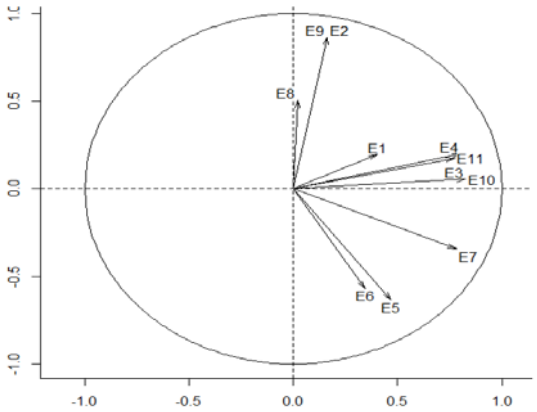

Figure 2: Boxplot of the association strength between companies, based on the presence of technologies

In Figure 2 it is observed that the companies E9 and E2, previously mentioned as the ones with better implementation of technologies, are also the ones with a strong association, in terms of innovation in all its processes and products. There is a medium strength association between these companies and the company E8, which shows some elements of technological innovation. The other companies show low technology levels. As a result, these companies are associated as a group.

Figure 3 shows the position of the variables in the four quadrants according to the results of the polls applied to the 12 companies that participated in this study, as follows: the upper right quadrant (I) shows the variables with the most influence and least dependence; these will be considered as *determinant variables*. Examples of these determinant variables are: training in technologies, use in transversal technologies (such as attending events, patents development, among others) and the type of maintenance performed on machines. These variables help to perceive the technological gaps in each company. The upper left quadrant (II) shows variables that are more influential/dependant. These are known as *relay variables*. Any action on these variables will affect the other ones. The variables located in quadrants I and II will be considered as key variables.

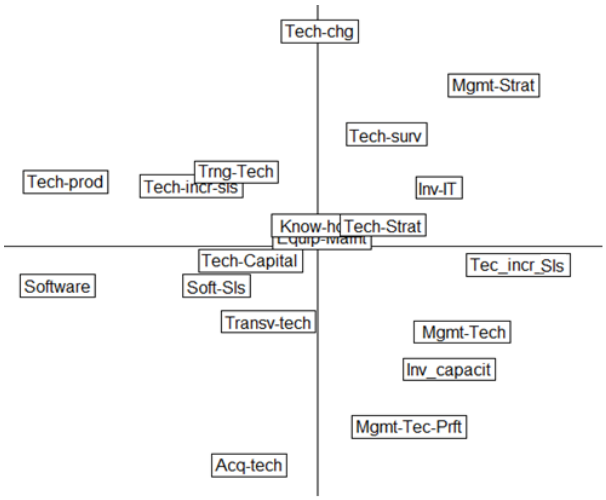

Figure 3: Influential and non influential variables in the four M's analysis

In the lower left quadrant (III), the variables are of little influence/dependence. These are known as *autonomous variables*. These variables do not stop the evolution of the system, and they do not determine the future, so they will not be considered as key variables. Finally, in the lower right quadrant (IV), the variables are of little influence but highly dependants. These are known as *dependant variables*. Their evolution is explained by the variables in quadrants I and II. These dependant variables will not be considered as key variables, due to their little influence.

Based on Figure 3, it is observed that the technology surveillance to the acquired machinery, the knowledge generated in seminars and training courses, the strengthening of technological innovation strategies, the

strategic management within the company and the continuous changes of technology have been a support for the other technological elements.

4. Conclusions

It is observed that the companies with more technological advances are in the municipalities near the capital of the region. Apart from this, it was found that in some companies, there is an insufficient infrastructure which together with politics related situations, causes a need for improvement of the working conditions. However, this is an evident opportunity for these craft companies to improve the aspect of the administrative management and the economic resources within the organization. This can be achieved by: 1) training the employees on technology issues, 2) doing (or hiring) technological surveillance, 3) improving the management technologies, 4) acquiring software that helps increasing the percentage of sales and 5) making investments in management technologies that generate profitability. These specific gaps can be taken as grounds for progress in achieving the business or organizational goals.

The concept of “non-formal” production is related to two main aspects: one is the production of raw milk, or home-made production, which would not classify as “industrial production”, and other is the production that is not supported by a quality system. The experience acquired from this study shows that market and family milk production can be articulated, and that it is possible to establish organizational models in order to integrate the small and medium size producers to the productive chains. This would help expand their market, as a base for the economic sustainability of primary production.

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