Technology transfer in equipment acquisition: An exploratory study in the Brazilian textile industry

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Abstract
This paper aims to develop an exploratory evaluation of Brazilian textile companies to identify common technology transfer practices being currently used in equipment acquisition. This was done through a multi case study that allowed the identification of best practices intended to improve the technology transfer process in textile companies.

Key words: Technology transfer; Textile industry; Equipment acquisition.

INTRODUCTION

The Brazilian textile industry represents a relevant role for the country's economy both in job creation and in industrial production value. In 2014, this sector was responsible for 1.5 million employees or 16.9% of the jobs in the manufacturing segment. In monetary values, it generated US$ 53.4 billion in sales corresponding to 5.6% of the transformation industry excluding civil construction and mining (IEMI, 2015).

Since mid-nineties, the Brazilian textile industry has been facing a fierce competition from low cost imports coming from Far East countries like China, Pakistan and others. To respond to this competitive challenge, the textile businesses adopted a defensive strategy based on new equipment acquisition to provide new products with higher quality and lower costs (Vieira Jr. et al. 2014). Moreover, according to Lager and Frishammar (2010, p. 670), "*when equipment is purchased, technology transfer takes place, by definition*". Equipment investment in the Brazilian textile sector has been significant, representing around US$ 1.0 billion a year (IEMI, 2015).

Nevertheless, despite the relevant importance of the Brazilian textile industry in terms of economic value added and investment spending in technology transfer, the existent literature dealing with this theme is very scarce. Actually only two articles connected to the technology transfer in the Brazilian textile industry were found. Vieira Jr. et al. (2014) proposed a framework for the local textile companies to optimize their technology transfer process through the utilization of a stage-gate approach. Braga Jr. et al. (2009) described and characterized the technology transfer process in the Brazilian textile sector through a five-step procedure that could be observed in the local companies. Those facts suggest an interesting research gap to be explored. Thus, this research

aimed at developing an exploratory evaluation of the technology transfer practices resulting from equipment acquisition and adopted by the textile companies located in three regions across Brazil. This was done through a multiple case study where 12 spinning and weaving firms were considered.

THEORETICAL BACKGROUND

According to Joshi (1977), technology transfer is a planned economic activity related to the technology flow from one country to another. Levin (1993) enlarges this concept considering two aspects: for the supplier, technology transfer is related to the delivery of goods and knowledge transfer and for the receiver it is a process that involves the acquisition of materials and knowledge necessary to operate an equipment. Hamzei (2011) informs that there is an interconnected chain of direct actions that use technology components for training, absorption, development and economic use in a place different from that where the technology was originally created, becoming this a very difficult and complex process. However, for Levin (1993) and Choi (2009) the technology is considered a social product that requires access to its socio-cultural knowledge. Therefore, besides equipment and tooling themselves, cultural skills are also required, i.e., the success of new technology transfer depends on the socio-technical changes. Besides, Oliveira and Segatto (2009) state that the technology transfer aims to obtain competitive advantage for society and firms, but the technology cannot be seen only related to product manufacturing and task and procedure execution. It is paramount to consider the knowledge involved that is linked to beliefs, people, values and data that can be spread through human relations. Choi (2009) highlights that in developing countries the technology receivers become dependent from the suppliers on a continuous way, even for raw material and component specifications. Braga Jr. (2009) and Vieira Jr. (2014) confirmed this specific point for the Brazilian textile industry, showing that the local textile producers rely heavily on supplier led technology transfer processes to improve their competitiveness. However, to avoid this situation, Choi (2009) suggests prioritizing training and skill development to enable the receiver to generate innovations from the received technology.

The next step in the literature search was to identify technology transfer models from which a sequence of logic steps could be identified. It was possible to locate 20 articles falling into that category that encompassed 24 different phases/practices for the technology transfer process. A summary of those findings is shown in Table 1. An analysis of the content of this table shows that among the 24 steps mentioned in the literature, 13 are the most cited ones. A brief description of each step follows:

Step 1 – Technology Planning – Involves the generation of a formal plan or strategy for the entire technology transfer process. It is the initial phase in which the project scope, the human resource requirements, the timetable and the accountability of each people involved are defined.

Step 2 – Technology Objective – Here the company objectives related to market, products, costs, margins, resource utilization and investment capacity are evaluated aiming at defining priorities and goals for the technology transfer process.

Step 2 – Technology Search – Taking into consideration the objectives stated in step 2, the people involved in the technology transfer process will search all available sources that could provide the necessary technology to meet the company objectives.

Step 4 – Technology Confirmation – Once the available technology suppliers are identified, a feasibility evaluation is made to confirm the adequacy of the alternatives considered. In this step, suppliers along with the technical body of the company develop projects involving production

capacities, necessary resources and facilities, investment requirements, costs involved and respective returns. Based on the final projects, the company will confirm which suppliers can meet the established objectives.

Table 1 – Steps of the technology transfer process mentioned in the literature

	Steps of the TT process mentioned in the literature																							
Authors	1. Technology Idea	2. Technology Team	**3. Technology Planning**	4. Technology Condition	**5. Technology Objective**	**6. Technology Search**	**7. Technology Confirmation**	8. Technology Price	9. Technology Capacity	**10. Technology Negociation**	**11. Technology Appproval**	**12. Inrteraction**	**13. Facility Adaptation**	**14. Technology Implementation**	**15. Technology Absorption**	**16. Technology Auditing**	17. Technology Verification	18. Technology Assistance	**19. Technology Utilization**	20. Technology Innovation	21. Technology Develop't	**22. Technology Opetization**	23. Technology Expansion	24. Technology Disposal
1 Köhler et al. (1973)						X	X			X	X	X	X	X		X								
2 Bommer et al. (1991)					X	X						X	X											
3 Hamzei (2011)						X					X				X				X		X			
4 Vieira Jr. et al. (2014)						X	X			X	X			X		X	X							
5 Lager and Frishammar (2010)	X					X				X	X	X		X				X	X			X		X
6 Vasconcelos and Amato Neto (2012)	X					X								X					X					
7 Braga Jr. et al. (2009)						X	X			X				X				X						
8 Levin (1993)	X					X								X					X					
9 Cormican and O'Connor (2009)		X	X											X	X									
10 Guan et al. (2006)										X					X							X		
11 Wang and Zhou (1999)														X	X				X		X	X		
12 Leonard-Barton (1995)														X								X		
13 Hobday (1995)														X								X		
14 Asghari and Takhshanikia (2013)					X	X	X							X	X				X			X	X	
15 Choi (2009)			X												X		X			X				
16 Worrell et al. (2000)						X	X			X	X			X		X						X	X	
17 Lane (2012)			X		X	X								X		X	X		X	X				
18 Castro and Schulze (1995)			X		X	X	X					X	X		X								X	
19 Oliveira and Segatto (2009)				X								X	X	X	X	X								
20 Bennett et al. (1999)					X	X	X	X	X	X	X			X										
Total Citations	**3**	**1**	**4**	**1**	**5**	**13**	**7**	**1**	**1**	**7**	**6**	**5**	**4**	**15**	**8**	**5**	**3**	**2**	**7**	**2**	**2**	**7**	**3**	**1**

Step 5 – Technology Negotiation – Based on the feasible projects defined in the previous phase, the commercial negotiations begin. They involve an intense interaction between the technology supplier and the receiver aiming to achieve a mutual agreement in terms of prices, payment terms, delivery time, technical assistance and training support. The negotiation phase is finished when a final technology supplier is selected.

Step 6 – Technology Approval – After the technology supplier is defined, a formal agreement, including every aspect already negotiated, is signed by both parties. In most cases, the receiver also provides a down payment as part of the negotiated terms.

Step 7 – Interaction – Involves an intense communication between technology supplier and receiver relating to technical detailed specifications taking into consideration the new products/processes that will be implemented. It is an important part of the whole process because what is discussed and defined here could influence the technology performance after its star-up.

Step 8 – Facility Adaptation – In this phase the technology receiving company starts the plant adaptation to receive the new technology. This includes the physical plant preparation as well as the people training, if required. The physical adequacy could comprise layout rearrangements and

utilities installation (power, compressed air, steam etc.). There is an intense exchange of information between supplier and technology receiver to assure that everything is adequately provided before the equipment arrives to assure a minimum time for installation and start-up.

Step 9 – Technology Implementation – It happens from the moment the new technology is available to be installed at the receiver premises. The new equipment is installed and its debug and star-up occur. Since the technology transfer process relies heavily on supplier's support, usually a supplier's technician supervises the equipment assembly and start-up.

Step 10 – Technology Absorption – As part of the start-up and production build-up, the supplier's technician will also provide the necessary training to the operational and maintenance personnel. This is where the technology transfer actually happens in the operational level. After this initial training, the receiver will continue to improve its knowledge about the new equipment as production yields continue to increase and the normal maintenance problems are overcome. Besides the supplier's technician support, interaction with equipment manufacturer continues for some time to deal with operating and maintenance details and fades out as the receiver gains the necessary knowledge to deal with the new technology on its own.

Step 11 – Technology Auditing – It is the final step of the transfer process. Here the receiver will verify if the objectives initially defined in step 2 and the dates established in phase 1 have been met. It is the technology transfer process analysis to identify possible learned lessons and generate knowledge about what was satisfactorily accomplished and what needs improvements in the future.

Step 12 – Technology Utilization – Is the phase in which the company can plenty use the new technology after star-up and production build-up.

Step 13 – Technology Optimization – It is the step where the technology receiver develops improvements in the acquired technology using the knowledge obtained as a result of the continuous and effective operation of the new equipment. This could involve operating at higher speeds, the production of different kinds of products, the utilization of different raw materials, always aiming at improving product quality at lower costs, enhancing overall company competitiveness.

These thirteen steps comprise the theoretical model that this paper considered for utilization in the Brazilian textile industry.

METHODS

This research intended to develop an exploratory assessment of the technology transfer practices employed for equipment acquisition in the textile companies located in Brazil. Therefore, the following research questions were posed: a) Are the technology transfer practices cited in the literature actually used by the textile companies in Brazil?; b) Is there a difference in technology transfer practice utilization depending on the size of the textile company? and c) Does the region where the company is located matter in terms of technology transfer practice adoption?

To answer these questions, multiple case studies were conducted in three textile-producing regions located in Brazil. The case study was used as research method because according to Cauchick Miguel and Sousa (2012) it is the most adequate research strategy for a situation where a detailed investigation of one or more items is desired. Furthermore, case studies are appropriate for exploratory evaluations where practices between different organizations will be considered (Yin, 2010). This work intended to compare technology transfer practice adoption by different textile firms.

As data collection technique, semi-structured interviews were chosen because it is considered the most adequate way for obtaining data in qualitative research (Bryman, 1995; Collins and Hussey, 2003). To assure that all of the required information was adequately gathered during the interviews, an *aide-memoire* was prepared with the main points to be checked. The principal topics covered in the interviews included questions that enabled the interviewer to verify the actual adoption of the 13 technology transfer steps identified in the literature.

To select the companies to support the case studies, Patton (1990) recommends the use of purposeful samplings, i.e., cases from which the researchers can obtain relevant information in relation the central questions under analysis. Among the several strategies suggested by Patton (1990) for selecting purposeful cases, this research adopted the sampling of typical cases, where the companies to be selected for the studies should be textile companies of different sizes and located in diverse regions in Brazil. Access of the researchers to the people that could effectively and properly supply the needed information was an additional criterion to select the firms. As a result, 12 textile companies were selected: 3 located in the South region, 3 in the Northeast and 6 in the Southeast. The number of companies was proportional to the textile activity in each region. In terms of firm sizes, this work adopted the following criteria based on the number of employees (N): Small – $N \leq 100$; Medium – $100 < N \leq 500$; Big - $500 < N \leq 1{,}000$; Very Big – $N > 1{,}000$. Among the 12 companies selected, 2 were small, 4 were medium, 4 big and 2 very big. The number of firms in each size was proportional to the textile firm sizes existing in the country. Table 2 supplies additional information about the selected companies.

Table 2 – The selected companies for the case studies

#	Company	Location	Size	Processes	Management Style	Interviwee
1	A	South	Medium	Spinning	Family and professional mix	Manufacturing manager
2	B	South	Medium	Spinning and weavinng	Family	TT Engineer
3	C	South	Small	Weaving	Family	Manufacturing manager
4	D	Southeast	Medium	Spinning and weavinng	Family	Manufacturing manager
5	E	Southeast	Small	Weaving	Family	TT Engineer
6	F	Southeast	Medium	Spinning and weavinng	Family and professional mix	Qualoty Engineer
7	G	Southeast	Big	Spinning and weavinng	Professional	Manufacturing director
8	H	Southeast	Big	Spinning and weavinng	Family and professional mix	Manufacturing manager
9	I	Southeast	Big	Spinning and weavinng	Family and professional mix	TT Engineer
10	J	Northeast	Very Big	Spinning and weavinng	Family	Manufacturing engineer
11	K	Northeast	Big	Spinning	Family and professional mix	Manufacturing manager
12	L	Northeast	Very Big	Spinning and weavinng	Professional	Manufacturing director

RESULTS AND DISCUSSION

The first question posed by this research was: Are the technology transfer practices mentioned in the literature being actually used by the textile companies in Brazil? According to the interviews developed, the results obtained regarding the technology transfer practices being actually used by the studied companies are summarized in Table 3. Those results show that there are five sets of practices that were used by all 12 firms researched. They were: setting the technology objectives, technology negotiation, technology approval, technology implementation and technology absorption, confirming what was suggested by Bennett et al. (1999). Evidently, those outcomes could be already expected and considered as mandatory because without one of those steps, the

technology transfer would not occur and the related equipment could probably not operate. It is interesting to observe that besides the implementation phase, the other four steps were not intensely cited in the literature (see Table 1).

Table 3 – Technology transfer practices being used by the researched companies

				Steps of the technology transfer process												
#	Company	Location	Size	1. Technology Planning	2. Technology Objective	3. Technology Search	4. Technology Confirmation	5. Technology Negociation	6. Technology Approval	7. Inrteraction	8. Facility Adaptation	9. Technology Implementation	10. Technology Absorption	11. Technology Auditing	12. Technology Utilization	13. Technology Opetization
1	A	South	Medium	X	X		X	X	X	X	X	X	X		X	
2	B	South	Medium	X	X		X	X	X	X		X	X	X	X	X
3	C	South	Small		X	X		X	X		X	X	X		X	
4	D	Southeast	Medium	X	X		X	X	X	X	X	X	X		X	
5	E	Southeast	Small		X		X	X	X	X	X	X	X		X	
6	F	Southeast	Medium	X	X		X	X	X	X		X	X		X	X
7	G	Southeast	Big	X	X		X	X	X	X	X	X	X	X	X	X
8	H	Southeast	Big	X	X		X	X	X	X	X	X	X	X	X	X
9	I	Southeast	Big	X	X		X	X	X	X	X	X	X		X	
10	J	Northeast	Very Big	X	X		X	X	X	X	X	X	X	X	X	X
11	K	Northeast	Big	X	X		X	X	X	X	X	X	X		X	X
12	L	Northeast	Very Big	X	X		X	X	X	X	X	X	X	X	X	X
			Total	10	12	1	11	12	12	11	10	12	12	5	12	7

Conversely, the literature points out an extensive mention of the technology search as one of the most relevant phases of the technology transfer process (see Table 1). Nevertheless, the results obtained in the case studies show that in the Brazilian textile industry this step was not considered by 11 of the 12 firms studied. This could be explained by two main reasons. First, the suppliers dominate the technology transfer process according to Choi (2009) and Braga Jr. et al. (2009), what gives the receiver a passive role in the process. In fact, the supplier becomes responsible for presenting to the prospect receivers the new technology alternatives. Second, Vieira Jr. et al. (2014) showed that in the Brazilian textile sector the equipment selection is made taking into consideration favorable past experience what exempts the receiver from making extensive technology search when acquiring new equipment. In 11 out of 12 firms considered in the research, the equipment sources were already defined even before the technology transfer process began. The only exception was Company C because it used to buy used equipment acquired from larger firms. Thus, a search phase was necessary to uncover where adequate used equipment was available.

The subsequent question proposed in this work was: Is there a difference in technology transfer practice utilization depending on the size of the textile company? To assess this subject, the results obtained in the field research were grouped by company size as seen on Table 4.

Table 4 – Results grouped by company size

				Steps of the technology transfer process												
				1. Technology Planning	2. Technology Objective	3. Technology Search	4. Technology Confirmation	5. Technology Negociation	6. Technology Approval	7. Inrteraction	8. Facility Adaptation	9. Technology Implementation	10. Technology Absorption	11. Technology Auditing	12. Technology Utilization	13. Technology Opetization
#	Company	Location	Size													
1	J	Northeast	Very Big	X	X		X	X	X	X	X	X	X	X	X	X
2	L	Northeast	Very Big	X	X		X	X	X	X	X	X	X	X	X	X
3	G	Southeast	Big	X	X		X	X	X	X	X	X	X	X	X	X
4	H	Southeast	Big	X	X		X	X	X	X	X	X	X	X	X	X
5	I	Southeast	Big	X	X		X	X	X	X	X	X	X		X	
6	K	Northeast	Big	X	X		X	X	X	X	X	X	X		X	X
7	A	South	Medium	X	X		X	X	X	X	X	X	X		X	
8	B	South	Medium	X	X		X	X	X	X		X	X	X	X	X
9	D	Southeast	Medium	X	X		X	X	X	X	X	X	X		X	
10	F	Southeast	Medium	X	X		X	X	X	X		X	X		X	X
11	C	South	Small		X	X		X	X		X	X	X		X	
12	E	Southeast	Small		X		X	X	X	X	X	X	X		X	
			Total	8	10	1	9	10	10	9	8	10	10	3	10	5

The results show that the very big companies applied all the steps of the technology transfer process identified in the theoretical framework proposed by this research, with exception of the search phase due to reasons already explained in this work. The big companies basically follow the same path, but in 2 of the firms the technology auditing was not performed. Among the 4 medium size companies the technology transfer practices employed are not as intense as seen in the very big and big firms. Finally, the small size companies are those with the least utilization of different steps in the technology transfer process, concentrating their activities almost exclusively in the five mandatory steps without which the technology transfer would not materialize. Therefore, the answer to this research question is affirmative as the differences increase as the size of the companies become smaller, confirming the findings obtained by Vieira Jr. et al. (2014).

The third and final research question tried to identify if there was a difference in the technology transfer practice adoption depending on the region where the company was installed. To verify this point, the results were grouped by region as shown in Table 5.

Table 5 – Results grouped by region

				Steps of the technology transfer process												
				1. Technology Planning	2. Technology Objective	3. Technology Search	4. Technology Confirmation	5. Technology Negociation	6. Technology Approval	7. Inrteraction	8. Facility Adaptation	9. Technology Implementation	10. Technology Absorption	11. Technology Auditing	12. Technology Utilization	13. Technology Opetization
#	Company	Location	Size													
1	A	South	Medium	X	X		X	X	X	X	X	X	X		X	
2	B	South	Medium	X	X		X	X	X	X		X	X	X	X	X
3	C	South	Small		X	X		X	X		X	X	X		X	
4	D	Southeast	Medium	X	X		X	X	X	X	X	X	X		X	
5	E	Southeast	Small		X		X	X	X	X	X	X	X		X	
6	F	Southeast	Medium	X	X		X	X	X	X		X	X		X	X
7	G	Southeast	Big	X	X		X	X	X	X	X	X	X	X	X	X
8	H	Southeast	Big	X	X		X	X	X	X	X	X	X	X	X	X
9	I	Southeast	Big	X	X		X	X	X	X	X	X	X		X	
10	J	Northeast	Very Big	X	X		X	X	X	X	X	X	X	X	X	X
11	K	Northeast	Big	X	X		X	X	X	X	X	X	X		X	X
12	L	Northeast	Very Big	X	X		X	X	X	X	X	X	X	X	X	X
			Total	10	12	1	11	12	12	11	10	12	12	5	12	7

Based on the results, it was not possible to identify any significant differences among the three researched regions, what could lead to a negative answer to the third research question. However, it is not possible to establish a definitive conclusion about this point because the sample is too small and was not randomically selected. For more strengthen results, further research would be required.

CONCLUSION

The results obtained in this work enabled the researchers to conclude that the Brazilian textile companies use to different extent the technology transfer practices suggested by the literature. The only exception is the technology search due to the peculiar characteristics of textile equipment procurement observed in Brazil. Furthermore, it was possible to verify that the differences in technology transfer practice utilization increase as the size of the companies become smaller. No definitive conclusion was possible to be achieved relating technology transfer process use and the region where the company was located.

In addition, the results attained here convey some contributions to theory and practice. To the body of knowledge of Operations Management, this work fulfills a gap in the literature since there is a very limited number of studies analyzing the technology transfer process in the textile industry.

On the practical side, this study can be used as an additional tool for practitioners to improve their respective technology transfer procedures, obtaining as a result more effective managerial processes to enhance their company competitiveness.

Finally, the main limitation of this research stems from the fact that the results cannot be generalized because they were obtained as a result of case studies, involving a small number of companies not randomically chosen. Therefore, as a suggestion for future studies, additional research employing the survey method could be developed to obtain more generalized and statistically endorsed results.

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