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Technology Management in SMEs: Suppliers as links for business collaboration.

Gestión de tecnología en PYMES manufactureras: el rol de los proveedores en la vigilancia tecnológica

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Abstract

The main aim of this paper is to analyse the process of technology management in footwear manufacturing firms and the influence of its suppliers on this management process. It is argued that suppliers contribute to inter-business collaboration that should serve as a strategy to mitigate the problems of competitiveness and sustainability in Small and Medium Enterprises (SMEs). The methodological strategy is quantitative. A random sample of 33 footwear manufacturers settled in Guanajuato, Mexico was selected. The instrument was applied to upper-intermediate level and top-level managers in the participating organisations and validated with the Cronbach Alpha Test ($\propto$ = 0.8891). This paper allows the understanding of the constituent elements in the process of technology management of these SMEs which is shown through the analysis of means' difference. The results allow the inference that suppliers play a key role in the diffusion and transfer of technology in the footwear cluster. However, SMEs perceive their influence in two directions: as a threat to their competitiveness by sharing information with other companies in the sector and as an opportunity to accelerate the design and development of innovative and competitive products.

Keywords: technology management; technological monitoring; business collaboration through suppliers

Resumen

El objetivo central del trabajo es analizar el proceso de gestión de tecnología en las manufactureras de calzado y la influencia de los proveedores en este proceso de gestión. Se asume que los proveedores son un enlace estratégico para lograr la colaboración entre las PYMES y pueden contribuir a mitigar sus problemas de competitividad y sostenibilidad. La estrategia metodológica utilizada es cuantitativa; mediante muestreo aleatorio se integró una muestra de 33 manufactureras de calzado instaladas en Guanajuato, México. El instrumento se aplicó a mandos medio-alto y alto en las organizaciones estudiadas y se validó con la prueba *alpha* de *Cronbach* ($\propto$= 0.8891). En esta investigación se discute cuáles son los elementos constitutivos en el proceso de gestión de tecnología de estas PYMES, mostrado mediante el análisis de diferencia de medias. Los resultados permiten inferir que los proveedores juegan un

papel clave en la difusión y transferencia de tecnología en el *cluster* de calzado, sin embargo, las empresas perciben su influencia en doble vía, como amenaza –para su propia competitividad al compartir información con otras empresas del sector- y como oportunidad –para acelerar el diseño y desarrollo de productos innovadores y competitivos-.

Palabras clave: gestión de tecnología; vigilancia tecnológica; colaboración empresarial mediante proveedores

Introduction

For decades the light manufacturing industry in Mexico has experienced cyclical crises and productive reconfiguration processes driven, in part, by the strong competitive pressure exerted by the commercial opening motivated that the different Free Trade Agreements in which the country takes part (Alvarez, Hernandez & Cazares, 2015). The availability of Asian footwear at a very low cost or even high value-added in fashion and technology of Brazilian footwear in the domestic market, as well as the increase in online sales, among other factors, has exacerbated the crisis and forced local manufacturers to search for different strategies to maintain and consolidate this industrial sector (Cruz & Alvarez, 2014). This productive sector is assumed to be relevant for the significant number of jobs that generates and its contribution to manufacturing Gross Domestic Product (GDP) (CICEG, 2015); this low-technology cluster is characterized by its organization and ease of association (Cruz & Alvarez, 2014).

Numerous explanations for the lack of competitiveness of the manufacturing industry agree that the main causes are the lack of technology, lack of training and low innovative capability (Akin, Bloemhof & Wysnstra, 2012; Alvarez *et al.*, 2015; Brown & Guzman, 2014; Krawczyk, 2017; Muinelo, 2012; Oyebisi, Modu & Olabode, 2013). Technology-based competitiveness facilitates the addition of value to products and to control costs (Aguilera, Hernández & Pérez, 2014), consequently, it is possible to generate sustainable competitive advantages through the technical knowledge and technology employed in these companies (Oyebisi *et al.*, 2013).

Technology Management (TM) is the mechanism used to operate strategies so as to achieve technology-based competitiveness (Krawczyk, 2017). Over the last few decades, companies have been involved in an unprecedented technological revolution. Therefore, TM has been used to optimize operations (Smith, Koohang & Behling, 2010), which requires effective communication within and between the organization. The main challenge is to achieve collaboration between technical and non-technical communities involved in this management process (Phaal & Palmer, 2010). Although, TM was a construct developed in high-tech companies, its implementation has exceeded the technological level of these organizations (Aguilera *et al.*, 2014). Also, any of them requires the effective management of technology due to its strategic importance (Alvarez et al., 2015; Foltz, Schwager & Anderson, 2008).

In view of the aforementioned scenario, this research aims to focus on how to operate TM in SMEs of a productive sector that uses low technology in an emerging economy, such as the footwear sector in Mexico, and the role of suppliers in such process. This is a controversial issue; therefore, this study is divided in four sections: the theoretical framework; the methodological strategy; the results obtained which are presented and analysed; the main conclusions drawn from the study.

1. Theoretical Framework

TM is defined by the National Award for Technology and Innovation as the cluster of activities and processes that are implemented by companies to optimize the use of their technologies (PNTI, 2014). This implies having a development plan, a better control of their productive processes and a solid strategy to generate value for their products (Smith et al., 2010). TM is the process of involvement and operation of decisions on policies, strategies, actions and plans related to the generation, production, diffusion and use of technology within the organizations (Etzkowitz, 2010). The TM in manufacturing SMEs crucially depends on the size of the organization and its structure (Krawczyk, 2017); in addition, the crucial problem of TM for manufacturing SMEs is how can these companies achieve value from technology for to compete globally (Purnendu & Kallol, 2016).

TM has gone through different styles in process management (Du Preez & Louw, 2008 quoted in Oyebisi *et al.*, 2013; Purnendu & Kallol, 2016; Tayaran, 2011) agree with the following management models: Technology Push, which consists in launching products to the market based on available technology; Market Pull, which refers to the exploration of the market and the use of technology to respond to those felt needs; the Coupling that is a mixture of the previous two but in nonlinear processes; the Functional Integration that strategically links the suppliers of the companies for the development of products. This allows the linking of the operating groups' activities with the suppliers through mechanisms of structural feedback; Networks and Systems involve external and internal stakeholders to manage technology, not only suppliers but companies within the same industrial sector.

In this situation, TM is made up of six processes: Technological Monitoring, Knowledge Protection (for example, through patents), Competitiveness Evaluation, Technology Strategy Design, increase of the Technological Patrimony, and implementation of Development Phases (Oyebisi *et al.*, 2013). For the PNTI (2014), the key to TM lies in Technological Monitoring that it is a systematic process of identification and evaluation of the technological advances that are critical to reinforce the competitive advantages of the organizations because it allows to identify technological trends, business opportunities, strategic partners and related technologies to the company that have an impact on producing added value.

The Mexican Standard of Technological Management (NMX-GT-003-IMNC-2008) outlines that TM is based on technological projects executed in four processes: Monitoring; Planning; Supplying; Protection – particularly ideas and technologies that make a difference in manufacturing processes-. These processes help firms to track which technologies are in trend and why, to know the technological innovations developed in research centres to identify the macro tendencies going on, to assess the interaction experiences between the different knowledge generators and the linkage with the companies, among others (Alvarez *et al.*, 2015). On this matter, the information that flows through suppliers in the Technological Monitoring Processes is assumed to be relevant.

2. Methodological Strategy

This research approach is explanatory and cross-sectional. It aims to explain the TM process in local manufacturing companies in a low-technology sector, as well as the influence of suppliers within the framework of this management process. The central proposition was designed taking into consideration the idea that TM takes place within small and medium sized footwear manufacturing firms, and it is influenced by their suppliers, as they are believed to be a key element in the TM process since they help accelerate the design and development of innovative products.

According to the literature review, Technological Management is conceptualized as a technical knowledge system that is fluid. It is stored and interacts within the footwear manufacturers themselves and extends to other companies of the cluster. TM operates in eight categories. The first four categories are related to policies, strategies, actions and plans related to creation, production, diffusion and use of technologies (Etzkowitz, 2010; Oyebisi *et al.*, 2013; PNTI, 2014). The next two categories refer to Technological Monitoring Processes and protection of Intellectual Property (Du Preez *et al.*, 2008 quoted in Oyebisi *et al.*, 2013; PNTI, 2014; Tayaran, 2011). The last two refer to Functional Integration and Structural Feedback –suppliers- (Nevis, DiBella & Gould, 1995; Tayaran, 2011). This research hypothesis is proposed in the following way:

H_i: Footwear Manufacturing SMEs operate TM processes that are influenced by the suppliers since they help accelerate the design and development of innovative products.

The research focused on the local footwear manufacturing SMEs located in Guanajuato, Mexico. According to INEGI (2014), more than two thousand footwear companies are settled in Guanajuato of which 20.5% are SMEs; thus, the targeted population in this research are 481 footwear companies. These SMEs produce fifty-four percent of the footwear production in Guanajuato. Random sampling was used. To calculate the sample size, the formula for finite and non-finite populations $\mathbf{n_{SMEs}} = \boldsymbol{\pi}(\mathbf{1}-\boldsymbol{\pi})(\mathbf{Z}_{\frac{\propto}{2}}/\mathbf{e})^{\mathbf{2}}\mathbf{DEFT}$ was used. The criteria employed in the calculation, at a level of confidence of 90%, was: $\boldsymbol{\pi}$ = 0.5; e = 0.145; DEFT = 1; $\mathbf{Z}_{\propto/\mathbf{2}}$= 1.64. A sample of 33 SMEs was determined and grouped by manufacturing type as shown in table 1.

Table 1. Sample Integration by Manufacturing Type

Men	**18.2%**	**6**
Women	24.2%	8
Men and Women	12.1%	4
Children	12.1%	4
Industrial Safety	15.2%	5
Boots	18.2%	6

Source: prepared by the authors.

The instrument was designed based on the eight aforementioned categories. The final version of the instrument included 49 items (Table 2); it was utilized a five-point Likert scale. Moreover, an open question was incorporated (item 50) so as to collect the views of the respondents about the role of suppliers in TM processes, which in turn allowed the contrast and explanation of the phenomenon being studied. This instrument was administered to medium and senior managers from the production area of the units under analysis. A data bank was created with 77 records, an average of 2.33 questionnaires per company.

Table 2. Items Distribution by Category

Category		Number of Items	Theoretical Review
C1 - Policies	Creation, production, diffusion and	5	Etzkowitz (2010); Oyebisi *et al.* (2013); PNTI (2014).
C2 - Strategies		5	
C3 - Plans		5	
C4 - Actions		5	
C5 – Technology Monitoring		10	Du Preez et al. (2008, quoted in Oyebisi *et al.*, 2013); PNTI (2014); Tayaran (2011).
C6 – Intellectual Property Protection		9	
C7 – Functional Integration	Suppliers	5	Nevis et al. (1995); Tayaran (2011).
C8 – Structural Feedback		5	

Source: prepared by the authors.

Once the data was collected and a database was built, each item was statistically described by calculating the values of the coefficients of asymmetry and kurtosis. In addition, the degree of univariate normality of each of these was verified (Hair, Anderson, Tatham & Black, 1999). The method used to determine the existence of constituent elements of TM processes was the analysis of means difference. In this method, the mean of the sample is compared to a neutral point – in this case three, since the scale ranges from one to five – the T-Student Test was used to determine if the mean of the given response differs in a statistically significant manner from that point at a significance level of five percent. In all the statistical analysis, Minitab 17.0[1] was used.

3. Analysis and Presentation of Results

The coefficients of asymmetry and kurtosis were calculated to verify the univariate normality degree of each item. A non-parametric analysis was performed on the 49 items using the Mood Median Test to detect if there were significant differences between the data collected for each company that could distort the analysis. When using Likert Scale the results may not seem to come from a normal distribution; therefore, the work hypotheses were:

H_0 = There are not statistically significant differences in the median values of the studied population.

H_a = There are statistically significant differences in the median values of the studied population.

The general median of the sample was 2.0 and the p-value = 0000. The test results provide sufficient evidence so as not to reject H_o; in other words, there are not statistically significant differences in the median population. Therefore, it is assumed that there is not analysis unit that could distort the data. In general terms, the studied SMEs carry out the processes of TM in their production process.

[1] Minitab® is a specialized computer program in basic and advanced statistics copyright by Minitab Inc.

The method employed to determine the existence of each of the elements in the Technological Management model was the analysis of means difference by using the T-Student Test. Also, it was measured using Likert Scale – from one to five, where one is "not frequent in the company" and five is "very frequent in the company"-. The significance of the difference in the mean of the sample was calculated with regard to the neutral value three, obtaining a confidence level of 95%. Based on the analysis, it is determined that elements are present in the TM of these SMEs. Thus, if the mean is greater than three and the interval between the lower and higher limit of confidence level cover the value of three, then it is present; else it is inferred that it is not present as the mean is below three (Table 3).

Table 3 shows significant and non-significant individual elements by category. Only, the non-significance of category six is evident. Therefore, it was proceeded to group the items in order to carry out the analysis. In other words, items were organized and grouped per columns so as to measure each of the eight categories. Immediately after that, the analysis of means difference was calculated again, as shown in Table 4. The table clearly shows that the intellectual property protection is definitely not present in the TM of these companies; however, the technological planning and the functional integration of suppliers are indeed key constituent elements in the process of Technology Management.

Based on the foregoing and after systematizing the responses of item 50, processes of simple unit production were identified to a greater extent. In addition, technically complex units produced one by one in small batches were also identified but to a lesser extent. Moreover, an intensive engineering level was detected with a high variability of tasks and a low degree of analysis in the production process. According to the aforementioned, footwear production process is regarded as low-tech (Moulay, Nabil & Réjean, 2012). Taking this evidence into consideration, TM processes depend on the type of manufactured footwear. All the TM processes were identified in the Manufacturing Companies of Industrial Safety and Lady Items. Likewise, they were also observed in Manufacturing Companies of Children Footwear and Boots, but to a lesser extent.

In all of these cases, suppliers have influenced the use of new materials and new production technologies. In addition, the participation in Industrial Fairs for suppliers has been a determining factor in the decisions related to TM. Companies consider that suppliers play an important role in knowledge transfer. However, they are also an effective way of disseminating strategic information between companies of the same line of business, which at the same time, can also be considered a risk factor if the shared knowledge is strategic for their competitiveness.

Table 3. Mean Difference Analysis by item

Test of mu = 3 vs not = 3

Categories	N	Mean	StDev	SE Mean	95% CI	T	P
C1-1	77	3.0650	1.311	0.149	(2.767, 3.363)	0.43	0.665
C1-2	77	3.0519	0.7930	0.0904	(2.8720, 3.2319)	0.57	0.567
C1-3	77	2.6880	1.103	0.126	(2.438, 2.939)	-2.48	0.015
C1-4	77	3.5580	1.141	0.130	(3.299, 3.817)	4.29	0.000
C1-5	72	2.5139	0.5033	0.0593	(2.3956, 2.6322)	-8.20	0.000
C2-1	77	3.0779	0.7908	0.0901	(2.8984, 3.2574)	0.86	0.390
C2-2	74	2.4730	1.219	0.142	(2.191, 2.755)	-3.72	0.000
C2-3	77	3.3380	1.046	0.119	(3.100, 3.575)	2.83	0.006
C2-4	76	3.0000	0.8485	0.0973	(2.8061, 3.1939)	0.00	1.000
C2-5	77	2.3900	1.126	0.128	(2.134, 2.645)	-4.76	0.000
C3-1	74	3.5950	1.059	0.123	(3.349, 3.840)	4.83	0.000
C3-2	77	2.4675	0.5022	0.0572	(2.3535, 2.5815)	-9.30	0.000
C3-3	75	2.9200	0.8014	0.0925	(2.7356, 3.1044)	-0.86	0.390
C3-4	77	2.6360	1.050	0.120	(2.398, 2.875)	-3.04	0.003
C3-5	76	3.3950	1.132	0.130	(3.136, 3.653)	3.04	0.003
C4-1	76	3.0132	0.8562	0.0982	(2.8175, 3.2088)	0.13	0.894
C4-2	76	2.5260	1.077	0.124	(2.280, 2.772)	-3.84	0.000
C4-3	76	3.4740	1.183	0.136	(3.203, 3.744)	3.49	0.001
C4-4	76	2.5263	0.5026	0.0577	(2.4115, 2.6412)	-8.22	0.000
C4-5	77	3.3380	1.210	0.138	(3.063, 3.612)	2.45	0.017
C5-1	75	2.4000	1.162	0.134	(2.133, 2.667)	-4.47	0.000
C5-2	73	3.7120	1.086	0.127	(3.459, 3.966)	5.60	0.000
C5-3	74	2.4459	0.5005	0.0582	(2.3300, 2.5619)	-9.52	0.000
C5-4	75	2.7200	1.391	0.161	(2.400, 3.040)	-1.74	0.085
C5-5	75	3.1867	0.8333	0.0962	(2.9949, 3.3784)	1.94	0.056
C5-6	77	2.4940	1.008	0.115	(2.265, 2.722)	-4.41	0.000
C5-7	77	3.3250	1.186	0.135	(3.056, 3.594)	2.40	0.019
C5-8	77	2.3896	0.4909	0.0559	(2.2782, 2.5010)	-10.91	0.000
C5-9	77	3.0779	0.8393	0.0956	(2.8874, 3.2684)	0.81	0.418
C5-10	74	3.1080	1.540	0.179	(2.751, 3.465)	0.60	0.548
C6-1	77	2.9091	0.7977	0.0909	(2.7280, 3.0902)	-1.00	0.320
C6-2	77	2.9350	1.507	0.172	(2.593, 3.277)	-0.38	0.706
C6-3	76	2.8684	0.8381	0.0961	(2.6769, 3.0599)	-1.37	0.175
C6-4	76	2.4470	1.248	0.143	(2.162, 2.733)	-3.86	0.000
C6-5	75	2.1330	1.082	0.125	(1.884, 2.382)	-6.94	0.000
C6-6	77	2.4416	0.4998	0.0570	(2.3281, 2.5550)	-9.80	0.000
C6-7	75	2.9600	1.350	0.156	(2.649, 3.271)	-0.26	0.798
C6-8	73	2.3699	0.4861	0.0569	(2.2564, 2.4833)	-11.08	0.000
C6-9	74	2.8380	1.414	0.164	(2.510, 3.166)	-0.99	0.327
C7-1	75	3.0533	0.7692	0.0888	(2.8764, 3.2303)	0.60	0.550
C7-2	77	3.3120	1.217	0.139	(3.036, 3.588)	2.25	0.027
C7-3	77	3.5190	1.210	0.138	(3.245, 3.794)	3.77	0.000
C7-4	75	3.1330	1.379	0.159	(2.816, 3.451)	0.84	0.405
C7-5	77	3.0000	1.405	0.160	(2.681, 3.319)	0.00	1.000
C8-1	77	3.1299	0.8168	0.0931	(2.9445, 3.3153)	1.40	0.167
C8-2	77	2.4160	1.185	0.135	(2.147, 2.685)	-4.33	0.000
C8-3	74	3.7700	1.001	0.116	(3.538, 4.002)	6.62	0.000
C8-4	76	2.5132	0.5031	0.0577	(2.3982, 2.6281)	-8.44	0.000
C8-5	75	3.0670	1.398	0.161	(2.745, 3.388)	0.41	0.681

Source: prepared by the authors based on data obtained from fieldwork.

Table 4. Analysis of Mean Difference by Category

Categories	N	Mean	St. Dev	SE Mean	95% CI	P

C1	76	2.9754	0.9703	0.1109	(2.7572, 3.1935)	0.000
C2	76	2.9592	1.0597	0.1219	(2.7203, 3.1981)	0.000
C3	**76**	**3.0027**	**0.9089**	**0.1045**	**(2.7981, 3.2073)**	**0.000**
C4	76	2.9755	0.9658	0.1108	(2.7587, 3.1923)	0.000
C5	75	2.8859	1.0037	0.1157	(2.6594, 3.1125)	0.000
C6	76	2.2558	1.0247	0.1179	(2.2247, 2.4868)	0.000
C7	**76**	**3.2035**	**1.1960**	**0.1370**	**(2.9349, 3.4720)**	**0.000**
C8	76	2.9792	0.9808	0.1126	(2.7584, 3.2000)	0.000

Source: prepared by the authors based on data obtained from fieldwork.

4. Some Conclusions

1. The execution of TM in the studied SMEs (Analysis of the Median Mood) is validated, which implies the dynamic operation of a process for the generation of knowledge structures with which they seek to heighten the technological level of their productive processes and their competitiveness. TM would allow them to guarantee the creation of value in their innovation system and to materialize facilitating mechanisms in order to increase their competitiveness (Akin *et al.*, 2012; Alvarez *et al.*, 2015; Brown & Guzman, 2014; Muinelo, 2012; Oyebisi *et al.*, 2013).
2. The statistical model of TM in manufacturing SMEs (Analysis of Mean Difference) explains what their functional elements are. In such circumstances, it is feasible to infer that TM seems to produce a favourable impact on the results of the organization (Akin *et al.*, 2012; Brown & Guzman, 2014; Foltz *et al.*, 2008; Oyebisi *et al.*, 2013; Phaal & Palmer, 2010; Smith *et al.*, 2010). This provides encouragement for further research on this line in order to identify the factors that foster the generation and transformation of knowledge so as to achieve new approaches to responsible and sustained management.
3. Suppliers play an important role in TM processes since they allow the flow of acquired knowledge by the companies under study. It is inferred that the more flow of knowledge resulting from the use of TM, the more innovative potential that SMEs are likely to have (Nevis *et al.*, 1995), although it is important to acknowledge that

other factors might need to be considered, including enacted values, entrepreneurial position, and organizational capability to adapt to the external environment, among others-. The foregoing opens up the possibility of follow-up research, acknowledging that it is not always possible to include all the proposals that the Theoretical Framework provides.

4. The research hypothesis is not rejected. TM in the Footwear Manufacturing SMEs is influenced by the suppliers. They are a key player in TM processes by accelerating the design and development of innovative products, as well as the decisions making on the technology employed in the production processes. The preceding relates to a greater or lesser extent with elements of the organizational culture in its instrumental form, but also with certain positions adopted within family owned organizations, as is the case of the companies under study (Rendon, 2003).
5. The companies studied are family owned business and this implies that cultural dynamics constitute a relevant factor. In other words, the individuals maintain links and make use of prerogatives in the decision-making (Rendon, 2003). In this sense, two main aspects for the continuity of the investigation are open: the first one relates to the elements that must be modified within family owned firms to implement a true culture of technological innovation; the second refers to the challenge faced by SMEs regarding the adaptation to innovative ability and the modification of production scales in concentrated or technologically disadvantaged markets, as is the case of footwear. (Rendon, 2003). In both cases, TM maintains a seam related to organizational culture, as it is a prerequisite to understand the phenomenon under examination.

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