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Firm-level Technological Upgrading Process in Low-tech Industries: the case of Clothing Industry in Brazil

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Abstract

There is a considerable amount of research on technological upgrading and innovation. However, the majority of studies tend to focus on R&D and patents aspects in high-tech industries. Seeking to contribute to rebalancing the analysis, we examine how occurs technological upgrading path in a low-tech industry, the clothing industry from emerging market. The low-tech industries represent around 90% of the economy of emerging countries, such as Brazil. The research design is operationalized from depth individual case study. The findings show that the clothing industry, even though characterized as low-tech, has not remained technologically stagnant, developing innovative activities and a path-follower. However, although it can be considered innovative, the industry shows little association with 4.0 technologies. The research questions biases in extant research and policy debate towards certain types of innovative capabilities, industries, and taxonomies that limit the understanding of innovation and technological catch-up in different industrial settings.

Keywords: Innovation, Knowledge Management, Brazil, Leather and Textile Industries, Technology.

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1 Introduction

Technology upgrading is a multidimensional process related to the efficiency of the production process and the degree of innovation of a firm and plays a role in growth acceleration in certain developing/emerging economies (Lee, 2013; Radosevic, Meissner, Lacasa & Günther, 2019; Yoruk, 2019).The technological upgrading process depends largely on the extent and how firms create and accumulate innovative technological capabilities through deliberate learning strategies (Figueiredo & Cohen, 2019). So, measuring technological capabilities can help firms understand their behavior and technological potential to achieve technological catch up and role to the growth acceleration (Bell & Figueiredo, 2012).

Although research in technological upgrading in firms and industries in developing economies dates back to the 1970s, the discussion of 4.0 technologies contributed to a proliferation of studies examining the process of technological upgrading in developing/emerging countries (see comprehensive reviews in Bell, 2006; Bell & Figueiredo, 2012; Radosevic & Yoruk, 2018; Lee, 2019).

Despite their enormous contributions, existing studies tend in one hand to measuring technological upgrading from indicators, which are overly R&D oriented. However, they do not reflect specificities of technology upgrading of emerging economies (Radosevic & Yoruk, 2018). Moreover, the indicators fall short in several ways: firstly, they lack a detailed account of the technological upgrading trajectory; secondly, they overlook intra-organizational variations and subtleties, failing to capture the performance heterogeneity across diverse technological activities; thirdly, they adopt a static perspective, focusing only on short-term intervals; and finally, they follow a narrow logic that disregards crucial activities like imitation, copying, adaptation, experimentation, and the adoption of new products, processes, and organizational arrangements (Lall, 1992; Bell & Pavitt, 1993; 1995; Figueiredo, 2001).

In other hand the studies tend to deem 'high-tech' manufacturing and service firms and industries as the major engine for innovation and growth. Again, this understandable as most studies have been undertaken in regions where these industries have played a major role in economic growth. However, such perspective tend to disregard the importance of innovative technological capability accumulation in other types of industries, such the so-called 'low' and 'medium tech' industries (Robertson, Smith & von Tunzelmann, 2009). Despite the prevailing notion that low-technology industries are inconsequential to the modern process of innovation and economic progress, it is increasingly recognized that innovation can occur in all types of industries and firms, regardless of their technological level. This includes low-technology firms, which are now being acknowledged as potential sources of valuable innovation (Zawislak et al, 2013).

So, despite some exceptions, there is a paucity of studies of technological upgrading based on a comprehensive perspective on innovative capabilities in industries that do not fit into the usual standard classifications such as 'high-tech' and assembled products. This lack of studies is worrying, since low-tech industries are extremely relevant for some emerging economies. For example, low-tech industries represent around 90% of the economy of Brazil (IBGE, 2009).

Seeking to contribute to rebalancing the analysis, this paper examines how occurs the technological upgrading process in the clothing industry in Brazil. The textile products industry is classified as low-tech and, it is often understood as stagnant in terms of innovation. Brazil offers a rich empirical reservoir to study these issues. The textile products industry is the second largest Brazilian industry in terms of jobs generation (ABIT, 2019). The industry is responsible for 3.5% of the Brazilian GDP and it is the 5th largest industry in the world (ABIT, 2019). In addition, it is a basic human need, clothing will never disappear (Gatti, 2019). In addition, with the advent of 4^{th} Industrial Revolution, the clothing industry can be responsible for making a great qualitative leap towards the classifications of greater use of science and technology, both in the areas of production, commercial or services (Duarte, 2017).

Therefore, this paper addresses the research question: How occurs the technological upgrading process in the clothing industry in a firm-level? To address this question, we draw on a qualitative and empirically grounded study based on an individual case study in depth in a clothing firm, within the scope of three areas: (i) organization of production and equipment; (ii) products; and (iii) management. The remainder of this paper is organized as follows. Section 2 contains the theoretical background; Section 3describes the methods used; Section 4 presents the findings, subsequently discussed in Section 5. The Section 6 presents the conclusions.

2 Technological Upgrading Process

The research are concerned with explaining technological upgrading process meant as the innovative technological capability accumulation. In other words, technological upgrading is about the

accumulation of technological capabilities to implement production and progressively higher levels of innovative activities (Bell, 2009; Lacasa, Jindra & Radosevic, 2018) and can occur in different ways, for example: path-following (technological follower), path-skipping and path-creation (Lee & Lim, 2001).

Early empirical research on latecomer firms' and industries' technological capabilities emerged through the works of J. Katz, M. Bell, and S. Lall among others (see reviews in Bell, 2007; Figueiredo, 2001). Those pioneer studies unpacked the firm-level processes of innovative technological capability accumulation. They dismissed the then prevailing claims that innovation was centred in advanced economies while the developing countries only had the task of selecting, acquiring and using imported technologies (Cooper, 1991). They showing the importance of technological upgrading beyond R&D and patents.

This perspective received researchers' attention during the late-1980s and 1990s, reflecting the rise of South East Asian firms (Amsden, 1989; Lall, 1992; Hobday, 1995; Kim, 1997; Mathews, 1999; Choung, Hwang, Choi & Rim, 2000) in studies examining technological capabilities as latecomer firms' following dominant incumbents' technologies through a sequence of 'acquisition–assimilation–improvement' reversed product life cycle (RPLC). Lee & Lim (2001) introduced contrasting perspective on technological catch-up beyond the notion of latecomers following global leaders' paths. Their framework identifies variations in catch-up patterns such as *path-following*, *stage-skipping* and *path-creating* (when firms explore their own technological development path), which has influenced several empirical studies. Furthering a history-friendly and systemic framework of catch-up.

Technological capability is present in four elements in a organisation: human capital, techno-physical systems, organizational systems and products (Bell & Figueiredo, 2012). Firms' technological capabilities reflect what they can actually do and refers to the incorporation of resources necessary to generate and manage technological changes (Bell & Pavitt, 1993). Therefore, the trajectory of accumulation of technological capabilities is understood as the path followed by the accumulation of knowledge, experiments and skills, aiming for the firm to develop, with this, competitive advantages in the market (Hobday, Rush & Bessant, 2004).

Currently, technological upgrading process involves new challenges but also new opportunities for firms and industries willing to move into 4th Industrial Revolution: it is characterised by the emergence of new technologies enabling a fusion between physical, digital and biological spheres, affecting all economies and industries; such technologies are likely to improve organisations' performance and regenerate the natural environment, potentially reversing the damage of previous revolutions (Schwab, 2016; Xu, 2018).

To operationalize the capability construct, we consider the 'revealed capability' approach (Sutton, 2012), with the observable outcome reflecting the symbiotic relationship between these capability dimensions as firm' technological activities. In addition, the capability construct captures the different degrees of innovative activities, and also takes into account R&D indicators and patents to understand the technological upgrading paths. This type of model has proved to be feasible, as other researchers have already used it successfully to trace technological capabilities accumulation paths (e.g. Dantas & Bell, 2011; Figueiredo, 2016; Figueiredo & Piana, 2018).

Consistent with studies taking this approach (Bell & Figueiredo, 2012), we identify production capabilities and innovative capability. The first one divided in levels: 'basic', and 'advanced'. The last one divided in levels: 'basic', 'intermediate' and 'advanced'. These levels were identified in three organisational areas (see Table 1).

Table 1. Scale for measuring technology capabilities in clothing industry

	Organizational areas and related activities		
	Production and Equipment	Products	Management
Types and Levels of Technological Capabilities			
▪ **Innovation Capability**			
Level 5 – Advanced Innovation	Capability to create new technologies and implement cutting-edge innovation based on world-class R&D and engineering through local and international partners. For example: R&D for the development of new equipment (automation, IoT).	Capability to create new technologies and implement cutting-edge innovation based on world-class R&D and engineering through local and international partners. For example: development of new products based on R&D (patents); R&D on new materials for fabrics and nanoparticles.	Capability to create new technologies and implement cutting-edge innovation based on world-class R&D and engineering through local and international partners. For example: R&D on highly complex management tools and solutions; projects involving management of global and simultaneous processes.
Level 4 – Intermediate Innovation	Capability to implement complex changes in dominant technologies and/or systematic exploratory search, engineering, experimentations, and tests related to a novel technology individually and/or in collaboration. For example: processes and equipment adaptation based in engineering; creation of exclusive company software to monitor the production process.	Capability to implement complex changes in dominant technologies and/or systematic exploratory search, engineering, experimentations, and tests related to a novel technology individually and/or in collaboration. For example: develops / adapts and launches new products based on design, research and engineering; creation of a new segment for the brand.	Capability to implement complex changes in dominant technologies and/or systematic exploratory search, engineering, experimentations, and tests related to a novel technology individually and/or in collaboration. For example: managing a new brand, modifying the segment and expanding products and production.
Level 3 – Basic Innovation	Capability to implement minor adaptations in dominant technologies and/or informal exploratory experimentations, search, and tests related to a novel technology individually and/or in collaboration. For example: improvements in processes and equipment based on experience, with a degree of local novelty.	Capability to implement minor adaptations in dominant technologies and/or informal exploratory experimentations, search, and tests related to a novel technology individually and/or in collaboration. For example: adjustments to existing products based on customer requests.	Capability to implement minor adaptations in dominant technologies and/or informal exploratory experimentations, search, and tests related to a novel technology individually and/or in collaboration. For example: improvements in management with a degree of local novelty; development of strategic planning; complaints analysis.

	Organizational areas and related activities		
	Production and Equipment	Products	Management
▪ **Production Capability**			
Level 2 – Advanced Production	Capability to execute activities and use dominant technologies with global levels of efficiency and quality. For example: structuring the modeling and fitting processes using software.	Capability to execute activities and use dominant technologies with global levels of efficiency and quality. For example: replicating products meeting international specifications and requirements.	Capability to execute activities and use dominant technologies with global levels of efficiency and quality. For example: use of management tools on a routine and continuous basis.
Level 1 – Basic Production	Capability to use existing technologies with a low degree of efficiency. For example: execution of operational processes without standardization; informal inventory control procedures.	Capability to use existing technologies with a low degree of efficiency. For example: offering traditional products (ex: t-shirts, sweatshirts); replication of garments following simple specifications.	Capability to use existing technologies with a low degree of efficiency. For example: industrial management unrelated to business strategy; low control and planning of the basic routines of the firm's areas.

3 Method

The research design was based on a single case study, in-depth and based on first-hand empirical evidence with long-term coverage that was obtained through extensive fieldwork. Data analysis adopted a qualitative perspective. This methodological approach highlights details and nuances that could not be captured by other methods, including, in particular, aggregate analyses derived from purely quantitative methods (George & Bennett, 2005; Yin, 2009). In addition, a research strategy is adequate, as it has been widely used in recent studies that examine research questions of a similar nature to this paper, demonstrating convincing and conclusive results (e.g. Figueiredo, 2017; Figueiredo and Piana, 2018).

3.1 Case selection criteria

First, the research is interested to analyse the clothing industry in Brazil because it is (i) the second largest Brazilian industry in terms of jobs generation; (ii) responsible for 3.5% of the Brazilian GDP and (iii) the 4th largest industry in the world, behind only China, India and Pakistan (ABIT, 2019, GOTEX, 2017).Brazil is the only complete chain in the West, being the one that produces since cotton, transforms it into threads, produces the fabric, benefits, produce, make fashion shows, in addition to strong retail (ABIT, 2019). In order to substantiate the research question, this study opted for a single case approach, selecting a firm that is information-rich and can provide pertinent examples of the issues at hand, thereby augmenting analytical generalization (Patton, 2002; Yin, 2009). In addition, the choice for an individual case study was due to the need and interest in observing the phenomenon of the technological upgrading process over time and with a high degree of detail (Patton, 2002).

The selected firm, called here X, is localized in Paraná state. The Paraná's clothing industry is the second largest employer in the state's manufacturing industry, accounting for 13% of formal jobs and represents 8.17% of the national textile and clothing GDP. Also, Paraná is the 5th largest

fashion hub in Brazil (Gatti, 2019). Specifically the firm is localized in the Paraná´s north, region known as the Brazilian "fashion corridor".

In addition, the firm was selected because it(i) has been in the market for 26 years (since 1993), that is, the firm followed the period in which the coffee economy began to fall in the State of Paraná (1990s) and new forms of local economy started with the opening of small and micro enterprises in the clothing industry (Gomes, 2013); (ii) is economically representative of the Paraná's industry. The firm employs 1,300 people, produce 2 million pieces a year and sold in more than 10 countries and; (iii) contains from the creation and development sector to the manufacture of the final product.

3.2 Data collection process

Substantiation of the research question demanded detailed and long-term firm qualitative evidence. To achieve this, extensive fieldwork was performed. Extended stays in the field increase the evidence quality (Miles & Huberman, 1994). The data collection process included open-ended interviews, non-participant observations (e.g., attending firms' workshops, presentations, and meetings), and the consultation of archival records (see Table 2). Each interview lasted approximately one hour, with interviewees such as firm directors, managers, engineers, and university professors. The interviews were conducted on the basis of a protocol, which was adjusted as the fieldwork progressed. In order to reconstruct the technological upgrading trajectory of the firm, the protocol sought information about the production and innovation activities developed by the firm in terms of: (i) "what"; (ii) "when it started"; (ii) "why"; (iii) "how it was done"; and (iv) "who performed it". Interviews were recorded. After the interview, informal conversation and, in some cases, a visit to the interviewee's department were allowed.

Table. 2. Data collection techniques and evidence sources

Data Collection Techniques	Evidence Sources	
	Quantity	Responsibility
Interviews	17	Group 1 (strategic level): Director of Production Planning and Control (PCP).
		Group 2 (tactical level): Managers, Coordinators (Communication Coordinator), Managers (Warehouse and Cut Manager), Assistants (Laboratory Assistant, Environmental Management Assistant, Management Assistant), Analysts (HR Analyst, Inspector (Inspector Quality), Auxiliary (Warehouse Assistant), Drivers, Dyeing.
		Group 3 (operational level): Technicians, specialists, engineers, supervisors (Commercial supervisor).
Informal meetings	6	Detailing
		Informal meetings with company professionals, inside or outside (e.g. during lunch). Informal conversations outside the scheduled time. Informal conversation with people in the city where the factory is located.
Non-participant observations	5	Detailing
		Observation of the organization's routine activities. Technical visits.
Secondary data		Detailing
		Searching websites, blogs. Reading articles. Videos on Youtube. Analysis of social networks like Facebook and Instagram.

3.3 Analysis process

The data analysis process began during a fieldwork. First, the interviews were transcribed and secondary data were organized. Then, the researchers started the selection, simplification and interpretation of the data. At this moment, the data from the different sources were compared (triangulation) thus avoiding distortions. To carry out this confrontation, the collected information was read several times by the researchers, providing a better understanding of the evidence.

Temporary data matrices were created for each organizational area with the main evidence related to innovative and production activities. To facilitate the analysis of the data, a cut of two periods was carried out over timeseparated by a major milestone of the company that occurs in 2012 - the sale of 60% of the company to a group of investors. So, the analysis was divided in Emergence Phase (1993-2011) and Consolidation Phase (2012-2018). The construction of the matrices was fundamental so that the researchers had mastery of the evidences collected, and the first answers of the research questions began to emerge.

Subsequently, the evidences found over time of technological activities were classified into levels of technological capabilities consistent with Table 1.We used several analytical techniques, including the observation of patterns and trends and the search for negative indications for the conclusions to be extracted from the data (Miles & Huberman, 1994). It should be noted that, as in other longitudinal studies (e.g. Rerup & Feldman, 2011), the interpretive effort was inductive side by side with the data coded and with a little creativity of the researcher. The final stage involved elaboration of narrative sketches derived from the interpretation of matrices. These narratives were the basis for the construction of the results.

4 Findings

4.1 Technological upgrading process in the "organization of production and equipment" area

The technological upgrading trajectory in the area of organization of production and equipment has advanced from basic production technological capabilities (Level 1) to advanced production technological capabilities (Level 2) from a path-follower.

In the first years of the Emergence Phase (1993-2011), the firm demonstrates basic production capability (Level 1). The production management and organization practices were informal and the firm had only four sewing machines. For example, process like modeling, fitting, bending and cutting were performed manually. The products were based on existing models or created from empirical knowledge of the employee experience. So, the operational processes were not formalized and there was no quality control. The handling of raw materials, semi-finished and finished products did not have any mechanization. Also, the maintenance of equipment was done in a corrective and punctual way, there was no preventive maintenance and systemic correction of the problem.

From 1999, the firm deepened the production technological capabilities, catching advanced production technological capability (Level 2). At this moment, the firm starts to present standardization of the basic phases of a project (planning, testing and development). In 2008, the firm implements a fitting software to reduce the time of the fitting molds and to reduce the waste. In addition, it was implanted a laser cutting to speeding up the time for cutting pieces. According to Operational Auxiliary:

> [...] this change greatly improved productivity. Before software, it was necessary to test fitting and wait for the cut, then only afterwards would another batch begin.

> With the automatic fitting software you create a file that is available to the cutter, that way, no sector is left waiting for finishing a batch to start another and both can to work together.

Between 2009 and 2011, the firm created a dyeing department responsible for dyeing trims such as buttons and zippers. The differential of dyeing trims is the ability to create and develop new colors on the market and exclusive to the piece. However, initially the dyeing laboratory used simple equipment (stoves, pots, spoons) consequently, the technique was also rudimentary, demonstrating basic production capability (Level 1).

From the Consolidation Phase (2012-2018), the firm creates a quality laboratory. The laboratory was equipped with cutting edge equipment (such as computers, washing machine, industrial centrifuge, circular cutter of fabric weight, scale, light booth, table, clothesline, among other accessories) contributing to the advanced production technology capabilities (Level 2).

In addition, during the Consolidation Phase (2012-2018), the firm automated the entire production process. For example, handling of raw materials, semi-finished and finished products were automated using conveyors belts; implantation of an integrated production system; implantation of a preventive management maintenance for equipment. Also, there was a change in the warehouse sector. According Warehouse Auxiliary:

> Before, we had a different structure that consisted of wooden shelves where materials were stored. We used to separate on large tables. Today we have a conveyor belt. It has a different storage and separation structure. We separate by product line inside the conveyor belt. It is a sequence that send the materials until the end of the process.

Seeking to keep the advanced production technological capabilities (Level 2), in 2018, the firm

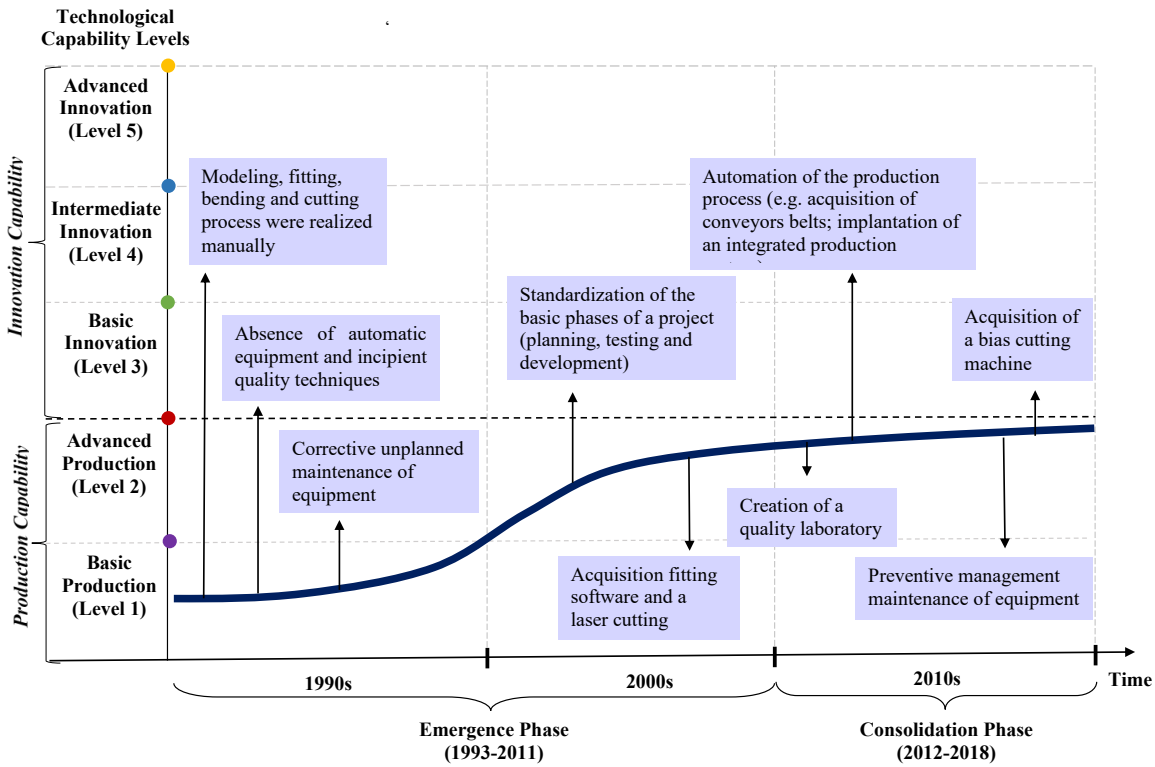

Figure 1. Technological upgrading path in the "organization of production and equipment" area

acquired a bias cutting machine. Previously, the machine used contained a system that generated several flaws in both the product and process, these flaws had an impact on production time, quality and waste. The Cutting Assistant explain:

> We worked a lot with benchmarking, I visited two large companies and Fairs. I find this bias cutting machine in a Fair. This machine savings fabric of approximately 40% and a gain of efficiency in the range of 25%, of productivity. So, it is an investment that pays for itself in less than a year.

Figure 1 shows the technological upgrading path in the "organization of production and equipment" area during the period between 1993 and 2018.

4.2 Technological upgrading process in the "products" area

The technological upgrading path in the area of "products" progresses from basic production technological capabilities (Level 1) to intermediate innovation technological capabilities (Level 4).

On the Emergence Phase (1993-2011), especially at the beginning, product mix was reduced to just one model: sweatshirt. Until 1995, the firm's focus was the commercialization of a single product of low technological complexity, characterizing the basic production capability (Level 1).

From 1996, the firm started to replicate greater technological complexity products, such as "trends market" t-shirts and pants. The expansion of products offered by the firm was characterized by advanced production capability (Level 2). Existing models inspire the pieces and there was a complexity in development. It was necessary a prior study to create these new products.

In addition, firm begins to make minor adaptations in the products influenced by the demands requested by the market and the needs customers. Between 1997 and 1998, the firm created two new brands: Gamma and Alfa, demonstrating the deepening of technological capability for basic innovation (Level 3). The firm was already capable of making small adaptations and improvements in products, and was successful in launching new private label products.

The Gamma brand comes with an innovation in the product mix. Now, the firm produces pants, shirts, shorts, skirts, blouses, jackets and dresses. These products are characterized as basic innovation capability (Level 3). They are new models that the company needs to adapt to develop, they are pieces with more complex modeling, different raw materials, choice of prints and types of washes (the last in the case of pieces in jeans). With this expansion of the product mix, the firm had to adapt itself internally and the relation with its outsourced staff - like other brands of the firm, all the confection of Gama is its own and the laundry services, stamping and embroidery are outsourced. The Gamma brand works with a lot of prints and laundry, because of this, it was necessary a great plan for the work between the firm X and the outsourced firms was standard and fulfilled all delivery deadlines.

The Alfa brand came with a proposal for more sophisticated women's clothing. The modeling was improved and the design of the pieces was developed for an audience of independent women who were looking for pieces with new cutouts, with great finish and quality. So, to develop the Alfa mix products, it was necessary to expand the research, to train stylists and designers and to hire specialized professionals.

In 2003, there was also the creation of the beach line and, in 2009 a new brand was launched, Zeta - a children's line. The expansion of products and brands demonstrated that the firm was already positioning itself in the market through innovation products. In addition, each brand was for specific market segmentation, requiring more research in product development, which began to demonstrate the intermediate innovation technological capabilities (Level 4). Also, in 2010, the firm develops new products related to footwear.

During the Consolidation Phase (2012-2018), the Sigma brand was created – focused on young fashion. Moreover, the firm launched the intimates line and the fitness line- two lines with different segments corroborating the intermediate innovation technological capabilities (Level 4).

Sigma brand is focused on urban style, the prices are competitive and there is a high turnover of collections. There are five collections per year, available in multi-brand shops and e-commerce. However, this brand reduced quantities of each model are available per collection. In 2018 the firm launching a new line within the brand: a beach line with a sustainability concept. According to Communication Coordinator:

> At the beginning we came with a beach line inside firm. More recently with the Sigma brand - with a different concept - we think in use balance, reuse fabric. How can this be done? We changed the production process. If today we take a year in the process, the idea was to reduce this to five months at first, so it was another step of change within the company. And to make all these changes happen, it involves a lot of people, practically everyone, since a seamstress understands that now I don't just make a type of product for a specific brand.

In 2016, the launch of the two lines: intimates and fitness, is classified as intermediate innovation technological capability (Level 4). The firm open a space underwear line, where labor and machines are specific to this segment. And the fitness line includes another product mix: cut top, plain and printed shorts, jumpsuit. They are products suitable for sports practice and require a critical study of modeling: they must be ergonomic, comfortable and with fabrics that offer quality for the practice.

Figure 2 shows the technological upgrading path in the "products" area during the period between 1993 and 2018.

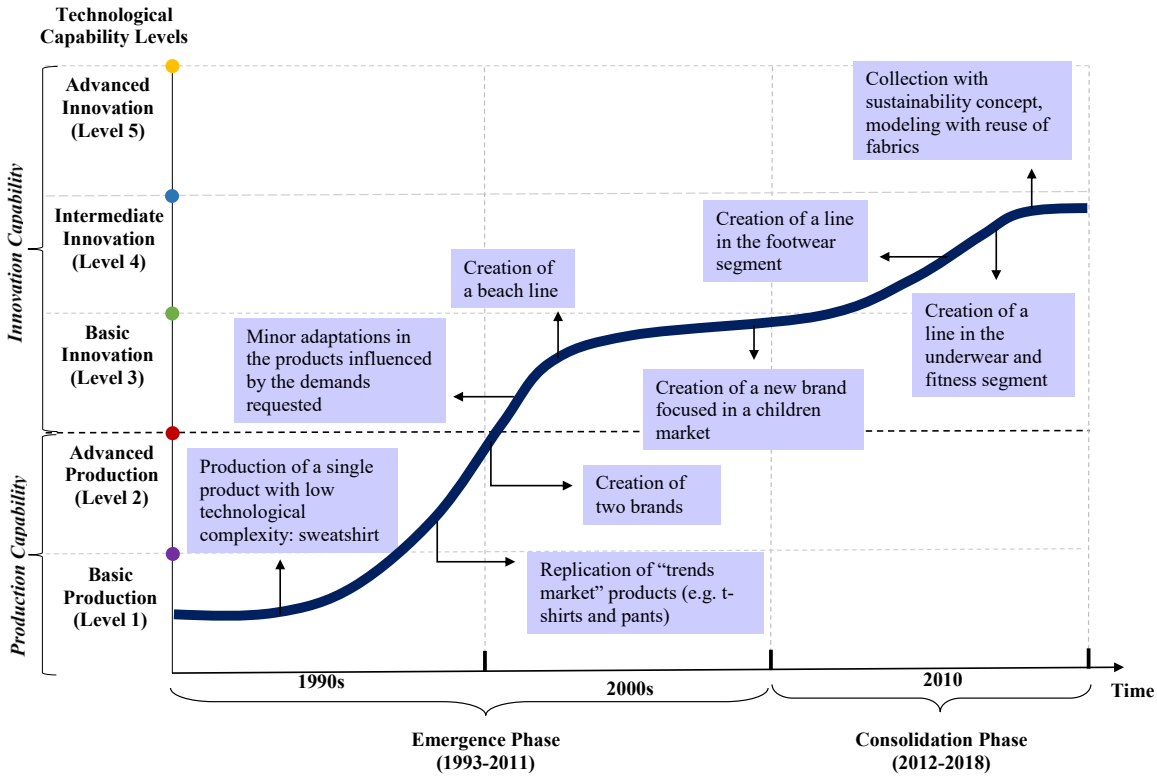

Figure 2. Technological upgrading path in the "products" area

4.3 Technological upgrading process in the "management" area

The technological upgrading process in the "management" area started with basic production technological capability (Level 1), evolving to intermediate innovation technological capability (Level 4).

The "management" area, during the Emergence Phase (1993-2011), had a fast rise because the founding partners already had management knowledge in other business and applied them quickly in the firm X. For example, planning and control of finance routines, accountability. Therefore, in the first years of the company's opening, it reaches advanced production technological capability (Level 2).

Between 1997 and 1998, with the launch of Gamma and Alfa brands, the firm needed to realize complex changes in the brand manage - with segment modification, expansion of products and production, proactive problem management, management team focused on integrated performance analysis and advanced industrial management. In addition to the launch of the two new brands, there was need to expand and restructure the firm's plant. At this time, the firm was looking for internationalization. These changes in the management area can be classified intermediate innovation capability (Level 4).

In 1998 firm changed the way of making sales. The company started to work with commercial representation, i.e., it produces a showcase, this showcase is delivered to the representative, and the representative makes the sale to the shops. This change was motivated by the growth in product sales also because, at this time, there were three different brands and it was impossible to continue with informal sales from door to door. It was necessary to professionalize the sales process as well. The firm also started to analyze customers' complaints and adapt the products. This change is characterized as basic innovation technological capability (Level 3).

In 2010, the company invested in a new segment: shoes. The entrance in footwear industry shows the change in the strategy of the company – the firm starts a diversification process - evidencing the intermediate innovation technological capability (Level 4). The new strategy comes with demand of new process, specific labor and equipment. In strategic terms, the firm chose to install a new unit in Sapiranga city, one of the Brazilian leather-footwear centers where tanneries and leather shoe manufacturers are concentrated. For this, a management team focused on integrated performance analysis was necessary. From this moment a manufacturing unit was in another state, it was necessary to analyze the whole logistics issue, cost to install this unit in the city, business feasibility study.

During the Consolidation Phase (2012-2018), specifically in 2012, the investment group Tarpon acquires 60% of the firm X. The objective was to expand the chain of own stores – until 2012 the firm just have 4 own shops. This year, with Tarpon, the investments came in the form of capital and, in addition, they brought many new things, including technological and process innovations to the firm. However, there was a culture shock. The firm was familiar and suddenly an international company arrived with changes. Little by little the employees have to adapt and create a new way to management theirs activities.

In 2015, the firm starts sales through e-commerce, which is located and shipped in São Paulo city. This activity is a new way of selling, however, to set up an e-commerce it is necessary to have a marketing strategy, delivery logistics and the introducing the brand to this type of market. The firm's information system needs to be integrated and the production monitored. Before the Group was dealing with shops and these shops who were responsible for sales. From this moment the firm sells to the end customer as well. This activity is characterized as basic innovation technological capability (Level 3),

In 2016, the firm brought the e-commerce to the host city, implementing a Distribution Center.

According to the Communication Coordinator:

> E-commerce is a very new process, and you probably won't find a company here in the region doing e-commerce at home. We have people who take care of the site, who are answering SAQ and everything behind the computer, we have our own shipping. The box for those who buy from firm X leaves from here this. Before it was all in São Paulo. So it is a very different process that sometimes enriches the work, I believe it is one of the few companies that do this.

So, the firm developed a business model that united all its sales channels to the virtual world, demonstrating the intermediate innovation technological capability (Level 4). Firm X has a strong presence in multi-brand stores (there are around six thousand in Brazil), and because of the resistance of storeowners the firm X took time to invest on web. The firm resolved this issue developing a business model that would meet the firm's strategy and benefit the stores. The model works like that: if a consumer in a city Y makes a purchase through the website of firm X, the priority of delivery of that product is the registered store who is closest. Therefore, the profit on that sale is from the region's store, not from the firm's virtual store.

In 2016, firm X launch two more lines: intimates and the fitness line. The challenges of launch these two new lines, in terms of management, is that it is necessary to carry out studies on costs, logistics, there is modification of the segment and expansion of products and production, each of the lines requires specific labor and equipment. The launch of these lines is compared to the launch of new brands, so it is characterized as an intermediate innovation capability (Level 4).

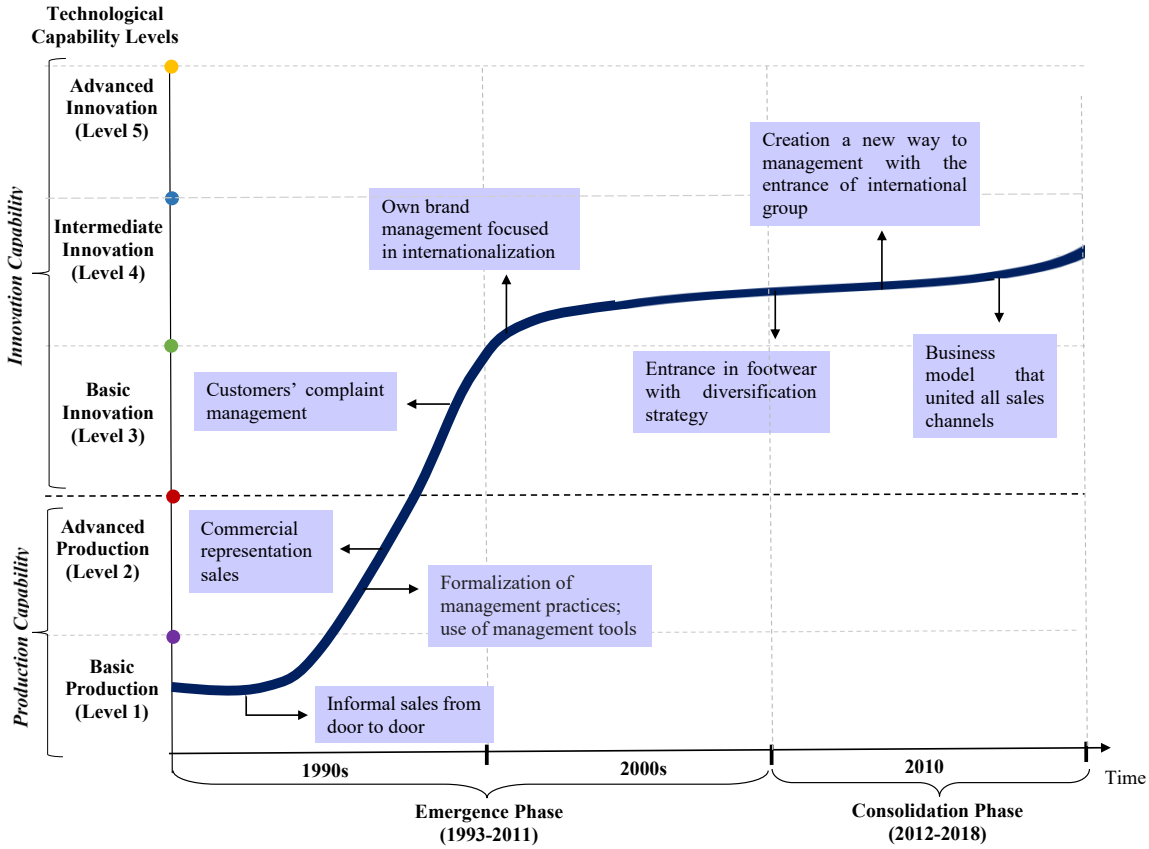

Figure 3. Technological upgrading path in the "management" area

Figure 3 shows the technological upgrading path in the "management" area during the period between 1993 and 2018.

5 Discussion

Technological upgrading path are necessary for understand the innovative activities of low-tech industries, mainly in emerging markets – such as Brazil - where the clothing industry plays an important economic role. To improve the understanding of these issues, this research scrutinized essential prove and accumulated data from broad hands on work, in an agent firm of the clothing industry in Brazil.

We utilized an in-depth approach to analyze the technological upgrading based in technological capability accumulation, which captures degrees of capabilities (from basic production capability to advanced innovation capability), and goes beyond investigation based exclusively on R&D and patents measurements.

The research captures the way and elements by the process of technological upgrading in low-tech firms of clothing industry. Particularly, such technological upgrading may include, for example, building continuously higher innovative capability up to intermediate innovation levels, followed by improvement in new lines of trade.

The findings show that over time the firm deepened the technological capabilities, developing innovative activities and following a path-follower. Variations were evidenced along the technological upgrading paths in different areas. The "product" and "management" areas that advance from basic production technological capability (Level 1) to intermediate innovation technological capability (Level 4). From this angle, the research shows that the industry, even characterized as low-tech, has not remained technologically stagnant, being able to carry out innovative activities based on complex modifications of an incremental nature. In addition, the findings support the notion that diversification is possible in low-tech firms, as long as the firm is able to work closely with their customers and offer them new services that meet their needs.

However, the area of "organization of production and equipment" when compared to the other areas shows little progress in terms of technological capabilities accumulation. During the two phases of analysis, Emergence and Consolidation, the company was able to absorb and implement production techniques and equipment that would guarantee standardization and quality to the products, which allowed it to reach advanced production capability (Level 2). The innovative activities developed by the firm in the area of "organization of production and equipment" were rare and incipient.

Therefore, despite advances in terms of innovation capabilities in the areas of "product" and "management", the company, in general, shows little association with 4.0 technologies, especially in the area of "organization of production and equipment" that tends to be completely reorganized by industry 4.0.In front of this, the research recommends that public policies aimed at the clothing industry and business innovation actions be sensitive to the technological capabilities accumulated by firms and take into account the areas of greatest need.

6 Conclusions

The case inspected uncover the subtleties, complexities, and flow of the technological upgrading process pursued by low-tech firms, in a specific clothing industry. In this manner, on one hand, the discoveries back the promising viewpoints that low-tech industries offer openings for learning, advancement in innovation, and expansion. The findings detailed in this and somewhere else

(Figueiredo & Piana, 2016; 2018; Hirsch-Kreinsen, Jacobson & Robertson, 2006; Zawislak, Zen, Fracasso, Reichert & Pufal, 2013) would back the contention against points of view that consider the low-tech industries with low openings for learning and advancement in innovation (Hatzichronoglou, 1997; OCDE, 2005). Therefore, the think about consider that indeed firms with low technological intensity have the capacity to innovate. Moreover, the innovation activities are come about of the capability they are solid at, which within the case, mainly related to management of the business and product´s development and launch.

Corroborating with Figueiredo and Piana (2018), the findings suggest that the process of technological upgrading seem to reflect the particular entrepreneurial impetuses and administrative competence of the firm. It ought to be emphasized that these entrepreneurial activities are being created in a disconnected way. Thus, this technological upgrading path examined herein have developed in spite of a nonattendance of government policies.

So, to invigorate the innovation activities the research about proposes reinforcing and empowering coordination for advancement in innovation among different industry partners, counting government part. Such policies approaches ought to be more comprehensive in terms of their scope of innovation activities, past ordinary approaches that relate advancement in innovation only to R&D and patent measurements, but consider diverse sorts of inventive activities and engineering-based activities. The policies should stimulate low-tech firms to qualify themselves to diversify their innovative and production activities and to compete in worldwide markets. Thus, for the adequacy of such proposed activities, policy makers and managers ought to receive a more comprehensive viewpoint on the low-tech industry, past common sees regarding this industry as with low openings for learning and technological innovation development.

Lastly, this paper has several limitations. Especially, there are limitations in the scope related to the research strategy adopted - which restricts the quantity and quality of the evidence collected - and the way of analyzing the data. Therefore, it is suggested to carry out similar studies with other firms: (i) in order to compare with the evidence found and discussed in this research; (ii) with the insertion of other variables (e.g. corporate strategies, technological learning, windows of opportunities) that corroborate the understanding of the technological upgrading process.

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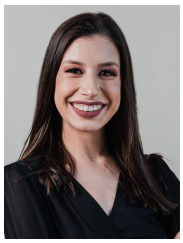

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