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Modeling Production Technological Advantage in Syrian Clothes Manufacturing Industry

Samer Dakak[1], Samer Nizam[2]

[1]Higher Institute for Applied Sciences and Technology, Damascus, Syria

[2]Higher Institute of Business Administration, Damascus, Syria

samer.dakak@hiast.edu.sy, samernizam@yahoo.com

Abstract. As technology has become more prevalent within manufacturing, it is essential to understand how technology plays a role in modern manufacturing. This study presents a scientific method to assess a company's production technological advantage. Evaluating the current technological route via operations performance ratios could aid in determining the appropriate time of technological change. The model's validation and verification are based on applying it in two similar and competitive Syrian clothes manufacturing to decide on performing technological upgrading. Results show that there is a continuous decrease in both companies' technological advantage indexes. However, this deterioration of technological production assets is accelerated in company H faster than in company A. Comparing the two companies; company A is better than company H in terms of technology. Company H should upgrade its production line in order to survive in the market. This deterioration in the technological position could be due to the inappropriate machine maintenance policy against accelerated out-of-service state or due to the frequent machine overloading or their incorrect exploitation. As a result, the study results underlined that machines' loading and maintenance policies should be reviewed.

Keywords: Technological advantage, technological route, operations performance ratios, technological upgrading, Companies, Clothes manufacturing.

1. Introduction

Accelerated evolutions and technological revolutions have led to new managerial methods, particularly in industrial manufacturing companies. Tough competition is imperative, and companies are invited to be flexible in order to realize the suitable adaptation to these contentiously changing conditions (Qalati et al., 2020). This adaptation guarantees their continuity in the market.

Keeping and improving their competitive position, companies should satisfy their customers' requirements by having new outputs and upgrading their ways of production. The technological dimension is critical in this perspective to enhance competitive advantages.

Operations management research papers do not pay enough attention to machine technology, production techniques, or performance relative to operations. Nowadays, the technological dimension is a primordial resource in all industrial companies. Therefore, technological upgrading and change are necessary according to strategic objectives in order to reinforce competitive capacities (Draft & Noe, 2001).

All industrial companies, particularly those facing extraordinary competition, should search for a quantitative and empirical model permitting the determination of their production facilities' technological advantages to make the suitable decision of changing or upgrading these facilities at the appropriate time.

Operations strategy, which is an essential part of the company's global strategy, is largely affected by the state of used technological machines and tools. So, there is a vital necessity to check up on the technological level of a company in comparison to other companies' levels to decide whether this level is still acceptable, or it is time to change (Kozubikova et al., 2019).

Conceptually, theories are still slightly interested in measuring competitive advantage, clarifying the strength and weaknesses of the used technology.

Even in practice, it is notable that deciding on the selection and installation of machines in companies is rarely based on scientific and managerial analysis. Changing or upgrading them is more challenging (Kozubikova et al., 2019).

This article attempts to answer the following two questions: 1- What types of measures could be adopted to diagnose the technological advantage of a company and evaluate its level? 2-Is there an appropriate quantitative and practical model, based on operations management ratios, to be used permitting industrial companies to measure their technological innovation before deciding to improve it?

2. Literature Review

Technological change. Technology change is the cornerstone of industrial development. Neglecting the continuous technology change may result in a risk of exclusion from the business domain or an inability to face market completion. Consequences could be product features weakness or production cost increases due to non-improving ways of design and production (Roure, 1988).

Analysis studies should be attentively performed before deciding on the appropriate required technological change. That is because innovation and applying fitting technology are crucial to efficiently producing high-quality products and satisfying environmental protection requirements.

Technological changes could take different profiles, such as using new production methods to produce a new or improved product, introducing new non-production technologies, such as communication tools or E-commerce mechanisms, and computerizing certain preparation procedures (Figueiredo & Piana, 2021). These changes could guarantee continuity in the market, the reduction of production costs, the rise of productivity, the improvement of quality, and the upgrading of workflows. Zeleny (2015) argues that technological changes cause organizations to perform new tasks, new methods, new cultures, and new management styles.

The importance of technological change is based on the competitive advantage resulting from searching for a minimal technological keeping up. Companies having old technology are defeating pressures and threats, putting their competitive positions in danger (Diab, 2014).

Reasons and steps of technological change. Different factors can affect a company's technological change, such as expected market, technical problems, research and development, and competitors (Uptown, 1985). These factors may push the company's top management to evaluate the current technology and analyze the available new technological alternatives in accordance with the new market conditions (Junbing et al., 2019).

However, why do companies decide to change technology? Diverse reasons may be behind this decision. The first reason can be increasing production capacity according to the market demand, such as accelerating the completion of operations, increasing the number of customers, and ameliorating service quality. The second reason can be decreasing costs by the optimal exploitation of resources, shortening operations' times. The third reason can be perfecting the quality of offered products and services and increasing sales volume. Finally, the last reason can be to achieve a higher level of flexibility by diversifying products and increasing the competitive market.

Several researchers determined steps of technological change be followed by companies planning to change technology. The first step should be the redesign requiring a plan based on an advanced strategy. It covers four phases: determining the change executer, determining the team responsible for this redesign, taking into account the requirements and objectives of this change in the plan, determining the appropriate time of applying the change, and finally, establishing the strategic plan pointing changes in work and the required modifications according to the new design of work. Outcomes of this redesign step improve operations performance, increase employee satisfaction and motivation, and ameliorate quality and work conditions. The second step is the socio-technological system. It means considering the social

impacts of technological change in terms of social relationships and interactions. The third step is the management style translated into increasing management knowledge and skills and facilitating understanding of new technologies in terms of work type of activities.

Measuring technological change. Different ratios can be used to measure technological change (Wahyuni et al., 2019), such as Employees part of the total invested capital = Total Invested Capital / Number of Employees

Or, production labor part of the machines invested capital = Total Machines Invested Capital / Number of Production Employees

Produced ton part of the machines invested capital = Total Machines Invested Capital / Real Production Quantity

Or, Produced ton part of electricity quantity = Total of Consumed Electric Energy / Real Production Quantity

However, these ratios do not consider the necessity of technological change in terms of competitive advantage indicators.

Research papers analyzing or determining production technological advantages are rare. Studies measuring technological change, particularly production technological advantage, are also infrequent. Few studies focused on new technologies and their impacts on the production process. Zangana (2017) presents a journalist's practice using automation systems in Kurdish news channels in Iraqi Kurdistan. The research project studies the Kurdish newsroom practice, culture, and journalists' arrangement with fresh technology. The researcher finds that the use of new technology in the KNN TV (Kurdish News Network Television) newsroom has had a big influence on the news practice and daily life of journalists in the workstation, principally in comparison with the results from the non-automation system used in the GK TV channel (The Television of the Kurdish People). The overall answers to these questions show that the automated newsroom influences news management production, and has augmented the quantity of news production, communication of news staff, and transfer of experience and knowledge. However, news production associated with the non-automation system used in the GK newsroom network has not increased.

On the other hand, Steve et al. (2015) studied previous changes through the short dynamic history of this worldwide agreement. It focuses on past shifts from ChloroFluoroCarbons (CFCs) to Hydro ChloroFluoroCarbons (HCFCs) to HFCs, intending to find lessons that can update consultations that are aimed at transitioning from high-Global Warming Potential (high-GWP) HFCs.

While the extensive presence of patents is not new or unique to sectors impacted by the Montreal Protocol, previous experience suggests that they have had limited influence on the evolution of ozone-depleting matters. However, worries have been raised that patents on the HFO production process and application patents on their use in several sectors could unfavorably influence efforts to transition from high-

GWP HFCs. While several transnational companies detained the original patents for these complexes, the list of applicants currently includes several national entities in China.

Denning (2022) articulates that the new age called "the digital age" is driven by a combination of digital and other technologies and an array of innovative management principles. But new technologies, lacking the change in management values, are not sufficient to realize transformative improvement.

Masrom et al. (2021) analyze the impact of innovation as an intermediating role in relation to TQM and competitive advantage inside the industrial sector in Malaysia. The result shows that total quality management (TQM) and innovation positively influence competitive advantage. The innovation intermediates the relationship between TQM and competitive advantage.

Bronwyn and Khan (2003) determine that the influence of new technology on economic growth can only be recognized if the new technology is broadly spread and used. This Diffusion outcomes from a chain of individual decisions to initiate using the new technology. These decisions are frequently the consequences of assessing the uncertain profits of the new invention against the uncertain costs of using it. Understanding the elements influencing this choice is indispensable both for economists analyzing the determinants of development and for the inventors of such technologies and their creators.

Our research differs from previous literature in that it evaluates the production technology in a place to decide if it becomes outdated and will be no longer appropriate to keep that place competitive in the market. In addition, it aims to build a quantitative model that determines technological advantage indicators in the function of competitive advantage indicators.

3. Bases of the Quantitative Model

Technology and its continuous change became the main feature of creating the competitive advantage because it includes tools that drive towards applying new knowledge concerning the improvement of offered products or services. (Bandaranayake & Pushpakumari, 2021). Hence, there is a strong interaction between technology and business strategies, as illustrated in Figure (1).

Coordination between technological objectives and business could be achieved via three tools: establishing an R&D strategy, matching this strategy and technology, and tailoring technological objectives to the product strategy (Hung et al., 2014).

Competitive indicators or operations management indicators are the product dimensions established by the company to satisfy customers' requirements. They are the bases of operations strategy determining the performance objectives) Gleißner et al., 2013). These indicators are quality (product and operations features and performance), delivery (delivering in the right place at the right time), flexibility (rapid adaptation to the demand), cost (lowest cost), and innovation (being creative

by using technology).

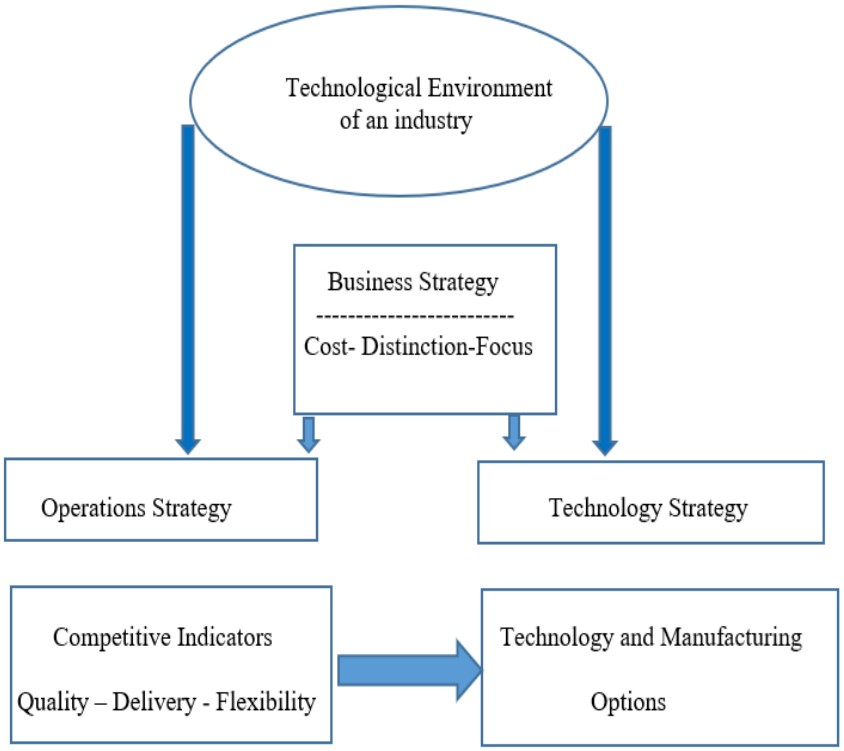

Fig. 1: Interactions between technology and business strategies (Allami, 2006)

4. Formulation of Technological Advantage Model

Tense competition leads industrial companies to evaluate used technologies. Determining the technological advantage is an appropriate way to identify the necessary technological changes to be performed (Lindqvist et al., 2000). This decision is based upon evaluating principal variables in quantitative data form. Data are collected from two companies of similar business nature (product, operations) over several periods (Heizer & Render, 2011).

The formulation of the model is based on measuring technological indicators. These indicators reflect relatively all aspects of the technological influence upon competitive advantages such as cost, quality, delivery, flexibility, and innovation. They are:

Market share is a function of product quality and delivery in the right place at the right time (quality, delivery).

Utilization of capacities: it is a function of resource exploitation in order to reduce expenses (cost). Also, exploiting available capacity against demand variation is a flexibility scale (flexibility).

Profit margin is a motivating factor in executing technological modifications and achieving higher performance levels (cost, quality).

Lead times are the capacity to deliver in the lowest possible time compared to competitors. It could also reflect the necessary flexibility to schedule and deliver just in time (delivery, flexibility).

New products are a function of innovation and capacity to develop new products and operations (innovation).

R&D cost compared to Net profit reflects the degree of technological innovation (innovation).

Table 1: Calculation of technological indicators (created by the authors)

Technology indicators	**Measurement unit**	**Calculation method**	**Connection with a competitive advantage**
Market share	%	Sales/sales of the most powerful competitor	Quality and Delivery
Utilization of capacities	%	Number of real working hours/number of available hours	Cost and Flexibility
Profit margin	%	Net profit/sales	Cost and Quality
Lead times	day	Production batch size * annual working days / annual demand	Delivery and Flexibility
New products	number	Number of new products	Innovation
R&D cost/ Net profit	%	R&D dispenses / net profit	Innovation

A technological advantage score could be obtained by calculating the sum of all competitive averages divided by 5 (their number). The calculation of the technological advantage index is obtained by dividing the technological advantage score of the current year by the technological advantage score of the baseline year (first year).

This resulted index could help provide a time-bounded framework to keep using the same technology or develop it. Also, it helps in offering a reference and proof of technology obsolescence pushing to diagnose the required changes. In addition, it contributes to identifying the appropriate investments necessary to upgrade the company's technical innovation.

5. The Case Study

In order to apply the model aiming at evaluating a company's technology pathway, two similar Syrian women's clothes factories have been chosen. The two companies are located in Damascus. The first is HAMDAN (H) Company for design and clothes having 21 sewing machines. The second is ALREDA (A) for the clothes trade, which also has 21 sewing machines. We collect data on annual electricity consumption, annual sales, new product costs, and extern orders' delivery lead times. Also, data for all machines about capacity and electricity needs are registered.

After getting data for the seven technological indicators over the last six years (2016-2021), as shown in Table 2 above, an evaluation scale from 1 to 5 is given to each technological indicator based on the ranges in Table 3. Each range meets an evaluation degree for each technological indicator.

Table 2: Data for technological advantage indicators calculation (Source: The two companies' documents and conclusions from meetings with directors and supervisors)

Year Data	**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
Companies H, A	H	A	H	A	H	A	H	A	H	A	H	A
Market share (%)	85	94	75	89	63	79	56	70	50	61	45	58
Utilization of capacities (%)	81	90	70	83	61	75	53	66	46	59	42	53
Profit margin (%)	8	10	11	12	12	16	15	19	16	22	17	20
Lead times (days)	22	16	33	23	38	26	44	33	50	39	58	46
New products (number)	1	2	1	2	1	3	2	3	2	3	2	3
R&D cost / Net profit (%)	3	5	3	5	2	4	1	4	0.8	3	0.6	3

Table 3: Technological advantage indicators' measurement unit and ranges (Source: The two companies' documents and conclusions from meetings with directors and supervisors)

Technology indicators	Measurement unit	Ranges	Evaluation degree
Market share	%	41% - 52%	1
		53% - 64%	2
		65% - 76%	3
		77% - 88%	4
		89% - 100%	5
Utilization of capacities	%	40% - 50%	1
		51% - 61%	2
		62% - 72%	3
		73% - 83%	4
		84% - 94%	5
Profit margin	%	4% - 9%	1
		10% - 15%	2
		16% - 21%	3
		22% - 27%	4
		28% - 33%	5
Lead times	Days	10 - 20	1
		21 - 30	2
		31 - 40	3
		41 - 50	4
		51 - 60	5
New products	number	1	1
		2	2
		3	3
		4	4
		5	5
R&D cost / Net profit	%	Less than 1%	0
		1%	1
		2%	2
		3%	3
		4%	4
		5%	5

These technological advantage indicators' limits and ranges are determined in collaboration with several experts, team leaders, and managerial supervisors regarding registers of production lines, work hours, and electricity consumption

(Kozena & Chladet, 2012).

Table 4: Average degree of competitive indicators according to technological indicators

Competitive Indicators	**Year**	**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
	Technology indicators	**H**	**A**	**H**	**A**	**H**	**A**	**H**	**A**	**H**	**A**	**H**	**A**
Quality	Market share	4	5	4	5	3	4	2	3	1	2	1	2
	Profit margin	1	2	2	2	2	3	2	3	3	4	3	4
Quality degree average		2.5	3.5	3	3.5	2.5	3.5	2	3	2	3	2	3
Delivery	Market share	4	5	4	5	3	4	2	3	1	2	1	2
	Lead times	4	5	3	4	3	4	2	3	2	3	1	3
Delivery degree average		4	5	3.5	4.5	3	4	2	3	1.5	2.5	1	2.5
Flexibility	Utilization of capacities	4	5	3	4	3	4	2	3	1	2	1	2
	Lead times	4	5	4	5	3	4	2	3	1	2	1	2
Flexibility degree average		4	5	3.5	4.5	3	4	2	3	1	2	1	2
Cost	Utilization of capacities	4	5	3	4	3	4	2	3	1	2	1	2
	Profit margin	4	5	4	5	3	4	2	3	1	2	1	2
Cost degree average		4	5	3.5	4.5	3	4	2	3	1	2	1	2
Innovation	New products	1	2	1	2	1	3	2	3	2	3	2	3
	R&D cost / Net profit	3	5	3	5	2	4	1	4	0	3	0	3
Innovation degree average		2	3.5	2	3.5	1.5	3.5	1.5	3.5	1	3	1	3

According to the results of Table 4, the average of competitive indicators can be calculated before obtaining the competitive advantage degree and its index by applying the formula:

$$\text{Technology advantage degree} = \frac{\sum_{k=1}^{5} \text{average of each competitive indicators}}{5}$$

$$\text{Technology advantage index} = \frac{\text{Technology advantage degree in the current year}}{\text{Technology advantage degree in the reference year (1st year)}}$$

Table 5: determination of technological advantage

Years	Technological advantage degree		Technological advantage index	
	Company H	Company A	Company H	Company A
2016	3.3	4.4	100%	100%
2017	3.1	4.1	93%	93%
2018	2.6	3.8	78%	86.3%
2019	1.9	3.1	57%	70%
2020	1.3	2.5	39%	56.8%
2021	1.2	2.5	36%	56.8%

6. Results & Recommendations

The proposed model permits the determination of technological advantage degree and its evolution in the function of competitive advantage results. Hence, the company's top management can decide when it is the right time to upgrade or change their machines' technology to keep its appropriate competitive position in the market.

Results in Table 5 show that there is a gradual and continuous decrease in the two companies' technological advantage index. However, this decrease or deterioration of production technology assets is accelerated in company H faster than in company A. Comparing the two companies; company A is better than company H in terms of technology. Company H is intensely invited to upgrade its production line to keep surviving in the market and keep its competitive position. This technological deterioration could be due to the absence of an appropriate machines maintenance policy to prevent them from accelerated out-of-service state or due to the machines' frequent overloading or incorrect exploitation.

Using the above quantitative model of production technological advantage in both studied companies, we could understand and analyze their technological position. That is to aid decision makers in deciding precisely and scientifically when they should change production technology in their companies in the function of the competitive position analysis of their companies.

The technology role should be considered in all companies' strategies, particularly production companies, because of its critical impact on productivity and performance. This technological advantage evaluation should be in function of competitive factors.

However, a few limitations characterize the model, such as its inability to determine the minimum acceptable threshold of the technological advantage index allowing the company to keep its technological position without any change.

Future research could focus on elaborating an assessment model describing the technological state of companies in the function of their competitive indicators or the function of one specific indicator such as flexibility or quality.

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