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The Role of Flexibility in Enhancing Operational Performance Through Sustainability Practices: A Case Study on the US and European Original Equipment Manufacturers

By

Mohamad Ali Mezher

A thesis

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Student Name: Mohamad Ali Mezher I.D. #: 201600054

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School: Adnan Kassar School of Business

The undersigned certify that they have examined the final electronic copy of this thesis and approved it in Partial Fulfillment of the requirements for the degree of:

Master in the major of Business Administration

Thesis Advisor's Name: Raed El-Khalil

Signature: [redacted] Date: 26 / 4 / 2021
Day Month Year

Committee Member's Name: Manal Yunis

Signature: [redacted] Date: 26 / 4 /2021
Day Month Year

Committee Member's Name: Abdul-Nasser El-Kassar

Signature [redacted] Date: 26 / 4 / 2021
Day Month Year

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Dedication Page

I dedicate this thesis to my mother, sister, father, and aunt Amal who supported me with love and understanding throughout my academic journey.

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The Role of Flexibility in Enhancing Operational Performance Through Sustainability Practices: A Case Study on the US and European Original Equipment Manufacturers

Mohamad Ali Mezher

ABSTRACT

Flexibility and Sustainability are two philosophies that the original equipment manufacturers (OEMs) invested heavily in since the 21st century. The impact of these two philosophies exceeds operations and extends to customers, communities, employees, and innovation. This thesis identified the lack of empirical research investigating the relationship between flexibility and sustainability and their combined interactions with operational performance metrics. Very few studies investigated this relationship in limited depth and breadth. Therefore, this thesis aims to investigate the interaction between flexibility, sustainability, and their impact on operational performance in the United States (US) and European (EU) OEMs. Based on the contingency theory and resource-based view theory, a conceptual model linking flexibility, sustainability, and operational performance was developed and empirically tested. After reviewing previous literature and consulting academicians and practitioners experienced in the topic, a survey was developed. The survey was conducted with a total of 140 respondents. The respondents are managers at OEMs facilities in Europe and the US. The results indicated a significant and positive relationship between flexibility and operational performance, flexibility and sustainability, and sustainability and operational performance. The results also revealed that sustainability mediates the relationship between flexibility and operational performance. This study can help managers know what flexibility and sustainability practices optimize operational performance.

Keywords: Flexibility, Sustainability, Operational Performance Metrics, Manufacturing, Original Equipment Manufacturers.

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LIST OF ABBREVIATIONS

FLX: Flexibility
FLXOP: Operational Flexibility
FLXTAC: Tactical Flexibility
FLXST: Strategic Flexibility
SUSECO: Economic Sustainability
SUSENV: Environmental Sustainability
SUSSOC: Social Sustainability
OPM: Operational Performance Metrics

Chapter One

Introduction

The Bureau of Economic Analysis, in its 2020 report, stated that the US manufacturing industry constitutes around 11% of the US economic output (BEA, 2020). With 16.6% of the global total manufacturing output, the United States is the second-largest manufacturing superpower after China (WEF, 2020). Considering the US manufacturing industry's GDP alone (World Bank, 2019), it is ranked 13th worldwide, which shows its strength and influence on the world economy.

In the last few decades, the European Union "EU" industrial sector has declined significantly (World Bank, 2019). In 1991, the manufacturing industry consisted of around 20% of the GDP. While in 2019, the EU manufacturing industry contributed 14% to the overall GDP. In the early 2000s, the EU represented 26% of the world's total manufacturing (Bernard et al., 2017). However, in the last decade, it declined to 20%. The decline of manufacturing in the EU results from many factors, including and not limited to an increase in demand for services compared to products, the emergence of China as a manufacturing superpower, and slower economic growth in the EU compared to other countries.

The above facts prove that the manufacturing industry became one of the main pillars of Europe and the US economy. And based on that, manufacturing firms started to reassemble their capabilities to gain a competitive edge and survive in the market. In the 1960s, cost was the primary concern for organizations. Throughout decades, and due to rapid industrialization, organizations' priorities changed. Products and services delivery speed and customer satisfaction became as important as quality and cost. Thus, firms started adopting and implementing “flexible” practices in their manufacturing process to cope with the fluctuating market environment.

To identify the drivers of global manufacturing competitiveness, Deloitte Inc., in 2016, conducted a global CEO survey (Deloitte, 2016). Out of the twelve identified drivers, “innovation and talent” was the most crucial one, as stated by the executives. And the primary driver component of innovation was flexibility (Deloitte, 2016). Slack (2005) and El-Khalil (2009) defined flexibility as the ability of the organization to absorb external disruptions without vandalizing the overall process output. Flexible manufacturing plays a significant role in improving efficiency, profit, customer service, and effectiveness (El-Khalil and Darwish, 2019). In the past few years, flexibility has been witnessing an increased interest from scholars and practitioners. Some scholars consider that adopting flexible practices is an important decision that any firm should take to survive in a complex and competitive market.

Companies that are not flexible cannot survive. During the COVID-19 pandemic, manufacturing industries faced many disruptions. Firms that integrated flexible practices within their strategic plan and operations were better at navigating the pandemic challenges (Rajesh, 2020). As shown in figure 1, the search for the word “flexibility” rose significantly in 2020, which at that time, the COVID pandemic was at its peak (Google, 2021). Thus, organizations were trying to search for flexible practices to implement in their day-to-day activities.

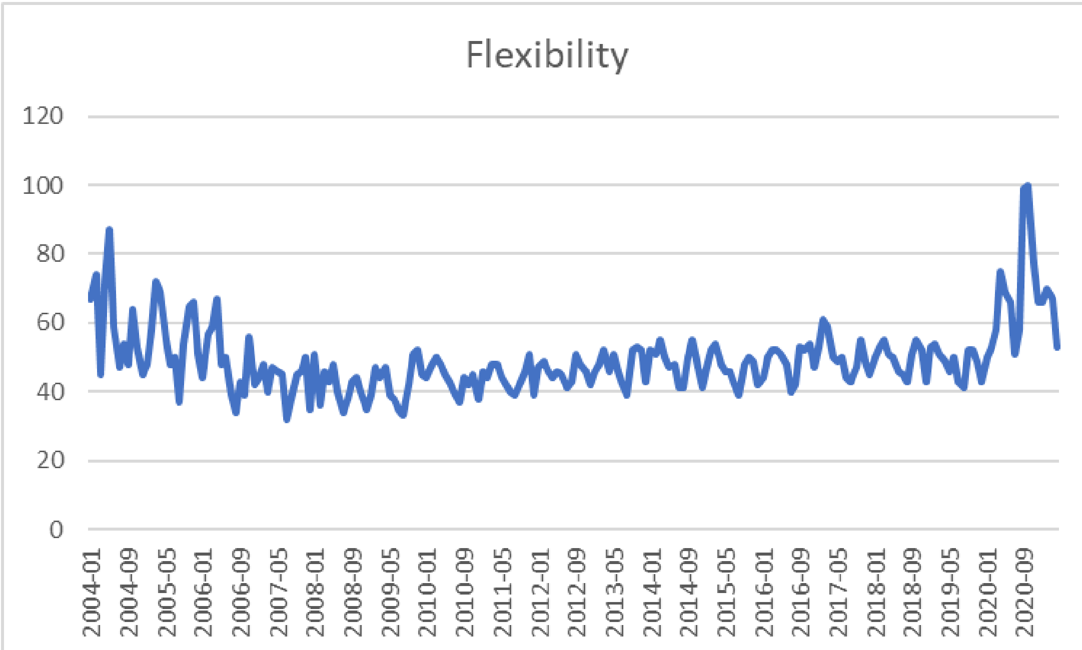

Figure 1: Search for the word "Flexibility" over time

According to a PWC report in 2020, the top two concerns for manufacturing managers concerning COVID-19/returning to the workplace and operating in a changing business environment are financial impacts and the need for better hardware and equipment (PWC, 2020). Also, the managers chose products and services to be the most important to rebuild or enhance the revenue streams. As for the situation that will make the company better in the long run, 73% of the managers chose work flexibility (PWC, 2020). The report concluded that flexibility practices could offer them the solution for companies aspiring to prosper in the long run (PWC, 2020).

Due to the brisk industrialization and its severe effect on the environment, various governments and organizations started to focus on implementing sustainable behaviors in the manufacturing process. Manufacturing industries consider implementing sustainable practices as a necessity for survival in the competitive market. The United Nations defined sustainability as the ability of the firm to meet its direct and indirect stakeholders' needs while taking into consideration the needs of the future stakeholders (Tang et al., 2016). The concept of "Sustainability" has been studied in several areas and most notably in the business and manufacturing sector (Gunasekaran and Spalanzani, 2012). Numerous benefits can result from integrating flexibility and sustainability, such as improved environmental performance, ability to hold a better competitive position, and reduced cost.

Several studies have examined the interaction between flexibility, sustainability, and operational performance. Some studies found a positive relation between flexibility and operational performance (El-Khalil and Darwish, 2019), sustainability and operational performance (Geyi et al., 2020), and flexibility and sustainability (Blome et al., 2014). However, most of these studies were limited in depth and breadth in selecting the metric or limited to a specific industry and/or country. Additionally, no studies have examined how flexibility can enhance operational performance through sustainability practices in Europe and the US original equipment manufacturers (OEMs). Accordingly, this study aims to answer the following research question:

Q1: How do sustainability practices mediate the relationship between flexibility and operational performance?

This study significance lies in its ability to direct managers toward what flexibility tools to focus on based on the performance metric required and what sustainability implementation will help optimize performance.

To answer the above research question, 140 OEM managers in the US and Europe were surveyed.

Chapter Two

Literature Review

2.1 Theoretical Framework

This research will focus on the theory of contingency and resource-based view (RBV). The previous work done by Slack (1988), Gerwin (1987), and Parthasarthy and Sethi (1993) suggests that manufacturing flexibility depends on the organization's external environment and internal operations. According to previous research, the dominant forces influencing manufacturing flexibility are four general areas: technology, organizational attributes, strategy, and environmental factors. For instance, Gerwin (1987) noted that certain sources of environmental uncertainty necessitate the use of specific manufacturing flexibility.

Previous frameworks, on the other hand, had the drawback of only addressing relationships in a limited way. Manufacturing flexibility, for example, is dependent on the type of competitive strategies used by a firm, according to Slack's (1988) hierarchical model of flexibility. His framework suggests that different competitive strategies will necessitate different levels of manufacturing flexibility. However, this framework neglects the contingent relationships that exist between a company's technology, associated environmental factors, and organizational attributes.

Parthasarthy and Sethi (1993) proposed a framework with a much broader view on the impact of manufacturing flexibility on performance. It takes into account the industry's technological environment, as well as organizational and strategic structure decisions.

However, their framework is limited in that it only considers one aspect of manufacturing flexibility, namely flexible automation.

Moreover, other models have concentrated on the contingent relationship between manufacturing flexibility and environmental factors. For example, Gerwin's (1993) strategic perspective model consists of the impact of environmental uncertainty on manufacturing flexibility. It implies that a firm's level of performance is dependent (contingent) on its ability to match the proper type of flexibility with the corresponding type of environmental uncertainty.

Furthermore, Suarez et al. (1995) concentrated on the contingency relationship between market uncertainty and manufacturing flexibility, portraying firm performance as a reasonable ‘‘fit" between manufacturing flexibility and the market environment.

Since Slack's (1988) and Gerwin's (1993) frameworks had some limitations, Vokurka and O'Leary-Kelly (2000) developed a framework that addresses these limitations. This framework is based on four exogenous variables: technology, organizational attributes, environmental factors, and organizational strategy. These variables are thought to affect organizations' choice of flexibility types and levels. The environmental factors involve current uncertainties and future uncertainties that the organization is expecting to happen. Organizational attributes focus on the organizational structure and the behaviors of employees. In the organizational strategy, organizations plan on what flexibility types and levels they will implement in their daily activities. And based on the organizational strategy, firms' business performance will be dictated. Also, firms' technological machines and equipment differ from each other. Therefore, every firm must implement the flexibility type and level suitable for the technological resources available. The contingency theory will help us understand the relation between flexibility, as a strategic decision, and operational performance in the existence of sustainability as a mediator. On the other hand, the RBV proposes that firm-level resources should be none-substitutable, rare, valuable, and imperfectly imitable to improve firms' competitive advantage (Barney et al., 2001). In other words, the RBV states that sustained organizational performance is determined and influenced by the resources that firms own (Wernerfelt, 1984). This research considers flexibility tools as a resource and capability that helps us understand its effect on sustainability and operational performance.

2.2 Flexibility

The concept of flexibility was first introduced in 1921 by Lavington (Lavington, 1921), in which he discusses the importance of creating flexibility in manufacturing. Flexibility is present in various topics and research fields, such as production, information technology, decision theory, and economics. The Japanese have been the early adopters of flexibility (Gerwin, 1993). In 1986, the Manufacturing Future surveyed manufacturing managers in over 400 facilities worldwide (DeMeyer et al., 1989). The Japanese manufacturing managers ranked flexibility for introducing new products and volume flexibility as their second and fourth priorities, while quality was their third priority. As for the European and North American managers, they ranked quality as their first priority and the two flexibilities as their sixth and eighth. The report concluded that the Japanese manufacturers did not face any quality issues due to their high implementation of flexibility practices. As for the North American and European facilities, they were constantly facing quality deficiencies.

Several industries from different countries implement flexibility practices to improve productivity, deal with uncertainties, and survive in the competitive market (Boyle, 2006; Anand and Ward, 2004). Table 1 presents the flexibility definition as stated by different authors. Flexibility implementation is a sophisticated process due to the multidimensional nature it possesses (Gerwin, 1993).

Table 1: Flexibility definition by different authors

Definition	Reference
Ability to confront the changes and uncertainties in market and business environments	Gupta and Buzacott (1996)
Vital instrument for dealing with uncertainties	Newman et al. (1993)
Ability of the organization to control its dynamic efficiency and equilibrium	Mariotti (1995)
The alternatives left after one has made an initial decision	Rosenhead et al. (1972)
Ability of the organization to absorb external disruptions without vandalizing the overall process output	Slack (2005) and El-Khalil (2009)
Channel between the system and the changes in the outer environment	Correa (1994)
Essential driver for organizations to survive in the competitive market	Hayes and Wheelright (1984)

Whether the organization plays a defensive or proactive approach, flexibility is required (Gerwin, 1993). Flexibility needs can be met by various methods, such as information technology, planning and control procedures, production equipment, product design, and materials management (Whitney, 1986).

Slack (1988) proposed a three-stage approach to defining flexibility requirements, conducting flexibility audits, and developing a flexibility action plan. The first stage requires the organizations to define and understand their competitive strategy. The second stage requires firms to conduct a flexibility audit. The audit's main idea is to understand the current system capabilities in terms of speed and range. The third stage involves benchmarking current production capabilities against the required level of flexibility, and then the firm develops a plan accordingly.

Suarez et al. (1991), like Slack (1988), recommended a three-phase approach to achieve manufacturing flexibility. The first phase involves identifying the levels and types of flexibility needed to examine uncertainties. At the second phase, and through all departments' coordination, such as accounting, information technology, production, and human resources, the organization implements the identified flexibility types and levels. While in the third phase, the managers evaluate the implementation and provide feedback when relevant.

Moreover, Gerwin (1993) also proposed a four-stage approach for implementing manufacturing flexibility. In the first stage, the top managers identify the required flexibility tools and dimensions for competing. Besides identifying the required flexibility tools and dimensions, the top management must also decide if excess flexibility is required. In the second stage, manufacturing engineers evaluate the actual and potential performance of the implemented flexibility types. As for the third stage, managers must develop methodologies to close the addressed gaps presented. The managers should also prioritize which gaps they should assess first. Finally, in the final stage, managers ensure that gaps are being closed. And this can be achieved by implementing an effective measurement system.

Nilsson and Nordahl (1995a, b) proposed three-level flexibility needs, namely strategic, production system, and production resource. First, at the strategic level, the input and output flexibility are addressed. Input flexibility is the flexibility found in the relationship between a manufacturing facility and supplier. Output flexibility is the flexibility found in the relationship between a manufacturing facility and customers. In the second level, the manufacturing facility production system characteristics are identified—for example, production lead times, capacity, and size. Finally, at the production resource level, potential resource characteristics are identified. For example, machine set up time and labor skills. The holistic coordination and integration of these levels are required to exploit the benefits of flexibility.

Narrain et al. (2000) stated that any firm aiming to implement flexibility practices must identify the uncertainties that exist. After identifying the uncertainties, firms should evaluate them against their capabilities. And this evaluation can be done using the SWOT (strengths, weaknesses, opportunities, and threats) analysis. Then, the firm competitive strategy is formulated based on the SWOT analysis. And thus, marketing, manufacturing, and other organizational strategies are dictated accordingly. Then, through marketing, functional strategies, and manufacturing, the strategic flexibility is determined. The main goal of strategic flexibility is to identify and solve long-term issues. Strategic flexibility can be achieved by utilizing a combination of market, expansion, and production flexibility. Then, the operational and tactical flexibility are identified using strategic flexibility. Operational flexibility is applied to accomplish goals related to product costs, product quality, fluctuation in demand, managing various product mixes, and introducing new product designs. Labor, product, machine, volume, routing, and material handling flexibility are all used to achieve operational flexibility. Tactical flexibility is accomplished by combining material handling, program, operations, and process flexibility. Tactical flexibility aims to resolve issues related to inventory difficulties, the variety of materials to be processed, shortened product life cycles, and uninterrupted operation for a long period of time. According to Narrain et al. (2000), certain flexibility levels and types chosen might overlap. Therefore, based on what flexibility is necessary, sufficient, and competitive, the tactical, operational, and strategic flexibility must be reconciled. In some cases, managers might need to prioritize the required flexibility types because not all facilities have the resources to implement all the required flexibility types.

From Olhanger and West (2002) perspective, firms must first examine customer's needs as "competitive priorities," such as innovativeness, quality, delivery speed, cost, and product range. The weighting of those priorities is then determined by their potential to attract consumer orders. After that, benchmarking is performed to see how the competitive priorities align with other organizations. Finally, the performance of the flexibility selected will be tracked using objective measurements.

2.2.1 Flexibility Classification

Various scholars tried to categorized flexibility dimensions. Slack (1983) classified flexibility into three categories: product flexibility, mix flexibility, and volume flexibility. Buzacott and Mandelbaum (1985) classified flexibility into machine flexibility and routing flexibility. Brown et al. (1984) proposed a set of eight characteristics for flexibility: machine, process, product, routing, volume, expansion, operation, and production. Sethi and Sethi (1990) categorized the flexibility types into three groups: basic flexibility, system flexibility, and aggregate flexibility. Narain et al. (2013) identified thirteen flexibility dimensions and categorized them into three groups: sufficient, competitive, and necessary. Vokurka and O'Leary-Kelly (2000) identified fifteen dimensions of flexibility that are based on lists developed by other scholars, such as Parthasarthy and Sethi (1993), Gupta and Somers (1992), Suarez et al. (1996)**,** Sethi and Sethi (1990), and Slack (1988). Vokurka and O'Leary-Kelly (2000) divided the fifteen flexibility dimensions into three levels: Operational, Tactical, and Strategic, as shown in table 2.

Table 2: Flexibility classification

	Indicator	Flexibility Type	Definition
Operational			
	FMS1	Machine	The system can switch operations with minimal effort
	FMS2	Material Handling	Different part types can be moved efficiently for proper positioning and processing
	FMS3	Automation	Automation is capable of performing different operations and/or add operations
	FMS4	Labor	The number of workers, tasks performed by workers, and responsibilities can be changed
	FMS5	Routing	A part can be produced by alternative routes
	FMS6	Product	New parts can be added or substituted for the existing parts easily
	FMS7	Volume	The system can be operated profitably at different product overall output levels
Tactical			
	FMS8	Operation	Parts can be produced in different ways with alternative process plans
	FMS9	Process	The system can produce a set of part types without major set-up
	FMS10	Material	Materials are easily transported to the manufacturing facility and to operations within the facility
	FMS11	Program	The system can run virtually untended for a long enough period
Strategic			
	FMS12	New Design	The system can easily produce a product with a different shape and/or dimension
	FMS13	Expansion	The system's capacity and capability can be easily increased when needed
	FMS14	Production	The FMS system can produce a big variety of part types
	FMS15	Market	The manufacturing system can easily adapt to a changing market environment

2.3 Sustainability

The origin of sustainability may be traced to over a century from a concept known as Spaceship Earth (George, 2009). Spaceship Earth is a paradigm that encourages all human beings on Earth to live together in harmony with the common good (George, 2009). After the Brundtland Report in 1987 on sustainable development, the concept gained significant interest and popularity among scholars and practitioners (Alhaddi, 2015). The United Nations defines sustainability as the ability of the firm to meet its direct and indirect stakeholders' needs while taking into consideration the needs of the future stakeholders (Tang et al., 2016). Sustainability consists of the triple bottom line (TBL) (Govindan et al., 2016). The TBL is a framework that measures the organizations' success through three dimensions: environmental, social, and economic. First, sustainability was measured only using environmental practices (Elkington, 1997). Through time, the environmental agenda was expanded and integrated other dimensions, such as social and economic.

The TBL is the integration of all three dimensions. However, some inconsistencies exist in previous literature regarding the usage of the TBL. For example, some studies only considered the social dimension while examining sustainability (Bibri, 2008). Others used sustainability in terms of the environmental dimension only (Yan et al., 2009). Therefore, to optimize sustainability outcomes, the TBL dimensions must be balanced and implemented simultaneously (Govindan et al., 2016; Epstein, 2008).

2.3.1 Economic Sustainability

Economic sustainability pertains to the business practices that support long-term economic growth without vandalizing the social and environmental elements. (Elkington, 1997). Also, it measures the economy's ability to thrive in the future to sustain future generations' needs (Spangenberg, 2005). The economic dimension must focus on improving the economy in various practices, such as creating jobs, paying all taxes, investing in infrastructure, among others (Yusuf et al., 2013).

2.3.2 Social Sustainability

Social sustainability refers to the organization's ability to conduct fair and beneficial business practices to all stakeholders, including the community (Elkington, 1997). Social sustainability primary goal is to give back to society through various means, such as ensuring product safety, complying with the law, respecting human rights, and providing health care coverage (Golicic and Smith, 2013). Firms that fail to respect the societies they are in might face economic downturns. For the greater good, the social performance must focus on building a healthy relationship between the organization and the community (Goel, 2010).

2.3.3 Environmental Sustainability

Environmental sustainability pertains to conducting eco-friendly activities that do not harm the environment or increase the scarcity of resources (Elkington, 1997). Some of the environmental practices include minimizing the use of hazardous substances in the manufacturing process, using alternative and renewable energies, and protecting biodiversity.

2.3.4 The TBL Practices

Table 3 illustrates the sustainability practices associated with each dimension (Yusuf et al., 2013; Golicic and Smith, 2013; Paulraj et al., 2017; Wong et al., 2012; Chin et al., 2015; Sarkis et al., 2010).

Table 3: Sustainability dimensions and practices

Sustainability Dimensions	Indicator	Practices
Economic	SUSECO1	The company works towards improving its market share
	SUSECO2	The company works towards improving its image in the society
	SUSECO3	The company works towards improving its position in the market place
	SUSECO4	The company generates sales and profits
	SUSECO5	The company tries to reduce its material purchasing cost
	SUSECO6	The company tries to reduce its utility bills
	SUSECO7	The company tries to reduce waste treatment fees
	SUSECO8	The company tries to reduce waste discharge fees
	SUSECO9	The company tries to reduce environmental accidents
	SUSECO10	The company works towards improving its products/services quality
Social	SUSSOC1	The company has very good relations with the community and stakeholders
	SUSSOC2	Work in the company is safe
	SUSSOC3	The company cares about employees health
	SUSSOC4	The company has a healthy work environment
	SUSSOC5	The company tries to improve the living quality of the surrounding community
	SUSSOC6	The company takes social welfare initiatives
	SUSSOC7	The company complies with laws and standards
	SUSSOC8	The company highly respects human rights
	SUSSOC9	The company has good working conditions
	SUSSOC10	The company treats suppliers fairly
	SUSSOC11	The company ensures product safety
Environmental	SUSENV1	The company minimize the use of hazardous substances
	SUSENV2	The company minimize the use of water
	SUSENV3	The company minimize solid wastes and emissions
	SUSENV4	The company use alternative and renewable energies
	SUSENV5	The company works toward protecting biodiversity
	SUSENV6	The company uses resources efficiently
	SUSENV7	The company comply with environmental standards

Chapter Three

Research Methodology

3.1 Hypotheses Development

3.1.1 Flexibility and Operational Performance

Different manufacturing strategies have been studied extensively in the literature, such as lean (El-Khalil et al., 2020) and agility (Geyi et al., 2020). Flexibility, as other manufacturing strategies, has been examined by numerous scholars.

The implementation of volume flexibility will support the manufacturer's ability to operate at different product output levels, leading to improved productivity (Marschack and Nelson, 1962). While, if volume flexibility is coupled with mix flexibility, the manufacturer can have more room for innovation in the production process, which means better quality and positive customer satisfaction (Zhang et al., 2003; Oke, 2013). In fact, if the organization has the ability and the resources to implement whatever type and level of flexibility, then productivity and efficiency will improve significantly (Wei et al., 2017). However, the implementation should be coupled with a valid and reliable plan that employees and managers can base their work on. As the departments' coordination improves, flexibility practices will enhance both competitiveness and business performance (Kaur et al., 2017).

Moreover, labor flexibility plays a significant role in improving the firm manufacturing performance; if the worker is cross-trained with other units/departments, then the worker's heterogeneity will increase, and thus, the worker performs better (Koste and Malhotra, 1999).

To optimize the effect of flexibility on operational performance, products, processes, and organizational innovation must be incorporated (Camison and Lopez, 2010). Sometimes flexibility practices are embedded in agile practices, and their combination has a significant positive impact on quality, cost, and innovation (Geyi et al., 2020). Furthermore, all flexibility types (i.e. operational, tactical, and strategic) might play a major role in improving operational performance (El-Khalil, 2018). However, the impact of each might differ from the other.

Therefore, and based on the above insights, the following hypotheses are formulated:

H1a: Operational flexibility has a positive impact on operational performance.

H1b: Tactical flexibility has a positive impact on operational performance.

H1c: Strategic flexibility has a positive impact on operational performance.

3.1.2 Sustainability and Operational Performance

An increased interest is witnessed by scholars in studying the effect of sustainability, namely the triple bottom line: economic, environmental, and social dimensions on the operational performance (Govindan et al., 2016). Increasing pressure is put on manufacturing industries to adopt sustainable practices in their manufacturing activities and services (Gunasekaran and Spalanzani, 2011). These sustainable practices are internal (employees safety, quality, productivity, and cost-saving) and external (government rules and regulations). Faulkner and Badurdeen (2014) developed a sustainability evaluation model for manufacturing systems based on integrating value stream mapping and triple bottom line dimensions. Several studies have stressed the importance of using the triple bottom line dimensions while assessing the manufacturing system performance (Hello et al., 2016). Sustainability is not only about performing well environmentally, but it is also the ability of the organization to perform socially and economically (Gunasekaran and Spalanzani, 2011). The more firms invest in sustainable practices, the better the performance (Esfahbodi et al., 2016).

When the organization engages in environmentally sustainable activities, such as reducing the use of hazardous materials and protecting biodiversity, it reduces the waste and energy consumption in its manufacturing process, leading to improved performance (Munasinghe et al., 2017; Rabadán et al., 2019). Also, implementing environmental practices might encourage the customer to deal with the organization, leading to increased sales and better financial performance (Ameer and Othman, 2012; García-Dastugue and Eroglu, 2019).

Additionally, when the firm implements social activities, it creates a healthy work environment for the employees, and employees' morale and productivity improve when they feel respected and safe (Kossek et al., 2014; Schoenherr and Talluri, 2013). The same thing applies to economic activities; when the company invests in the infrastructure and local community, it improves its image and reputation in the society (Jin et al., 2017). And when the company image and reputation improve, more customers will come, leading to more sales and improved profitability (Jin et al., 2017).

Therefore, and based on the above facts, the following hypotheses are derived:

H2a: Economic sustainability practices have a positive impact on operational performance.

H2b: Environmental sustainability practices have a positive impact on operational performance.

H2c: Social sustainability practices have a positive impact on operational performance.

3.1.3 Flexibility and Sustainability

Flexibility in manufacturing helps to prolong the useful lifetime of machines and tools by allowing adaptation and thus promoting reusability. Reuse optimizes the use of natural resources while also limiting waste and emissions in the environment, lowering the overall ecological effect (Taneja et al., 2012). It also greatly reduces lifecycle costs and conserves energy resources. The money saved could be used to improve the environment or social equity. Flexibility, in this way, aids (long-term) financial viability in the face of economic instability while minimizing environmental and social impacts (Taneja et al., 2012). A sustainable product is a product that supports the economy, society, and environment while ensuring public and environmental safety during their entire life cycle, from raw material extraction to final disposal (Greden, 2005), and as observed, flexibility makes this possible. Flexibility aims to improve efficiency, productivity, and reduce cost, and this aligns with sustainability objectives.

Adaptation has costs, but it has a payoff in the form of reduced ecological effects. As stated by De Neufville et al. (2005), “A flexible design will have a different risk-reward profile than an inflexible system, and thus may be more attractive to investors. Flexible designs will help to advance sustainability goals by specifically addressing future uncertainty at the design stage”. Flexible resource use during operations helps to maximize resource utilization and thereby contributes to sustainability.

In KRONOS's 2016 report on the future of the manufacturing industry 2020 and beyond, they stated that the ability of the manufacturing firm to stand out in the competitive environment would rely on its ability to adopt flexible practices that help them adapt to market fluctuations and implement sustainable practices. The report also indicates that to exploit the benefits of flexibility, sustainability practices should be coupled with it. Organizations can not maintain sustainable outcomes without being flexible (Ojstersek et al., 2019). The customer's need for new sustainable products and services will drive manufacturing firms to implement flexibility practices (Blome et al., 2014).

To sum up, as stated by Greden (2005), " Flexibility's contribution to sustainability goals lies in reducing waste and/or positioning a product/design/or system with sustainability benefits to hedge financial risk and, on the upside, to take advantage of evolving opportunities."

Thus, and based on the above arguments, the following hypotheses are formulated:

H3a: Operational flexibility has a positive impact on sustainability practices.

H3b: Tactical flexibility has a positive impact on sustainability practices.

H3c: Strategic flexibility has a positive impact on sustainability practices.

H4: Sustainability practices mediate the relationship between flexibility and operational performance.

3.2 Conceptual Model

Following the work of Sethi and Sethi (1990), O'Leary-Kelly and Vokurka (2000), and El-Khalil and Darwish (2019), among others, this study developed a similar model, as illustrated in figure 2. Moreover, and after going through previous literature and practitioners' feedback, this study filled the literature gaps. For example, in El-Khalil and Darwish (2019) paper, they did not consider sustainability practices in their study. Furthermore, the study was limited to the US automotive industry. Other studies like Wei et al. (2017), Zhang et al. (2013), and Koste et al. (2004) were also limited to a particular industry/country or did not examine all flexibility dimensions simultaneously. This is the first study that examines Flexibility and Sustainability practices in the US and European OEMs.

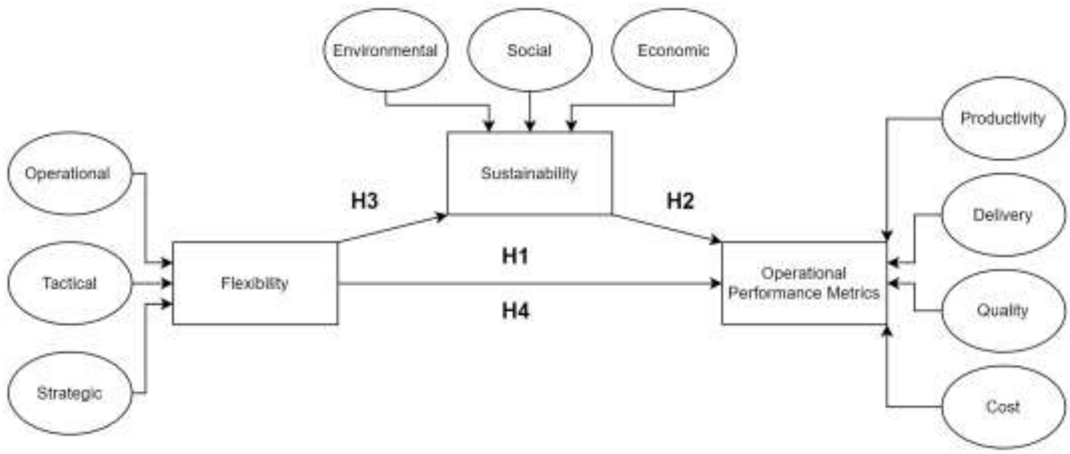

Figure 2: Conceptual Model

3.3 Survey Development

The research aims to determine the current state of sustainability and flexibility implementation and their impact on the US and European OEMs' operational performance. The developed survey was adopted from several studies, such as Chauhan and Singh (2013), Shah and Ward (2007), Slack (2005), and El-Khalil and Darwish (2019). The final version of the survey was shared with senior operational managers at big manufacturing companies and academicians with extensive experience in the industry. The survey was divided into two parts. The first parts consist of demographic questions, such as gender, facility location, job position, level of education, years of experience, company annual sales, number of employees, years of flexibility implementation, and years of sustainability implementation. The second part contains fifteen questions about the level of implementation of the fifteen flexibility tools (Table

2) and sustainability practices (Table 3). Then the participants were asked how the implementation of these practices affected productivity, cost, quality, and delivery. The survey items were based on a seven Likert scale, where 1 is no implementation (0%), and 7 is complete implementation (100%).

(1) No implementation (0-10%);

(2) Very little implementation (Around 15%);

(3) Little implementation (Around 30%);

(4) Some implementation (Around 45%);

(5) Frequent implementation (Around 60%);

(6) Extensive implementation (Around 75%);

(7) Complete implementation (90-100%).

The data gathered using the survey involved conducting interviews with managers from OEMs facilities in Europe and the US. A total of 140 valid response was collected.

Chapter Four

Results

4.1 Respondents Demographics

Table 4: Respondent's demographics and facilities information

Dimensions	EU Facilities	US Facilities
Location	50% (70 managers)	50% (70 managers)
Gender	52% Men 48% Women	58% Men 42% Women
Position	38% Production, 30% Engineering, 32% Other	42% Production, 32% Engineering, 26% Other
Education	50% BS/BA, 40% Masters, 10% Ph.D./DBA	55% BS/BA, 30% Masters, 15% Ph.D./DBA
Years of Experience	17% 5 years or less, 80% 6-15 years, 3% Above 15 years	20% 5 years or less, 75% 6-15 years, 5% Above 15 years
Company size/ Annual Sales	2% small (annual sales less than $100 million), 30% mid-size ($100 - $999 million), 68% large ($1 billion plus)	1% small (annual sales less than $100 million), 28% mid-size ($100 - $999 million), 71% large ($1 billion plus)
Number of Employees	10% 1000 or less, 40% 1001-5000, 50% 5000 and above	0% 1000 or less, 46% 1001-5000, 54% 5000 and above
Flexibility Implementation	100% 10 plus years	100% 10 plus years
Sustainability implementation	15% 5 years or less, 57% 6-10 years, 28% 10 plus years	12% 5 years or less, 55% 6-10 years, 33% 10 plus years

As illustrated in table 4, the managers' location is equally divided between the US and EU facilities, with 50 managers for each. Female workers in the EU (48%) are more than in the US (42%). In both the US and EU facilities, most managers work in the production department, followed by the engineering department. The majority of US (68%) and EU (71%) facilities have annual sales of more than $1 billion. All US and EU facilities have more than ten years of experience in implementing flexibility. As for sustainability implementation, most of the EU (57%) and US (55%) facilities have between 6 and 10 years of experience implementing sustainability.

4.2 Correlation Matrix

Table 5: Correlation Matrix

	FLXOP	FLXTAC	FLXST	SUSECON	SUSSOCI	SUSENVI	Cost	Quality	Delivery	Productivity
FLXOP	1									
FLXTAC	0.923**	1								
FLXST	0.902**	0.887**	1							
SUSECON	0.917**	0.873**	0.905**	1						
SUSSOCI	0.93**	0.897**	0.881**	0.891**	1					
SUSENVI	0.893**	0.9**	0.884**	0.905**	0.912**	1				
Cost	0.893**	0.854**	0.826**	0.854**	0.882**	0.861**	1			
Quality	0.847**	0.838**	0.836**	0.832**	0.854**	0.842**	0.783**	1		
Delivery	0.814**	0.802**	0.794**	0.831**	0.841**	0.838**	0.791**	0.779**	1	
Productivity	0.783**	0.788**	0.74**	0.790**	0.843**	0.846**	0.790**	0.746**	0.75**	1

** significant at the 0.01 level (2-tailed)

Before conducting the exploratory factor analysis, the suitability of data for factor analysis was examined. The results of the correlation matrix revealed coefficients >= 0.7 (Table 5).

As shown in Table 5, operational flexibility (FLXOP) has the highest correlation with social sustainability (SUSSOCI) (0.93), then economic sustainability (SUSECON) (0.917), then environmental sustainability (SUSENVI) (0.893). Also, tactical flexibility (FLXTAC) has the highest correlation with environmental sustainability (0.9), then social sustainability (0.897), then economic sustainability (0.873). Strategic flexibility (FLXST) has the highest correlation with economic sustainability (0.905), then environmental sustainability (0.884), then social sustainability (0.881).

Moreover, operational flexibility has the highest correlation with cost (0.893), then quality (0.847), then delivery (0.814), then productivity (0.783). Tactical flexibility has the highest correlation with cost (0.854), then quality (0.838), then delivery (0.802), then productivity (0.788). Strategic flexibility has the highest correlation with quality (0.836), then cost (0.826), then delivery (0.794), then productivity (0.74).

4.3 KMO and Bartlett's Test

Table 6: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.962
Bartlett's Test of Sphericity	Approx. Chi-Square	2185.301
	df	45
	Sig.	0

As shown in Table 6, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value was 0.962, which is more than the recommended value of 0.6 (Kaiser,1974), and Bartlett's Test of Sphericity (Bartlett, 1954) is 0.000, supporting the correlation matrix factorability.

4.4 Exploratory Factor Analysis

For factor extraction, a principal component analysis was utilized (SPSS). The results show seven factors with eigenvalue >1, explaining the variance (Table 7a->g) (Hair et al., 2014). All loadings were above 0.5; thus, none of the 46 items was removed (Marshall et al., 2007).

Component 1 represents operational flexibility (FLXOP), component 2 represents tactical flexibility (FLXTAC), component 3 represents strategic flexibility (FLXST), component 4 represents economic sustainability (SUSECO), component 5 represents environmental sustainability (SUSENV), component 6 represents social sustainability (SUSSOC), and component 7 represents operational performance metrics (OPM).

Table 7a: FLXOP Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings 1 FLXOP	Extracted communalities h2
FMS1	0.866	0.75
FMS2	0.872	0.76
FMS3	0.859	0.738
FMS4	0.873	0.762
FMS5	0.877	0.769
FMS6	0.804	0.646
FMS7	0.846	0.716
% of variance	73.4	

Table 7b: FLXTAC Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings 2 FLXTAC	Extracted communalities h2
FMS8	0.837	0.701
FMS9	0.858	0.737
FMS10	0.888	0.788
FMS11	0.846	0.716
% of variance	73.5	

Table 7c: FLXST Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings 3 FLXST	Extracted communalities h2
FMS12	0.903	0.815
FMS13	0.91	0.829
FMS14	0.909	0.827
FMS15	0.889	0.791
% of variance	81.5	

Table 7d: SUSECO Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings 4 SUSECO	Extracted communalities h2
SUSECO1	0.838	0.703
SUSECO2	0.84	0.706
SUSECO3	0.863	0.744
SUSECO4	0.831	0.69
SUSECO5	0.794	0.63
SUSECO6	0.788	0.621
SUSECO7	0.797	0.635
SUSECO8	0.683	0.466
SUSECO9	0.842	0.708
SUSECO10	0.849	0.721
% of variance	66.2	

Table 7e: SUSENV Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings	Extracted communalities h2
	5 SUSENV	
SUSENV1	0.818	0.67
SUSENV2	0.867	0.752
SUSENV3	0.79	0.625
SUSENV4	0.852	0.726
SUSENV5	0.829	0.688
SUSENV6	0.868	0.753
SUSENV7	0.845	0.714
% of variance	70.3	

Table 7f: SUSSOC Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings	Extracted communalities h2
	6 SUSSOC	
SUSSOC1	0.816	0.666
SUSSOC2	0.797	0.635
SUSSOC3	0.834	0.695
SUSSOC4	0.797	0.635
SUSSOC5	0.845	0.715
SUSSOC6	0.784	0.615
SUSSOC7	0.842	0.708
SUSSOC8	0.876	0.768
SUSSOC9	0.843	0.71
SUSSOC10	0.857	0.734
SUSSOC11	0.867	0.752
% of variance	69.4	

Table 7g: OPM Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings 7 OPM	Extracted communalities h2
Cost	0.924	0.854
Quality	0.908	0.824
Delivery	0.911	0.83
Productivity	0.901	0.812
% of variance	82.9	

4.5 Psychometric Properties

A test for reliability and validity was conducted using Cronbach's alpha. The results indicate a Cronbach's alpha value of 0.94 for operational flexibility, 0.88 for tactical flexibility, 0.92 for strategic flexibility, 0.943 for economic sustainability, 0.956 for social sustainability, 0.93 for environmental sustainability, as shown in Table 8a,b. All Cronbach's alpha coefficient values are above the required 0.7 (Furr, 2018), which indicates a solid consistency and reliability. The convergent validity was measured using average variance extracted (AVE), composite reliability (CR), and item loading. AVE, CR, and item loading values are above the required value of 0.5, 0.7, and 0.5, respectively (Furr, 2018).

Table 8a: Measurement model result (PLS)

Dimensions	Outer weight	Loadings	AVE	Composite Reliability
FLXOP: Operational Flexibility (Cronbach's Alpha=0.94)			0.735	0.951
FMS1	0.165	0.864		
FMS2	0.168	0.872		
FMS3	0.163	0.858		
FMS4	0.173	0.874		
FMS5	0.169	0.876		
FMS6	0.164	0.807		
FMS7	0.164	0.846		
FLXTAC: Tactical Flexibility (Cronbach's Alpha=0.880)			0.735	0.917
FMS8	0.291	0.839		
FMS9	0.288	0.857		
FMS10	0.294	0.886		
FMS11	0.293	0.848		
FLXST: Strategic Flexibility (Cronbach's Alpha=0.924)			0.815	0.946
FMS12	0.268	0.9		
FMS13	0.296	0.915		
FMS14	0.284	0.911		
FMS15	0.259	0.885		

Table 8b: Measurement model result (PLS)

Dimensions	Outer weight	Loadings	AVE	Composite Reliability
SUSECON: Economic Sustainability (Cronbach's Alpha=0.943)			0.66	0.951
SUSECON1	0.136	0.847		
SUSECON2	0.131	0.848		
SUSECON3	0.137	0.863		
SUSECON4	0.132	0.834		
SUSECON5	0.130	0.787		
SUSECON6	0.113	0.778		
SUSECON7	0.101	0.791		
SUSECON8	0.113	0.680		
SUSECON9	0.091	0.846		
SUSECON10	0.137	0.850		
SUSSOC: Social Sustainability (Cronbach's Alpha=0.956)			0.69	0.961
SUSSOC1	0.105	0.816		
SUSSOC2	0.107	0.855		
SUSSOC3	0.114	0.868		
SUSSOC4	0.104	0.797		
SUSSOC5	0.108	0.833		
SUSSOC6	0.110	0.800		
SUSSOC7	0.115	0.847		
SUSSOC8	0.098	0.781		
SUSSOC9	0.111	0.843		
SUSSOC10	0.115	0.876		
SUSSOC11	0.112	0.842		
SUSENV: Environmental Sustainability (Cronbach's Alpha=0.93)			0.7	0.943
SUSENV1	0.160	0.815		
SUSENV2	0.173	0.867		
SUSENV3	0.156	0.789		
SUSENV4	0.177	0.854		
SUSENV5	0.167	0.830		
SUSENV6	0.192	0.873		
SUSENV7	0.167	0.843		

4.6 Discriminant Validity

The discriminated validity is used to check how many constructs differ from each other in the same measurement model. And this is done by comparing the square root of the average variance explained (AVE) in the diagonal with the correlations among the reflective construct (Fornell and Larcker, 1981). Table 9 shows that all constructs are related to their items compared to other items. Therefore, the model is valid, reliable, and satisfies the discriminant validity recommendations.

Table 9: Correlation between the latent variables

	Flexibility	Sustainability	Operational Performance Metrics
Flexibility	0.97		
Sustainability	0.96	0.97	
Operational Performance Metrics	0.93	0.96	0.97

4.7 Inner Model Analysis

Both the goodness of fit (GoF) and R^2 are examined in the structural model analysis. The R^2 for operational performance is 0.917, which indicates that the proposed construct explains 91% of the operational performance variance. Sustainability practices R^2 is 0.921. The structural model for the GoF is 0.92, which is suitable for evaluating path significance (Furr, 2018).

4.8 Hypotheses Testing

Testing the hypotheses results was done using path coefficient, p-value, and t-statistics, all illustrated in tables 10,11, 12, and 13. H1a,b,c, H2a,b,c, and H3a,b,c are all supported at significance level of 0.01. As for the mediation (H4), a Sobel test was conducted. And it was also significant at the 0.01 level (Table 13).

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Table 10: Testing hypotheses 1a,b,c

Hypothesis	Path	Direct Effect	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Result
1a	FLXOP -> Cost	0.893	0.894	0.017	53.485	0.00	Supported
	FLXOP -> Delivery	0.814	0.812	0.038	21.646	0.00	
	FLXOP -> Productivity	0.783	0.781	0.035	22.652	0.00	
	FLXOP -> Quality	0.847	0.844	0.033	25.377	0.00	
1b	FLXTAC -> Cost	0.854	0.855	0.02	41.81	0.00	Supported
	FLXTAC -> Delivery	0.802	0.803	0.032	25.13	0.00	
	FLXTAC -> Productivity	0.788	0.787	0.037	21.18	0.00	
	FLXTAC -> Quality	0.838	0.837	0.026	32.177	0.00	
1c	FLXST -> Cost	0.826	0.826	0.032	25.981	0.00	Supported
	FLXST -> Delivery	0.794	0.794	0.037	21.6	0.00	
	FLXST -> Productivity	0.74	0.741	0.041	18.206	0.00	
	FLXST -> Quality	0.836	0.834	0.03	28.157	0.00	

Table 11: Testing hypotheses 2a,b,c

Hypothesis	Path	Direct Effect	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Result
2a	SUSECO -> Cost	0.854	0.852	0.026	32.57	0.00	Supported
	SUSECO -> Delivery	0.831	0.829	0.026	31.947	0.00	
	SUSECO -> Productivity	0.79	0.788	0.031	25.703	0.00	
	SUSECO -> Quality	0.832	0.83	0.03	27.879	0.00	
2b	SUSENV -> Cost	0.861	0.861	0.022	38.916	0.00	Supported
	SUSENV -> Delivery	0.838	0.837	0.029	28.46	0.00	
	SUSENV -> Productivity	0.846	0.847	0.021	39.869	0.00	
	SUSENV -> Quality	0.842	0.842	0.028	29.681	0.00	
2c	SUSSOC -> Cost	0.882	0.883	0.019	47.259	0.00	Supported
	SUSSOC -> Delivery	0.841	0.838	0.027	30.835	0.00	
	SUSSOC -> Productivity	0.843	0.843	0.025	33.196	0.00	
	SUSSOC -> Quality	0.854	0.852	0.028	30.688	0.00	

Table 12: Testing hypotheses 3a,b,c

Hypothesis	Path	Direct Effect	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Result
3a	FLXOP -> SUSECO	0.917	0.917	0.015	63.176	0	Supported
	FLXOP -> SUSENV	0.893	0.891	0.018	50.144	0	
	FLXOP -> SUSSOC	0.93	0.929	0.013	72.813	0	
3b	FLXTAC -> SUSECO	0.873	0.872	0.02	42.87	0	Supported
	FLXTAC -> SUSENV	0.897	0.895	0.017	51.505	0	
	FLXTAC -> SUSSOC	0.9	0.898	0.019	48.126	0	
3c	FLXST -> SUSECO	0.905	0.904	0.017	52.908	0	Supported
	FLXST -> SUSENV	0.884	0.884	0.02	44.842	0	
	FLXST -> SUSSOC	0.881	0.881	0.02	43.144	0	

Table 13: Testing hypotheses 4

Direct Effect Without Mediation Variable			With mediation variable					Sobel Test Statistics	Decision
Path	Effect	P Values	Path	Effect	Std. Error	T Statistics	P Values	10.2 (p value = 0.0**)	Supported
FLX -> OPM	0.93	0.0**	FLX -> OPM	0.132	0.084	1.583	0.114		
			FLX -> SUS	0.96	0.008	113.138	0.0**		
			SUS -> OPM	0.83	0.081	10.182	0.0**		
**** significant at the 0.01 level (2-tailed)**									

Chapter Five

Discussion

5.1 The effect of flexibility on operational performance metrics

The results of this study indicate that all flexibility types have a significant positive impact on all performance metrics. Therefore, the higher the level of flexibility implementation, the greater the improvements in operational performance metrics. Thus, H1a,b,c is supported. Operational flexibility has the highest impact on cost (0.893), then quality (0.847), then delivery (0.814), then productivity (0.783). Tactical flexibility has the highest effect on cost (0.854), then quality (0.838), then delivery (0.802), then productivity (0.788). As for strategic flexibility, the highest impact is on quality (0.836), then cost (0.826), then delivery (0.794), then productivity (0.74). The results also reveal that operational flexibility has the highest impact on all performance metrics, followed by tactical flexibility and strategic flexibility. The results are in line with previous studies that stated that flexibility has the highest impact on cost and quality (Narsalay et al., 2016; El-Khalil and Darwish, 2019, Oke, 2013; Wei et al., 2017). This significant improvement in operational performance is due to the advanced level of flexibility implementation. As shown in Table 4, all OEMs implement flexibility practices in their manufacturing process, and all of them have more than ten years of implementing flexibility. Manufacturing facilities know that they should be flexible to navigate today's challenges. And since today customer's preferences are continuously changing, flexibility practices can offer managers the solution.

5.2 The effect of sustainability on operational performance metrics

The results indicated that the effect of all sustainability dimensions on all performance metrics was positive and significant. Thus, H2a,b,c is supported. The results support previous work done by El-Khalil and Mezher (2020), Lin et al. (2006), Esfahbodi et al. (2017), and Geyi et al. (2020), in which all of them prove that sustainability practices lead to improvement in operational performance metrics. The higher the sustainability practices implementation, the more significant the improvement in operational performance metrics. Economic sustainability has the highest impact on cost (0.854), then quality (0.832), then delivery (0.831), then productivity (0.790). Social sustainability has the highest effect on cost (0.882), then quality (0.854), then productivity (0.843), then delivery (0.841). Environmental sustainability has the highest impact on cost (0.861), then productivity (0.846), then quality (0.842), then delivery (0.838). Most of the sustainability dimensions have the highest correlation with cost and quality. This is because sustainability practices focus on reducing waste and enhancing the quality of products and services, leading to reduced cost and better quality. Some scholars argue that sustainability practices do not enhance performance. However, research has shown that sustainability practices enhance performance in the long term. And that is why some practitioners resist implementing sustainability practice because they expect to see results immediately.

5.3 The effect of flexibility on sustainability

The results of the study indicate that all flexibility types have a significant positive impact on all sustainability dimensions. Therefore, the higher the level of flexibility implementation, the greater the improvements in sustainability. Thus, H3a,b,c is supported. Operational flexibility has the highest impact on social sustainability (0.93), then economic sustainability (0.917), then environmental sustainability (0.893). Tactical flexibility has the highest effect on social sustainability (0.9), then environmental sustainability (0.897), then economic sustainability (0.873). Strategic flexibility has the highest impact on economic sustainability (0.905), then environmental sustainability (0.884), then social sustainability (0.881). This is the first study that shows that each flexibility type has a high impact on a different sustainability dimension. For example, for the best social performance, operational flexibility should be focused on. For the best environmental performance, tactical flexibility should be focused on. And for the best economic performance, strategic/operational flexibility should be focused on.

5.4 The mediating role of sustainability

This study confirms the mediation of sustainability practices in the relationship between flexibility and operational performance metrics. Thus, H4 is supported. Most of the previous studies focused on studying the direct relationship between flexibility and operational performance. This is the first study that examines the developed model in the US and Europe OEMs. The Sobel test was used to test the mediation, and it resulted in a value of 10.2 and a p-value of 0.0. Therefore, mediation exists and is significant at the 0.01 level. However, the mediation is complete mediation since the p-value from the direct relationship from flexibility to operational performance metrics is 0.114, as illustrated in table 13. So, without the mediator, the relationship between flexibility and operational performance metrics is not significant. Some scholars like El-Khalil and Mezher (2020) and Geyi et al. (2019) discussed some of the drawbacks of sustainability practices, such as the cost it might incur and the inability to observe the results in the short term. While sharing these discussions with experts from the field, they indicated few reasons why sustainability might not enhance performance, such as:

- No collaboration between different departments within the organization.
- Stakeholders are not involved in the decision-making.
- No alignment between sustainability and flexibility objectives.
- Lack of training sessions for the employees.
- Most managers focus on achieving results in the short term, while sustainability is a long-term goal.
- Lack of commitment.
- The continuously changing market environment makes managers only think for the short term.

5.5 Theoretical Implications

This is the first study that links the contingency theory with the resource-based view theory within this context. Under the contingency theory, the results showed how sustainability plays a significant role in the relationship between manufacturing flexibility and operational performance. Also, under the resource-based view theory, the results revealed that by applying the right flexibility and sustainability practices, better operational performance can be achieved.

Manufacturing firms around the world are shifting towards integrating sustainable practices within their manufacturing process. By adopting innovative practices, such as flexibility and sustainability, organizations will be able to compete in the market. When adopting such practices, organizations are not only benefiting themselves. They are also benefitting all stakeholders, including the surrounding community. For example, adopting flexibility and sustainability practices will not only enhance quality, productivity, or quality, but it will also benefit the community, employees, and customers while reducing the impact on the environment.

This study enhances our understanding of the interactions between flexibility, sustainability, and their impact on operational performance metrics in the US and European OEMs. The findings in this paper prove that flexibility has a significant positive impact on operational performance and sustainability. This study contributes to the literature by providing empirical evidence on the effect of flexibility on operational performance and sustainability. This is the first study that investigates this relationship in this depth and breadth. Also, it shows that sustainability plays a significant role in supporting the impact of flexibility on operational performance.

5.6 Managerial Implications

This study provides an insight into the role of flexibility in enhancing operational performance metrics through sustainability practices. Increased competition, scarcity of resources, globalization, and market uncertainties will necessitate firms to implement sustainable practices. The TBL dimensions will improve the competitive stance of the organization, leading to improved performance. Sustainability and flexibility practices must be implemented simultaneously to exploit their benefits and improve performance. Managers can use the developed model to know what flexibility and sustainability practices optimize operational performance. And managers should refrain from implementing certain practices if they intend to improve a specific performance metric. Also, organizations should prioritize flexibility types by their importance and plan when to implement each type.

Chapter Six

Conclusion

The results presented in the study enhanced our understanding of flexibility and sustainability practices used by the European and US OEMs. We provided empirical evidence that flexibility has a significant and positive impact on sustainability and operational performance. Sustainability has a significant and positive impact on operational performance, and sustainability mediates the relationship between flexibility and operational performance. The results also showed that higher implementation of flexibility and sustainability practices would lead to better operational performance metrics. Sustainability is necessary to maximize the impact of flexibility on operational performance metrics. The study also provides managers with the ability to know which flexibility type enhances which sustainability practices and operational performance metrics.

In this paper, the performance metrics were limited to four. Thus, future studies should include more metrics, such as morale and sales. Additionally, future research should include more variables in their study, such as Industry 4.0, lean tools, supply chain, among others. Another limitation is that the study was conducted in European and US OEMs. Therefore, the results might not be accurate in other countries/regions. Further research can replicate and extend the study in other countries and with bigger samples.

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