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Research Article

Examining Innovation through Technology Management in Manufacturing Firms: Empirical Insights

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Abstract

In today's interconnected global scene, the importance of technology management in defining the modern economy, especially within industrial businesses, cannot be overemphasized. These companies continually invest in and incorporate new technology, encouraging innovation in both product creation and manufacturing processes. This deliberate use of technology is a tried-and-true technique for increasing operational efficiency and effectiveness while also strengthening global competitiveness by managing the risks associated with changing market demands. This study delves deeply into the complex elements that influence innovation and technology management practices in manufacturing businesses, with a particular emphasis on the Ethiopian setting. Despite the global demand for innovation, Ethiopian manufacturing enterprises have struggled to build a notable reputation in their field for pioneering inventions. This paper includes the perspectives of scholars, industry experts, consultants, and direct involvement from manufacturing firms. A cross-sectional methodology is used to collect data from several stakeholders at a certain point in time. The Pareto chart's analytical capabilities are used to condense meaningful findings, allowing for the discovery and prioritization of impediments to manufacturing innovation. The study's findings highlight formidable barriers to innovation in manufacturing firms, including a lack of well-defined innovation strategies, an absence of innovative leadership, a scarcity of qualified and creative talent, limited access to innovation funding, and a general lack of awareness about technological advancements and innovative best practices. These insights provide a substantial contribution to expanding the innovation environment within industrial enterprises, increasing resilience and global competitiveness.

Keywords: Pareto Chart, Manufacturing Firm, and Innovation

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Introduction

Technology has become more essential to daily life over the past few decades and effective technology management is becoming more and more important in today's competitive corporate climate because of how pervasive technology is in everyday life (Ivaldi, Scaratti and Fregnan, 2022). It has had a big impact on how businesses are run and how people interact at work. The development of technology is the most important factor in a company's performance in the twenty-first century (Kraus *et al.*, 2019). To set and attain their strategic and operational objectives, businesses engage in "technological management," which is the process of organizing, directing, managing, and coordinating the creation and use of technology capabilities (Chanaron and Jolly, 1999; Cetindamar, Phaal and Probert, 2016). It entails a collection of management practices that assist businesses in managing their technological advances to acquire a competitive edge. Major ideas including technology strategy, forecasting, road mapping, project portfolio, and portfolio are used in today's technology management disciplines (Massa and Testa, 2009; Mahdi and Nassar, 2021; Arsawan *et al.*, 2022).

Many studies have revealed the importance of mechanisms in manufacturing firms' ability to innovate and create value (Duan, Wang and Zhou, 2020; Paiola and Gebauer, 2020; Sudolska and Łapińska, 2020). Technology management mechanisms are viewed as a technology process of an ordered series of steps that a company follows and implements when investing in basic and applied research initiatives to foster creativity, innovation, firm performance, and maintain a competitive advantage (Kalko, Erena and Debele, 2023); the second step is technology acquisition or external technology acquisition, which refers to a company's attempts (Technology roadmap, strategic technology acquisition plan) to acquire new technologies from outside sources. By understanding previous, present, and future technologies, these technology management traits enhance technology and innovation. Researchers identified several other important factors that influence the innovation management of manufacturing firms, including technology, the innovation process, business strategy, organizational structure, and organizational culture (Büschgens, Bausch and Balkin, 2013; Kalay and Gary, 2015; Azeem *et al.*, 2021).

Furthermore, as global market competition grows and is influenced by technological advancements, organizations with global ambitions may discover that a thorough understanding of key technologies is becoming increasingly important (Huang, 2016; Jantsch, 1967; Lundvall, 2007). While developing countries acknowledge the importance of technology management in the global economy, their capacity to do so will depend on how much they invest in and use it for product and process innovation in their manufacturing firms (Bell and Pavitt, 1995; De Marchi, Giuliani and Rabellotti, 2018; Chang and Andreoni, 2020). Selecting the right technology and managing it to drive organizational innovation are the main challenges. Poor business models, political instability and governance, low education and lack of world-class research universities, underdeveloped and mediocre physical infrastructure, and lack of solid technology based on trained human resources make innovation and technology in developing countries problematic (Juma and Yee-Cheong, 2005; Ali and Park, 2010; Ndesaulwa and Kikula, 2016; Rammal *et al.*, 2022; Zhuang and Zhou, 2023). This is a significant task for most firms, particularly those from developing countries, but it also offers numerous chances to enhance productivity and create high-quality jobs. To diversify their manufacturing bases, developing countries should adopt new technology and master old ones.

In this regard, there is observable evidence that several studies confirm that Ethiopia's manufacturing sector lacks technological know-how, skilled labor, industry expertise, technological goods and innovation, inter- and intra-sectoral linkages, and links with universities and research organizations (Mehari and Ababa, no date; te Velde, 2019; Gebremariam, Malimo and Hussen, 2021; Kalko, Erena and Debele, 2022). According to the World Economic Forum's 2022 study, Ethiopia must invest in and implement upgrades to its digital infrastructure and innovative technological approaches to achieve its goal of accelerating economic growth through increased production and efficiency in all sectors.

In this paper, we employ Pareto Principle Pareto to inquire into the relationship between technological management and innovation in Ethiopian firms. (Muthuraj *et al.*, 2016; Kumar, Singh and Jain, 2020) discovered that technology management strategies, such as monitoring emerging technologies and integrating technology into business strategies, boost innovation using the Pareto Principle. The first section of this research examined the elements that have an impact on the innovation and technology management strategies of Ethiopian manufacturing enterprises. Therefore, the study identifies the variables affecting innovation in Ethiopian manufacturing organizations in the context of technology management, and implementing excellent technology management procedures within firms is crucial to enhancing innovation practices and establishing good innovation ecosystems. The second section of this research delves into how the adoption of technology management methods influences the inventiveness of businesses. According to the research, the future of technology management would involve conceptualizing processes like acquisition, integration, and dissemination. Innovation may be facilitated through established processes, established goods, and established methods. The findings provide credibility to the theory that fostering technological innovation yields a useful competitive edge. Overall, the results of the study provide evidence in favor of the notion that encouraging technical innovation might result in a competitive advantage.

The rest of this paper is organized as follows: Methodological issues are discussed in Section 2; Section 3 contains the results and discussions; while Section 4 concludes the paper.

Methodological issues

To reach the goals of the study, descriptive research methods and both first-hand and second-hand sources of data were used. This chapter talks about how to collect, sample, analyze, and interpret data. It also talks about the different types and sources of data.

Population Target and Sampling Strategy

This study's target audience includes a sample of Ethiopian medium- and large-scale manufacturing companies, as well as consultants, researchers, technicians, and other experts. We classified manufacturing firms as medium- and large-scale using criteria established by the Ethiopian Statistical Authority and the Federal Democratic Republic of Ethiopia's Ministry of Industry (2018). Manufacturing firms with more than 10 but fewer than 51 employees are classified as medium-scale, while those with 51 or more employees are classified as large-scale. The research focuses on medium- and large-scale manufacturing firms because they are more likely to engage in innovative or creative activities (Gebreeyesus, 2009). Researchers from leather and leather goods research centers and textile, chemical, and food and beverage manufacturers respond to survey questionnaires.

Ethiopian manufacturers operate in a wide range of industries, including food and beverage manufacturing, textile manufacturing, pulp and paper, chemicals, rubber and plastics, non-metallic minerals, metals, leather, and others. Due to the high density of manufacturing firms in Addis Ababa and Shager City, we distributed hard copy and Google Form questionnaires to 140 manufacturing firms, one research institute, thirty research center researchers, nineteen individual consultants, and ten university professionals or technologists. As a result, 40 respondents completed the survey and provided their responses via a Google form, while 12 others provided paper copies of their responses. In total, 200 questionnaires were distributed, with only two respondents returning them.

Data Collection Methods

This research employs both primary and secondary sources of data. Standardized questionnaires are being developed for distribution in hard copy, along with primary data on technology management and innovation in Ethiopia's industrial sectors. A Google form will be used to survey the respondents. For the secondary source of data, we conducted a thorough literature review on important topics in technology

management and innovation in the manufacturing industry. Academic publications, books, business reports, and other information sources were investigated. Compiling comments from the selected manufacturing sectors, as well as cross-referencing the results with secondary data, will be beneficial.

Data Analysis Tool

The Pareto analysis tool was used to evaluate the primary data collected from respondents. The Pareto Principle, named after the economist Vilfredo Pareto, states that there is an asymmetric relationship between inputs and outputs, with 80% of outcomes resulting from 20% of the causes. It is known as the "rule of the vital few and trivial many" because it is used to exclude less important factors from decision-making. The Pareto Principle is also known as the 80/20 Rule. In this study, the Pareto technique is used to rank the key obstacles or influences limiting innovation in manufacturing organizations. As a result, the data are arranged and evaluated, and the important and irrelevant elements for the decision or policy implications are determined.

Finding and Analysis

The conclusions of this study were derived from the questionnaires that were developed specifically for target groups and then distributed to those groups. As a consequence of this, the data are analyzed and interpreted in this subject area using both theoretical and empirical frameworks. The findings from the empirical research are studied using a tool called Pareto analysis, whilst the findings from the theoretical research are analyzed qualitatively.

Qualitative Findings

The findings of this study were reported in this section. We have used qualitative analysis to determine the determinants that affect innovation in Ethiopian manufacturing enterprises by asking open-ended questions to the target groups in addition to guiding questions and reviewing the relevant literature. The responses from the target group show that all respondents' manufacturing company's ability to come up with new ideas is affected by several internal and external factors. The capacity to invest in innovation (funds, R&D facilities), the quality or skill level of managers or employees, the firm's strategy (employees' participation culture, motivation, vision, priority, etc.), cooperation for open innovation, an attitude or awareness of the importance of innovation for manufacturing firm's competitiveness and profitability, and other external factors include the strategy and policy of the government, the labor market, and cooperation among or between firms for open innovation exchanges.

However, all the target group respondents agree that manufacturing enterprises need innovation and technology management, and improving major internal and external aspects improves innovation in manufacturing firms. An organization's internal or external strategy and policy, management's commitment to innovation and innovativeness, knowledge of innovation's importance, innovation facilities (money, R&D), skilled personnel, and other elements play a crucial role in the manufacturing firms' performance. A well-designed government and firm innovation strategy, the involvement of trained professionals and human power in manufacturing firms, making people aware of how important innovation is, setting up facilities and budgets for innovation, and so on help to improve innovation in manufacturing firms.

Empirical Results

Using the Pareto chart as an analysis and prioritization tool, the primary problems or factors that affect manufacturing firms' innovation have been identified and prioritized according to the empirical data. The Pareto analysis is a statistical method that was named after Vilfredo Pareto, an Italian economist who worked in the area around 1896. This theory says that, at that time, only 20% of Italians owned 80% of the land in the country. This means that only 20% of the people had 80% of the wealth during that time. In later years, the Pareto analysis technique was utilized as one of seven different statistical quality tools. The tool is primarily utilized to prioritize the so-called "vital few" problems and the "trivial many" problems, and it arranges the frequency of occurrences in the order of highest frequency to lowest frequency. The use of this tool assists the management in making decisions.

According to this guiding principle, "just 20% of the conceivable causes are responsible for 80% of the difficulties, issues, consequences, or faults that

occur in a system." The remaining 20% of possible causes are referred to as the "vital few," while the remaining 80% of factors that make a smaller contribution to the effect are referred to as the "trivial many" or the "useful many." These causes only account for the remaining 20% of occurrences. The managers can comprehend which of the potential reasons need to be addressed first by applying these ideas. It is claimed, per the Pareto principle, that addressing the essential few probable reasons requires addressing both the vital few and the helpful many causes since the useful many are dependent on the vital and there can't be more than one of each.

The research identified the critical and useful causes that affect the innovations of manufacturing enterprises. Considering the significance and usefulness of this instrument, the research came to this conclusion. Accordingly, unsupportive innovation strategy and culture, lack of qualified workforce, Insufficient innovation funding, technology and innovation awareness gap, and absence of innovative leadership manufacturing firms were discovered to be the vital few and causes for 80% of Ethiopian manufacturing firms' innovativeness. The useful many or trivial factors, on the other hand, included lack of Research and development facilities, limited demand for innovative products, and a lack of funding.

The information that led to these conclusions came from 58 people who worked in manufacturing businesses in the textile and clothing, leather and leather goods, chemical, food and beverage, and metal and metal products' sectors. These findings are based on the data. Others came from professionals in the industry, including researchers and consultants.

Table 1: Pareto Chart

Innovation Factors	Acronyms	Frequency	Parentage total	Cumulative percentage	Marker (80%)
Unsupportive innovation strategy and culture	UISC	13	22.4	22.4	80%
Lack of Qualified workforce	LQW	10	17.2	39.6	80%
Insufficient innovation funding	IIF	9	15.5	55.1	80%
Technology and Innovation Awareness Gap	TIAG	8	13.8	68.9	80%
Absence of Innovative leadership	AIL	8	13.8	82.7	80%
Lack of Research and Development Facilities	LRDF	6	10.3	92.9	80%
Limited demand for innovative products	LDIP	3	5.2	98.1	80%
Other	Others	1	1.7	100.0	80%

Source. Authors' output from input data.

In Table 1 above, the primary obstacles that affect the innovativeness of manufacturing companies are organized in such a way that the frequency of occurrences goes from most frequent to least frequent. It divided the components into two groups: the "important few" and the "trivial many." So, the first five elements are a few critical factors that need to be addressed first, while the last three components are insignificant numerous causes that contribute less to the consequences. The first five elements are critical and must be addressed first. The contributions of the vital few, expressed as a percentage, are, in order, 22.4%, 17.2%, 15.5%, and 13.8%, respectively.

The overall contribution of a few critical causes comes to 82.8% of the total. In other words, these are the elements that are responsible for the occurrence of 82.8% of impacts, which is the lack of innovativeness on the part of Ethiopian

manufacturing enterprises. The contributions of elements that are not important at all are as follows: 10.3%, 5.2%, and 1.7%, respectively. In Ethiopia, the creation of innovative manufacturing enterprises can be attributed to a total of 17.2% of the contributions made by numerous trivial causes.

Conclusion

In the fourth industry revolution (4IR), manufacturing enterprises compete fiercely with one another due to open innovation and globalization. Thus, creativity and innovation/technology management are essential to the competitiveness and survival of manufacturing organizations; manufacturing firms are forced to be inventive. The research's findings show that Ethiopian manufacturing companies lack innovation due to both internal and external factors. Some of the internal factors are company innovation strategies, innovation budgets, lack of awareness of innovation and technology, lack of innovative leadership, and facilities for product development. Both qualitative and empirical quantitative findings are produced through the investigation. The qualitative or theoretical findings can be summed up as follows: initiatives for innovations in manufacturing firms are for the sustainability of the businesses, productivity improvement, quality improvement, customer satisfaction, market demand, profitability, cost minimization, problem-solving, and in general, to be competent in local and global markets. Innovation strategy, inventive leadership, an innovation fund, innovation awareness, and skilled employees all play important roles in satisfying manufacturing enterprises' innovativeness and ensuring their sustainability and competence. Along with these, other ways to encourage innovation are to train people in a wide range of skills, encourage partnerships, reward employees for their ideas, and use technology predictions based on data from the past, the present, and the future.

Technology management is essential for developing cutting-edge manufacturing businesses. Technology roadmaps, technology forecasts, technology strategies, technology policies, and technology portfolios must all be supported for technology management to be effective and efficient. An effective government and business innovation strategy, the participation of experts and skilled labor in manufacturing enterprises, raising awareness of the value of innovation, setting up infrastructure, and distributing funding are the actions that will be put into practice. Collaborating with others on technology transfer and innovation, getting government recognition and incentives, engaging in incentive programs, and commemorating innovation day(s) are all critical components of cultivating a vibrant and dynamic ecosystem for growth and creativity.

Pareto analysis was the main topic of the research's empirical summary. Pareto analysis was used to identify the characteristics that influence a firm's capacity for innovation and to rank them as "essential few" and "trivial many." As a result, there are 82.8% of important causes overall, and many unimportant variables make up the remaining portions. In theory, solving the issues requires focusing on a few selected crucial ones.

Policy Implications: It is recommended that the government consider implementing measures to promote innovation within the manufacturing sector. This may be achieved through the establishment of an annual Innovation Day and the provision of national recognition for enterprises that demonstrate creative practices. Such initiatives have the potential to cultivate a culture that values and encourages innovation within the manufacturing industry. In industrial firms, it is advisable to prioritize vital qualities over less significant ones to promote innovativeness. This can be achieved by the application of Pareto analysis.

To effectively tackle labor market dynamics, it is essential to allocate resources towards enhancing human capital. This can be achieved through a combination of short- and long-term training initiatives, utilizing the expertise of universities and colleges for sustained growth, and adopting both on-the-job and off-the-job training programs to yield immediate benefits. It is imperative to emphasize the significance of recognizing the value of innovation within industrial contexts.

One recommendation is to create an innovation fund that receives financial backing from both governmental and non-governmental groups. This fund would provide financial assistance to

entrepreneurs aiming to successfully introduce novel products, processes, and services to the market.

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