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The mediating impact of sustainability on the relationship between agility and operational performance

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The mediating impact of sustainability on the relationship between agility and operational performance



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ABSTRACT

Keywords: Agility Manufacturing industry Sustainability Operations performance metrics Agility and sustainability are two philosophies that the North American manufacturing industry invested heavily in, since the beginning of the twenty-first century. The impact of the two philosophies go beyond operations and extend to innovation, employees, communities, and customer. This paper identified the lack of empirical research investigating the relationship between agility and sustainability as well as their combined interactions with operational performance metrics. Very few researchers investigated this relationship with limited depth and breadth. Therefore, this paper investigated the interaction between sustainability, agility, and their influence/ impact on operational performance in the United States (US) automotive manufacturing Industry. Based on the literature review conducted and after consulting several particulars from the US automotive manufacturing industry a survey was developed, this survey reflects a comprehensive list of agility practices, sustainability practices, and top-five performance metrics utilized by the US automotive industry. A survey was carried out with a total of 212 respondents. Respondents are all top managers at 152 manufacturing facilities including assembly/manufacturing, Powertrain, and component plants. We established a comprehensive list that includes seven agility categories with 52 factors and identified the top five performance metrics. The results identify a significant and positive relationship between agility and sustainability, agility and operational performance, and sustainability and operational performance. The result shows a significant correlation between agility practices and sustainability. An agility performance index was determined by combining the analytic hierarchy process and partial least square. Utilizing the partial least square method, sustainability was identified as a mediator on the relationship between Agility and operational performance.

1. Introduction

The Environmental Protection Agency (EPA) [25], in its report in 2019, stressed the issue of the importance of implementing Agility and Sustainability to achieve competitiveness. Their report pertained to several benefits such as lower resource costs, improved sales and brand recognition, lower regulatory compliance costs, flexible employee retention and hiring, and greater access to financial resources. Manufacturing is a significant contributor to the United States economy. According to the Bureau of Economic Analysis report in 2019 [84], the manufacturing industry consisted of \$2.33 trillion out of the 2018 GDP, and it contributed 11.6% in the U.S economic output. In the 2019 World Bank report [97], the United States GDP in 2018 was ranked the second with \$20.54 trillion. The U.S manufacturing industry alone is ranked 13th worldwide, with \$2.33 trillion [85], which indicates the manufacturing power of the U.S and its influence on the world economy.

In the past few decades, brisk industrialization has severely affected the environment. The increasing concern for the environment by various international organizations, specifically on the impact of "Climate Change," has led many governments, businesses, and organizations to focus on reducing the unsustainable behaviors in the manufacturing process.

The increasing competition among organizations, in addition to the increasing market dynamism and product complexity, has led organizations to change their strategies. Customer satisfaction became a priority for every organization, thus, delivery speed became as important as cost and quality. Customization started to appear as the market became more and more complex. To adapt to these changes, organizations were urged to become more agile and flexible. These changes in the market have led to the development of a new manufacturing concept known as "Agile Manufacturing." Agile manufacturing (AM) enables organizations to respond quickly to dynamic market demands [91]. Agile

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Received 29 June 2020; Received in revised form 28 October 2020; Accepted 21 November 2020 Available online 27 November 2020 2214-7160/© 2020 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-ad/4.0/). practices entail applying market knowledge to utilize profitable opportunities from the dynamic and volatile market [63]. Agile manufacturing plays an important role in improving customer service, efficiency, profit, and effectiveness of manufacturing industries [40]. In the past few years, AM has been receiving increased attention from practitioners and scholars. Some researchers consider that adopting AM practices is a crucial decision that organizations should take to survive in a competitive market [76,99].

On the other hand, manufacturing companies consider sustainability an essential model for survival in an intense and competitive market [59]. The concept of sustainability has been utilized in many areas, especially in the manufacturing and business sectors [32]. Dyllick and Hockerts [22], interpreted sustainability in a "corporate" perspective, they defined it as the ability to meet the needs of an organization's indirect and direct stakeholders without compromising its ability to meet the needs of the future stakeholders. According to the Brundtland Report, sustainability is the ability to accommodate []the demand of the current generation without compromising the ability of the next generations to meet their demands and needs [94]. While Vinodh [90] defined sustainability as the ability to minimize the impact on the environment while increasing the rate of recycled materials. Several benefits can derive from the integration of Agility and Sustainability, such as increased product differentiation and variety with reduced environmental impact, higher chances of surviving the competitive market, and cost-effectiveness.

Several studies have examined sustainability and agility practices (Blome et al., 2013). To identify the problem systematically, two relevant sources were identified. First, senior-level managers in big automotive organizations in North America were consulted; the managers have a minimum of 15 years of experience in implementing agile and lean manufacturing practices, and they are considered pioneers in the field. The managers emphasized the absence of a clear and comprehensive agility list. The available lists in previous literature are based on the authors' point of view only or limited to a specific industry (i.e. small size or medium companies), the practitioners' perspective was not examined.

Second, after an extensive review of the literature, which includes reputable and high impact factor journals, none of the previous studies have examined sustainability and agility at the same depth and breadth presented in this research. However, relevant reports and studies were very crucial for our study. Accordingly, our study aims to investigate the mediating impact of sustainability on the relationship between agility and operational performance.

Therefore, the following hypotheses are derived:

H1: Agile practices have a positive effect on operational performance.

H2: Agile practices have a positive effect on sustainability.

H3: Sustainability has a positive effect on operational performance. H4: Sustainability mediates the relationship between agility and operational performance.

2. Literature review and hypothesis development

2.1. Manufacturing agility performance

The significant change in customer demands, technology, and market demands has led to a substantial modification in the industrial environment [40,41,89,43,48]. Accordingly, competition has been intensified and many organizations have begun to reassemble their distinctive capabilities and develop various practices and tools to survive and enhance their competitiveness. The adoption of these tools and practices has been weighed by the practitioners and academic society to develop a new manufacturing concept based on agility and known as "Agile Manufacturing" [89].

Agile manufacturing is an original management/manufacturing model that has arisen from the adjustments and developments of the environment [49,75,92]. A variety of views on Agile Manufacturing is present in the literature, regarding the firm itself, its environment, products, workforce, and resources [42].

Uncertainty is still present regarding the concept of Agile Manufacturing. Despite the considerable interest demonstrated by scholars, there is a lack of agreement amongst researchers regarding the official definition of agility [53,54]. This is due to the fact that the model of agility originates from other approaches such as lean manufacturing [23,95], flexible manufacturing [8], fast-cycle innovation [82], and time-based competition [80]. Some agile definitions are based on implementation or operation (i.e. proactivity, technology, integration, market orientation, etc.). Others are expressed in terms of outcomes (i.e. speed, flexibility, responsiveness, innovation, dynamism, etc.). While others try to combine both operation/implementation and outcomes.

According to Adeleye and Yusef [1], the main objective of agile manufacturing is to merge lean manufacturing efficiency with operational flexibility. Consequently, agile manufacturers are viewed as flexible manufacturers that can deliver high-level value products at a minimal cost, with improved service and faster delivery periods [50].

Agile manufacturing is considered by several authors as a descendant of existing manufacturing models, such as flexibility and lean management, or a revised version of them [77,87].

According to Yusuf et al. [104], agile manufacturing is not completely different from previous production models. However, few variances can be recognized in previous literature between agile and lean manufacturing. Agile manufacturing is based on producing highly customized products when needed, while lean manufacturing is viewed as a revised model of mass production (Sheridan, 1993). In terms of market conditions, agile manufacturing is more effective in unstable situations due to its strategic and operational responsiveness, while lean manufacturing is more appropriate in stable market conditions. Efficiency and productivity are given more weight than responsiveness in lean manufacturing, while agile manufacturing gives the same weight for both. Thus, various researchers considered agile manufacturing as a solution to the limitations of lean manufacturing [101].

In agile manufacturing, the integration of management, workforce, and technology into a harmonized and collective system results in a more flexible approach towards inter-company collaboration. Moreover, it contributes to the development of the employees and management creative and critical thinking skills, which result in an innovative, competitive, and adaptable organization [36,62]. Agile manufacturing has a high potential for enhancing market share, minimizing production costs, satisfying customer needs, and enhancing competitiveness [40, 41].

Therefore, agile manufacturing is considered as a new form of industrial competition. Goldman et al. [37] divided agile manufacturing into four dimensions, the first dimension is enhancing competitiveness through collaboration, and it incorporates inter- and intra-organizational collaboration. The second dimension is to acknowledge the significance of the employees in the organization by developing their teamwork, training, and educational skills. The third dimension is enhancing the customer's experience by quickly understanding and meeting their needs. The fourth dimension consists of deploying innovative managerial and organizational technology and structures to eliminate uncertainties.

Firms must have a set of enablers to agile. Agile enablers are a set of competencies that permit organizations to instantly react to a dynamic business environment [9]. Several authors such as Conforto et al. [19] analyzed a set of agility enablers including and not limited to "Knowledge management, organization learning, leadership commitment, multidisciplinary teams, organizational culture, decentralized decision making, customer and stakeholder involvement". Vinodh et al. [91] classified the agility enablers into two groups "Technology" and "Management". Technology enablers include rapid prototyping, reverse engineering, virtual enterprise, computer-aided design, and production and integration of information. While the management enablers consist of total product management (TPM), lean approach, and supply network management. Gunasekaran [39,40,41], Gunasekaran and Yusuf [42], and Jin-Hai et al. [51] classified agility enablers into competency, material handling, and delivery, responsiveness, concurrent engineering and among others.

Based on previous literature and practitioners' point of view, agility enablers (As shown in Table 1) can be grouped as follows. The first enabler is process management/planning, and it incorporates developing a plan that can guide daily decisions. The second enabler is the workplace & team, and it is the ability to perform collaborative work to achieve a common goal. The third enabler is quality, and it is the ability to conform to specific specifications to maintain customers' satisfaction. The fourth enabler is technology, and it includes the utilization of various technologies (i.e. CNC, CAPP, CAM) to increase production efficiency. The fifth enabler is material handling & delivery, and it is the process of movement, storage, control, and protection of materials throughout the manufacturing process. The sixth enabler is competency/efficiency, and it entails the efficient and effective use of the organization's capabilities to achieve a certain goal. The seventh and final enabler is responsiveness, and it is the ability to respond quickly to market changes and customer demands.

Several studies have been conducted to study the relationship between agile manufacturing and operational performance. Vazquez-Bustelo et al. [89] showed that implementing agile manufacturing tools in turbulent environments increase competitiveness strength, and thus leads to better market, financial, and operational performance. A study conducted by the Strategic Direction in (2019) indicated that organizational agility helps to react better to unforeseen market changes. Geyi et al. [35] examined the relationship between sustainable practices, agile practices, sustainable supply chain practices, and operational performance. The results of their study showed that to maximize the outcomes of the execution of sustainability practices, agile capabilities must be present and implemented. We thus hypothesize that:

H1: Agile practices have a positive effect on operational performance.

H2: Agile practices have a positive effect on sustainability.

2.2. Sustainability performance

An increasing number of scholars have studied the sustainability levels of manufacturing industries while taking into consideration the Triple Bottom Line "TBL" integration. The significance of the balance among social, environmental, and economic dimensions in a company, have been highlighted by Govindan et al. [3]. Based on the integration between TBL dimensions and value stream mapping (VSM) in manufacturing, a sustainability evaluation model for manufacturing systems was developed by Faulkner and Badurdeen [28] and Helleno et al. [46]. These studies stressed the significance of utilizing the triple bottom line (TBL) dimensions to assess the manufacturing system performance. Moreover, the Dow Jones Sustainability Index (DJSI) and the Global Reporting Initiative (GRI), have been developed based on the TBL dimensions, as a benchmark for evaluating the levels of sustainability in manufacturing systems ([21]; GRI, 2016).

Organization performance metrics are crucial for firms to evaluate

Reference

Table 1.

Latent Variable/	Indicators/Manifest
construct	variables
Agility	

Constructs and their indicators, sources.

P1: The ability to develop a plan that can guide daily decisions and evaluate the progress of business based on a set of measurable goals and responding to changes speedily.	Gunasekaran [39], Gunasekaran and Yusuf [42] Gehani [33], Sahin [73], Sharifi and Zhang (1998), Zhang and Sharifi (2000), Goldman and Nagel [36], Fliedner and Vokurka (1997), Katayama and Bennett (1999), Yusuf et al. [104], Kakeh Baraei et al. (2018), Parkinson (1999) and Maskell (2001)
P2: The ability to design a map diagram that	
emphasizes the organization objectives in a way that all employees can visualize and track how their jobs can affect the overall objective of a business in a timely	
manner.	
P3: The ability to have an organizational structure that promotes innovation, training and education. P4: The ability to gain union (
management buy-in	
planning. P5: The ability to allocate/	
determine/accomplish cost goals and objectives. P6: The ability to involve early different agents in the	
product development process and concurrent execution of functions/activities. P7: The ability to form	
strategic alliances based on core/complementary	
competencies. W1: The ability to implement easy flowing of information between departments and employees. Improving communication between all levels of organization to enhance the adaptation to changes in business plan.	Sharp et al. [77], Sharifi and Zhang (1998)[75,76], Zhang and Sharifi (2000), Gehani [33], Sheridan [78], Gunasekaran [39, 40], Gunasekaran and Yusuf [42], Forsythe (1997), Yusuf et al. [104], Sahin [73], Meredith and Francis (2000), Goldman and Nagel [36], Fliedner and Vokurka (1997), and Sindhwani et al. (2019)
 W2: The ability to relocate employees quickly to respond to any changes in demand. W3: The ability to enhance employees belonging (morale) and gain their trust which can positively affect their productivity. W4: The ability to guide employee decisions through acquired knowledge where 	
	 plan that can guide daily decisions and evaluate the progress of business based on a set of measurable goals and responding to changes speedily. P2: The ability to design a map diagram that emphasizes the organization objectives in a way that all employees can visualize and track how their jobs can affect the overall objective of a business in a timely manner. P3: The ability to have an organizational structure that promotes innovation, training and education. P4: The ability to gain union/management buy-in regarding new processes and planning. P5: The ability to allocate/determine/accomplish cost goals and objectives. P6: The ability to involve early different agents in the product development process and concurrent execution of functions/activities. P7: The ability to form strategic alliances based on core/complementary competencies. W1: The ability to implement easy flowing of information between all levels of organization to enhance the adaptation to changes in business plan. W2: The ability to relocate employees lungrowing (morale) and gain their trust which can positively affect their productivity. W4: The ability to relocate employee belonging (morale) and gain their trust which can positively affect their productivity.

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Table 1. (continued)			Table 1. (continued)		
Latent Variable/ construct	Indicators/Manifest variables	Reference	Latent Variable/ construct	Indicators/Manifest variables	Reference
	W5: The ability to have a range of tasks that an operator can perform within the manufacturing system. W6: The ability to perform collaborative effort to achieve a common goal within groups/teams. W7: The ability to form a cross-functional products development teams.		Material Handling/ Delivery (MHAG)	physical part or assembly using three-dimensional computer aided design data (Rapid prototyping). M1: The ability to keep track and control of inventory and material processing so it is found easily whenever needed. M2: The ability to protect.	Gunasekaran [1998] [40], Gunasekaran and Yusuf [42], Venugopal and Saleeshya (2019), Fliedner and Vokurka (1997) and Yao and Carlson (2003)
Quality (QUAG)	 Q1: The ability to implement autonomation. Q2: The ability to monitor and control quality by tracking production metrics (i.e. SPC). Q3: The ability to implement Lean and Six Sigma. Q4: The ability to improve product quality by eliminating downtime, defects, and accidents (TPM) Q5: The ability to eliminate problems at their source (Kaizen). Q6: The ability to implement lean production system (7 wastes, standardization, 5s.). 	Gunasekaran [[40], 1998] and Gunasekaran and Yusuf [42]	Competency/ Efficiency (CEAG)	 The ability to protect, transport, and control the materials throughout the whole supply chain process. M3: The ability to arrange, control, and optimize work and workloads in the production process. M4: The ability to optimize the flow of equipment with real-time data. M5: The ability to project/ forecast your raw material requirements. M6: The ability to implement automated guided vehicle systems (AGVs); automated storage and retrieval systems (AS/RS). C1: The ability to implement a systematic determination 	Gunasekaran [1998] [40], Gunasekaran and Yusuf
Technologies (TCAG)	 Q7: The ability to implement TQM. T1: The ability to use technologies/automation to perform different operations (i.e. robots, CNC machines, and pulse tools). T2: The ability to control maintenance of equipment and machines during manufacturing process (Visual inspection). T3: The ability to use computers in process planning as a way to decrease time responsiveness to changes during planning (CAPP). T4: The ability to combine all functions and information and design all departments processes across the organization in one system as a way to improve the workflow efficiency while responding to customized products manufacturing (ERP). T5: The ability to use software and computer-controlled machinery to automate a manufacturing process (Computer aided manufacturing). T7: The ability to a system to run virtually unattended for a long enough period. 	Gunasekaran [1998][40], Gunasekaran and Yusuf [42] Group technology Gunasekaran [39,40], Gunasekaran and Yusuf [42] and Yao and Carlson (2003)	Responsiveness (REAG)	 and documentation of work element sequence and process for each operation. C2: The ability/ease to increase the number of new products introduced/added/ substituted each year to cope with competition. C3: The ability to develop a strategy that can precisely adhere to customers needs with less time and waste while introducing new products. C4: The ability to equally divide the tasks among all the portions of production line to decrease bottleneck. C5: The ability of the system to switch operations without incurring a major setup/ effort. C6: The ability to produce produce different part types without incurring a major setup. C7: The ability to operate profitably at different dimensions and shapes (new design). C8: The ability to produce a wide range of part types utilizing a flexible production system R1: The ability to benefit from historical data to project future market sales and improve business decisions. 	Gunasekaran [1998] [40], Cho et al. (1996), Gunasekaran and Yusuf [42], Jin-Hai et al. [51], Goldman and Nagel [36],

Table 1. (continued)

able 1. (continued)			Table 1. (continued)				
Latent Variable/ construct	Indicators/Manifest variables	Reference	Latent Variable/ construct	Indicators/Manifest variables	Reference		
Sustainability "Sustainability Group/ Category/type"	 R2: The ability of the manufacturing system to adapt to changing market environment. R3: The ability to design a recovery plan after a change that affect the process and then implementing it by the IT team to make things better and more efficient. R4: The ability to produce parts in multiple ways with multiple process plans. R5: The ability of the system to increase its capacity and capability when needed. R6: The ability to utilize alternative routs in order to produce a part. R7: The ability to quickly identify changes in market demand. R8: The ability to create an efficient supplier relationship that is able to respond efficiently and effectively to changes. 		Operational Performance Metrics (PerfMetrics)	SSO2: Work in the firm is safe SSO3: Improvement in employee health and safety SSO4: Improvement in work environment SSO5: Improve the living quality of surrounding community SSO6: The firm takes social welfare initiatives SSO7: The firm complies with laws and standards SSO8: The firm highly respects human rights SSO9: The firm has good working conditions SSO10: The firm treats suppliers fairly SSO11: The firm treats suppliers fairly SSO11: The firm ensures product safety Quality: Improvement in Quality (OM1). Productivity: Improvement in employee Morale (OM3) Delivery: Improvement in product Delivery (OM4).	[102,106]; Ren et al., 2003; Blome et al., 2013; Eckstein et al. (2015)		
Economic Performance (EcoS)	SEC1:Improved market share	[102,103]; Golicic and Smith (2013); Paulraj et al. [67]		Cost: Improvement in overall Cost (OM5).			
	SEC2: Improved company image. SEC3: Improved company's image in market place		their performance [100]. Beske-Jans	e against defined objectives a sen et al. [5] stated that an	and detect discrepancies y performance measure		

ment system must have the ability to create a baseline. Neely et al. [64] defined the "performance measurement system" as the set of metrics/indicators used to measure/assess both the effectiveness and efficiency of activities. Hence, the current performance measurement system must focus on three sustainability dimensions [66]. Environmental, financial, economic, and social performance has

been the main variables of previous studies. Several authors such as Zhu and Sarkis [105], Vachon and Klassen [86], and Esfahbodi et al. [26] examined the economic and financial effects of sustainability on the company's performance metrics. Their study indicated that implementing sustainable practices positively impacts firms' performance. The impact of Green Supply Chain Management "GSCM" on operations, economic, social, and environmental performance in the emerging economies were examined by Geng et al. [34]. In their results, they found out that GSCM is positively correlated to social, economic, financial, and environmental performance. Similar results related to GSCM were reported by Stefanelli et al. [81], Vanalle et al. [88], and Youn et al. [98]. Chin and Tat [14], Lu et al. [58], and Mani et al. [60] identified dishonesty, safety, human rights, and insufficient wages as social issues related to manufacturing industries in emerging economies such as India, China, and Malaysia.

Many studies have highlighted the significance of social sustainability [93]. Chen et al. [13] categorized social performance into two groups, "Social capital" and "Human capital". Social capital is the ability to appreciate the interests of the societies in which the capitals/resources are based, enhancing the quality of individuals' lives without harming the environment and not vandalizing the resources confined in it [15]. On the other hand, human capital consists of the integrity and equity in the working conditions, workers inclusions and diversity, enhanced safety and health of employees, stable development of employees skills, and the worker commitment level ([12]; Porter and Kramer, 2006).

Social Performance (SocS)

relations with the community and stakeholders

standards

SEC4: Increase profitability.

SEC5: Decreasing in material

SEC7: Decrease in waste

SEC8: Decrease in waste discharge fees.

environmental accident

SEC10: Improved product

SEN1: Reduce CO2 emissions

purchasing cost. SEC6: Decrease in utility

treatment fees.

SEC9: Reduction of

SEN2: Reduction of

SEN3:Reduction of solid

SEN4: Reduction of energy

SEN6: Decrease in material

SEN7: Improved compliance

SSO1: The firm has very good

bills

cases.

ouality.

wastewater

consumption

substances

usage

SEN5: Decrease in

production of toxic, hazardous, or harmful

with environmental

wastes

Paulraj et al. [67]; Jennings (2013); Krause et al. (2009). Chin et al. [15]; Sarkis et al. (2010); Klassen and Vereecke (2012)

[27,67,96,106]; Blome

et al. [7]



Fig. 1.. Conceptual framework and hypotheses.

The economic performance concentrates on reaching increased sales and profitability. Several studies demonstrated a positive correlation between increased sales and "sustainability" [74]. For instance, economic performance such as ROA, growth in market share, and profit as a ratio of sales is improved due to sustainable practices [67]. This can be attained by efficiently utilizing the resources, where products consume a reduced amount of energy and materials.

As for environmental sustainability performance, it focuses on minimizing the utilization of natural resources such as atmosphere, energy, materials, and water [67]. Moreover, it is essential to take into consideration the impact of economic and human activities on the origin of resources throughout the entire process [106]. This was referred to as the "protection of scarce resources" to gratify people's needs [103]. Environmental performance has a variety of indicators such as reduced CO2 emissions, reduction of wastewater, reduction of solid wastes, reduction of energy consumption, decrease in the production of toxic and hazardous substances, decrease in material usage, and improved compliance with the environment [7,96]. In light of the above, the following hypotheses are thus proposed:

H3: Sustainability has a positive effect on operational performance. H4: Sustainability mediates the relationship between agility and operational performance.

2.3. Operational Performance Metrics

Firm operational performance objectives rely heavily on the method it chooses to compete in the industry/market and on the conditions of markets it seeks [69]. Numerous authors such as Sahin [73], Gehani [33], and Gunasekaran [39–41] stated several operational metrics to measure the firm's performance. One of the metrics is cost. Some of the cost metrics include material, startup, equipment, labor, and material. The company's cost position might indicate its pricing and sales volume [45]. For example, a low-cost position enables the firm to implement a competitive pricing policy and large sales volume. In that case, for a better value of money, the firm stabilizes a low cost of services and products. For a better competitive edge, organizations must compete in dimensions other than cost. Quality, for instance, is a good indicator of the firms' performance. Quality can be measured through statistical process control (SPC), total productive maintenance (TPM), lean production system (i.e. 7s, 5 wastes, standardization), lean six sigma, kaizen, and autonomation. There are two types of quality: process quality, and service/product quality. Process quality is the ability of the organization to conform to the defined set of criteria and standards [43]. While service/product quality is the ability to meet the customers' needs and demands, continuously improving the product, and thus enhance customers' satisfaction [43]. Fast product/service delivery might give the company a competitive advantage [102]. Customers tend to lose trust if the company fails to deliver on time. Faster delivery means less inventory, waste reduction, therefore reduced operational cost [38]. And it can be measured through lead time, cycle time, queues, work in process (WIP), throughput, and blockers. Thus, delivery is a significant performance indicator. In the current fast-paced environment, organizations must be able to change processes or products quickly [39]. Innovation and productivity must always be improved to order to survive in the market. Organizations must introduce new products, services, and processes consistently to attract and retain customers [44]. Productivity is measured through sales growth [79], overall labor effectiveness [70], downtime [70], labor utilization [79], and employee turnover rate [6]. Hence, innovation and productivity is a vital indicator of the organization's performance. Another measure of organizational performance is the employee's morale. Higher employee morale leads to better overall productivity and performance [4], and vice versa. Organizations must treat employee's morale as a critical indicator. According to Baehr and Renck [4], employee morale can be measured through commitment, loyalty, citizenship, motivation, empowerment, and absenteeism.

3. Conceptual model and research methodology

3.1. Conceptual model

Following the work of Gunasekaran [39,40,41], Vazquez-Bustelo et al. [89], and Geyi et al. [35], among others, this research established a similar model (Fig. 1) to previous work. And based on previous literature and practitioners' feedback, the depth and breadth were expanded to reflect the gaps of the literature and the needs of the practitioners. For example, in Geyi et al. [35] paper, only five agility indicators were studied, and the performance metrics did not include morale, productivity, and delivery. Moreover, the study was limited to the UK's higher carbon and energy-intensive supply chains. As for the paper of Vazquez-Bustelo et al. [89], they examined five strategic areas for agility, and their study was limited to the manufacturing industries in Spain only. As for this paper, seven constructs and fifty-two indicators of Agility were proposed and examined. This study is the first paper that examined Agility and Sustainability practices in the US Automotive industry.

3.2. Research methodology

Agility and sustainability philosophies implementation in the US manufacturing industry started between the late twentieth century and early twenty-first [24,35,71]. The main objective of this research is to conduct an empirical study that investigates the relationship between agility and sustainability in the automotive industry. This research focused on the domestic automotive industry facilities, the Big Three (General Motors, Ford Motors, and Fiat Chrysler LLC), and their Powertrain and Components suppliers. The manufacturing facilities studied are all located in North America.

After a detailed review of the literature on sustainability and agility, a draft survey was developed, see Fig. 2 for research methodology. The initial draft survey (Table 1) was based on empirical research conducted on agility and sustainability by several authors including but not limited to Ciccullo et al. [16], Gunasekaran et al. [43], and Geyi et al. [35]. This survey was shared with ten senior operations/engineering managers at the Big Three automotive manufacturers and three academics in the field at two universities in Michigan to review and provide recommendations. Accordingly, the final survey was amended and developed, and it consists of seven categories for agility and three categories for sustainability. Five indicators were selected for performance metrics, construct and indicators are illustrated in Table 1.

The survey is divided into two parts. The first set of questions are related to demographics/characteristics details of the respondent, such as gender, experience, level of education, age of the facility, type of facility, history of agility, and sustainability implementation. The second part includes questions related to the constructs presented in Table 1. Since managers interviewed are highly educated and experienced, and they supervise the implementation of these dimensions,



Fig. 2.. Research methodology.

Table 2.

Respondent's demographics and facilities information

Relevant Dimension	Type/Issue measured and ratio						
Type of manufacturing Facility	Assembly	Powertrain	Component				
	41%	28%	31%				
Managerial position	Production	Engineering	Other (Comptrollers, Material handling, Facility, HRetc)				
	53%	30%	17%				
Manager Level of Education	BS/BA	Masters	DBA/PhD				
	21%	77%	2%				
Participants work experience	5 years of less	6-15years	Above 15 years				
*	0%	21%	79%				
Gender by the type of facility (Female/ Male/Other)	Assembly 40% F/60% M	Powertrain 42%F/55% M/3%O	Component 53%F/43%M/4%O				
Revenues/Size	Small (annual sales less than \$100 million) 0%	Mid-size (\$100-\$999 million) 33%	Large (\$1 Billion plus) 66%				
Age of the Firm	15 Years or less 4%	16 - 20 years 8%	Above 25 Years 88%				
Number of employees	1000 or less 0%	1001-5000 40%	5000 and above 60%				
Agility implementation history	5 Years of less	6-10 years	10 years +				
	48%	27%	25%				
Sustainability implementation history	5 Years of less	6-10 years	10 years +				
	13%	51%	36%				

items in the survey were measured using 10 points Likert scale [17], where 1 and 10 were "No implementation" and "Full implementation" respectively [65]. Respondents were also asked to rank the most important operation performance metrics.

The data collection utilizing the designed survey involved conducting personal visits to one hundred thirty-nine facilities were two hundred and twelve interviews were conducted, no more than two interviews at any of the facilities visited. All data were collected through face to face interviews. The survey was conducted among the US automotive firms located in different locations in the US. The characteristics and details of the respondents and facilities are illustrated in Table 2. The majority of the respondents (41%) work in the assembly facility. Fifty-three percent of the managers are responsible for the production. Most of the respondents (77%) hold a master's degree, where 79% have more than 15 years of experience. Sixty-six percent of the facilities have revenues of \$1 Billion and above, and all of the facilities have more than 1000 employees. The majority of the facilities (48% and 51%) have less than 5 years in Agility implementation and 6-10 years of Sustainability implementation, respectively.

Partial least square (SmartPLS) was utilized for assessing the proposed conceptual model, that incorporates path analysis, basic descriptive statistics, partial algorithm, and bootstrapping. The SmartPLS used 5000 samples for computing the t-values [29]. In addition, structural equation modeling was utilized to analyze the structural relationship between the latent construct and measured variables [65].

Table 3.	
KMO and Bartlett's test.	

Kaiser-Meyer-Olkin Measure of Sa	0.984	
Bartlett's Test of Sphericity	33158.1	2455.5
	3570	677.23
	0.000	0.000

Table 4.

Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Image: Problem in the state of the	Items	Factot loadin	gs					_	-	_			Extracted
P1 D00 D00 <thd00< th=""> <thd00< th=""> <thd00< th=""></thd00<></thd00<></thd00<>		TEAG	2 MHAG	PPAG	4 OUAG	5 REAG	6 TCAG	7 WPAG	8 EcoS	9 EnvS	10 SocS	<u>11</u> OPM	Communalities b2
Pi 97 98 Pi 98 97 Pi 98 98 Pi 98 98 Pi 99 98 Pi 99 98 Pi 997 98 </td <td>P1</td> <td>CLING</td> <td>MILLO</td> <td>0.97</td> <td>Quito</td> <td>REAG</td> <td>Tento</td> <td>WING</td> <td>1205</td> <td>LING</td> <td>5005</td> <td>01 m</td> <td>0.94</td>	P1	CLING	MILLO	0.97	Quito	REAG	Tento	WING	1205	LING	5005	01 m	0.94
Pi 0.07 0.04 Pi 0.071 0.04 Pi 0.071 0.04 NA 0.077 0.05 NA 0.077 0.07 NA 0.077 0.07 <tr< td=""><td>P2</td><td></td><td></td><td>0.97</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0.941</td></tr<>	P2			0.97									0.941
n 0.071 0.071 0.041 r 0.072 0.041 0.041 r 0.071 0.041 0.041 r 0.071 0.041 0.041 r 0.071 0.040 0.041 r 0.071 0.040 0.041 r 0.077 0.040 0.041 r 0.040 0.041 0.041 r 0.040 0.041 0.041 r 0.040 0.041 0.041 r 0.040 0.041 0.041 r 0.041	P3			0.97									0.941
PF 0.921 0.941 PF 0.971 0.931 NI 0.971 0.931 NI 0.961 0.931 NI 0.961 0.931 NI 0.961 0.931 NI 0.971 0.931 NI 0.971 0.931 NI 0.971 0.931 NI 0.977 0.933 OI 0.977 0.934 OI 0.977	P4			0.971									0.942
P?0.910.93W0.970.94W0.940.94W0.940.94W </td <td>P6</td> <td></td> <td></td> <td>0.974</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.944</td>	P6			0.974									0.944
NI	P7			0.974									0.948
NoNoNoNo000No000<	W1							0.969					0.938
NiImage: state st	W2							0.971					0.944
	W 3 W 4							0.971					0.943
N°0.9570.957010.0900.931020.9520.932040.9730.935050.9730.935040.9770.935050.9730.935170.7070.935180.7070.935190.7070.935190.7070.935190.7070.935190.7070.935190.7070.935190.7070.935190.9370.935190.9370.935190.9370.935190.9370.935100.9370.935100.9370.935100.9370.935100.9370.935100.9370.935100.9370.935110.9370.935120.9450.935130.9350.935140.9350.935150.9350.935160.9350.935170.9450.935180.9350.935190.9350.935190.9350.935190.9350.935190.9350.935190.9350.935190.9350.935190.9350.935190.9350.935190.9350.935190.9	W5							0.972					0.944
NT0.0000.000020.0070.001030.0070.001040.0070.001050.0710.031060.0710.031070.0710.031180.0710.031190.0710.031100.0710.031100.0710.031110.0710.031130.0770.031140.0770.031150.0770.031160.0770.033170.0770.033180.0970.0710.770.0350.035190.0970.035100.0970.035100.0970.035100.0970.035100.0970.035140.0970.035150.0970.035160.0970.035170.0350.035180.0970.035190.0970.035190.0970.035100.0350.035110.0970.035120.0970.035130.0970.035140.0920.035150.0970.035160.0970.035170.0250.035180.0220.035190.0240.045190.0450.045190	W6							0.967					0.936
○●97●97○●96●975○●975●956○●975●956○●977●957○●977●957□●977●977○0.767●985□●977●977○0.773●987□●977●977○0.773●977○0.773●987○●977●977○●977●977○●977●977○●977●977○●977●972○●977●972○●977●972○●977●972○●977●972○●977●972○●977●972○●971●972○●971●972○●972●972○●973●973○●973●973○●974●973○●974●973○●974●973○●974●973○●974●973○●974●973○●974●973○●974●973○●974●973○●974●973○●974●973○●974●974○●974●974○●974●974○●974●974○●974●974○ </td <td>W7</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.969</td> <td></td> <td></td> <td></td> <td></td> <td>0.939</td>	W7							0.969					0.939
Q2UU <t< td=""><td>Q1</td><td></td><td></td><td></td><td>0.97</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0.941</td></t<>	Q1				0.97								0.941
of 096 0975 06 0778 085 17 0761 083 18 0751 083 19 0761 083 19 0761 083 19 0761 083 19 0771 083 19 0773 083 19 0773 083 19 0773 083 19 0773 083 19 0773 083 19 0977 083 19 0973 083 10 0973 083 10 0973 083 10 0974 083 10 0974 083 11 0976 083 11 0977 083 11 0977 083 11 0977 083 11 0977 083 12 061 093 13 0971 093 14 0971 093 15 084 16 0971 17 0971 18 0971 19 0971 19<	Q2 Q3				0.969								0.939
06 0.072 0.643 07 0.73 0.643 17 0.751 0.633 18 0.757 0.838 19 0.757 0.635 17 0.757 0.635 18 0.757 0.635 19 0.756 0.663 19 0.757 0.635 19 0.757 0.635 10 0.757 0.635 11 0.907 0.635 12 0.756 0.635 14 0.907 0.635 15 0.907 0.635 16 0.907 0.635 17 0.907 0.635 18 0.907 0.635 14 0.907 0.632 15 0.907 0.632 16 0.907 0.632 17 0.907 0.632 16 0.907 0.632 17 0.907 0.632 18 0.907 0.632 19 0.907 0.633 10 0.907 0.633 10 0.907 0.633 10 0.905 0.934 10 0.945	04				0.965								0.932
060.730.85070.7610.83110.7610.83120.7610.80130.7910.62160.7930.60170.7790.60180.970.810.8140.970.81180.970.83190.9970.83100.9970.83110.9970.83120.9970.83130.9970.83140.9970.83150.9970.83160.9970.82170.9960.83180.9970.83190.9970.82100.9970.82110.9970.83120.9970.83130.9970.93140.9970.93150.9960.93160.9970.93170.9450.93180.9450.93190.9420.93190.9420.94190.9420.94190.9420.94190.9420.94190.9420.94190.9420.94190.9420.94190.9420.94190.9420.94190.9420.94190.9420.94190.9420.9419<	Q5				0.972								0.945
07 0.971 0.843 11 0.767 0.852 15 0.777 0.823 16 0.777 0.824 17 0.766 0.864 18 0.907 0.825 19 0.907 0.834 10 0.907 0.834 11 0.907 0.835 11 0.907 0.835 11 0.907 0.835 11 0.907 0.835 12 0.961 0.837 13 0.907 0.835 14 0.907 0.835 15 0.907 0.835 16 0.907 0.835 17 0.966 0.923 12 0.961 0.923 12 0.961 0.923 13 0.995 0.923 14 0.926 0.923 15 0.926 0.923 16 0.966 0.931 17 0.924 0.923 18 0.925 0.924 19 0.924 0.925 18 0.924 0.925 19 0.924 0.925 18 0.924	Q6				0.978								0.956
11 0.751 0.854 12 0.751 0.894 13 0.773 0.665 16 0.779 0.606 78 0.773 0.693 M2 0.907 0.894 0.816 M3 0.907 0.818 0.818 M4 0.919 0.818 0.818 M4 0.919 0.818 0.818 M4 0.919 0.816 0.816 C1 0.961 0.973 0.923 C2 0.66 0.997 0.924 C3 0.967 0.925 0.925 C4 0.965 0.929 0.923 C5 0.969 0.935 0.937 C5 0.969 0.935 0.937 C5 0.966 0.937 0.935 R4 0.992 0.935 0.935 R5 0.942 0.943 0.943 R4 0.942 0.943 0.943 R5 0.942 0.943 0.943 R4 0.942 0.943 0.943 R5 0.942 0.943 0.943 R4 0.942 0.943 0.943 R5 <	Q7				0.971								0.943
Ti 0.767 0.828 Ti 0.814 0.625 Ti 0.776 0.600 Ti 0.776 0.638 MI 0.907 0.638 C1 0.907 0.638 C2 0.961 0.637 C3 0.907 0.638 C4 0.965 0.638 C5 0.966 0.907 C6 0.909 0.638 C7 0.966 0.907 C6 0.909 0.931 C7 0.966 0.901 C8 0.951 0.902 C9 0.971 0.932 C9 0.921 0.943 R1 0.921 0.943 R2 0.951 0.913 R3 0.921 0.943 R4 0.922 0.943 R5 0.921 0.943 R6 0.921	11 T2						0.763						0.582
T4 0.73 0.62 T5 0.775 0.62 T6 0.775 0.63 T8 0.907 0.73 0.83 M2 0.905 0.81 0.81 M4 0.907 0.73 0.83 M5 0.907 0.73 0.83 M6 0.907 0.73 0.83 M6 0.907 0.73 0.83 M5 0.907 0.83 0.93 C1 0.961 0.93 0.93 C2 0.966 0.937 0.92 C3 0.967 0.93 0.93 C4 0.965 0.93 0.93 C5 0.909 0.93 0.93 C6 0.909 0.94 0.93 C7 0.966 0.93 0.93 C8 0.955 0.93 R4 0.957 0.93 R4 0.92 0.93 R5 0.93 0.93 R4 0.93 0.93 R5 0.93 0.93 R6 0.93 0.93 R7 0.93 0.93 R8 0.93 0.93 R94 <td< td=""><td>T3</td><td></td><td></td><td></td><td></td><td></td><td>0.767</td><td></td><td></td><td></td><td></td><td></td><td>0.588</td></td<>	T3						0.767						0.588
15 0.814 0.627 76 0.779 0.607 77 0.776 0.638 M1 0.907 0.733 0.839 M2 0.905 0.831 0.831 M3 0.836 0.837 0.839 M6 0.907 0.831 0.835 M6 0.907 0.832 0.832 C1 0.961 0.832 0.932 C2 0.966 0.932 0.932 C4 0.965 0.933 0.933 C5 0.969 0.935 0.933 C6 0.965 0.933 0.933 C7 0.966 0.933 0.933 C8 0.965 0.935 0.934 C9 0.967 0.935 0.934 R1 0.955 0.934 0.934 R8 0.924 0.932 0.944 R8 0.924 0.932 0.944 Ecos3 0.934 0.935 0.935 Ecos4 0.944 0.935 0.945	T4						0.793						0.628
16 0.779 0.607 17 0.776 0.603 18 0.907 0.823 M2 0.905 0.813 M3 0.866 0.876 M4 0.919 0.815 M6 0.807 0.825 M6 0.907 0.825 M6 0.907 0.825 M6 0.907 0.825 C1 0.961 0.825 C2 0.961 0.825 C3 0.967 0.825 C4 0.965 0.939 C5 0.966 0.939 C6 0.969 0.931 C8 0.951 0.903 R4 0.955 0.903 R4 0.959 0.913 R4 0.959 0.913 R5 0.962 0.923 R4 0.951 0.923 R5 0.959 0.913 R6 0.959 0.913 R6 0.923 0.944 Eox52 0.924 0.924 R8 0.924 0.924 Eox51 0.936 0.935 Eox52 0.936 0.935 Eox54	T5						0.814						0.662
1' 0.76 0.89 M1 0.997 0.81 M3 0.896 0.87 M4 0.990 0.82 M6 0.997 0.82 C2 0.96 0.82 C3 0.865 0.82 C4 0.907 0.82 C5 0.969 0.82 C6 0.907 0.923 C7 0.966 0.933 C6 0.906 0.931 C7 0.966 0.931 C8 0.965 0.931 C9 0.965 0.931 R1 0.951 0.935 R2 0.959 0.935 R3 0.959 0.935 R4 0.959 0.937 R5 0.962 0.937 R8 0.959 0.932 C8 0.922 0.945 C9 0.957 0.932 R8 0.922 0.945 C9 0.923 0.945 C9 0.924 0.945 C9 0.924 0.945 C9 0.924 0.945 C9 0.931 0.932 C9 0.932 0.94	T6						0.779						0.607
n 0.73 0.93 M10.9070.813M20.9060.814M30.9070.825M40.9070.825C10.9610.921C20.9670.923C30.9670.923C40.9650.935C50.9690.935C70.9660.935C80.9510.935R10.9510.903R20.9660.939R40.9550.935R20.9560.935R40.9550.913R50.9590.913R60.9590.92R80.9620.92R80.9620.92R80.9620.92R80.9620.92R80.9620.92R80.9620.92R90.9340.93R90.940.934R90.9590.919R00.920.94EcoS10.920.94EcoS20.9670.92EcoS30.9190.935EcoS40.9190.93EcoS90.9190.92EcoS90.920.95EcoS90.920.95EcoS90.920.95EcoS90.920.95EcoS90.920.95EcoS90.920.95EcoS90.920.95EcoS90.920.95Eco	T7 T8						0.776						0.603
M2 0.05 0.05 M4 0.09 0.05 M4 0.09 0.05 M6 0.007 0.02 C1 0.061 0.02 C2 0.06 0.02 C3 0.067 0.02 C4 0.055 0.090 C5 0.969 0.03 C6 0.966 0.03 C7 0.966 0.03 C8 0.965 0.03 C9 0.967 0.036 C8 0.965 0.03 C8 0.965 0.03 C9 0.967 0.056 C9 0.967 0.056 C9 0.962 0.02 R1 0.955 0.01 R4 0.962 0.02 R5 0.961 0.04 R6 0.923 0.84 R7 0.962 0.92 C83 0.91 0.84 R6 0.92 0.86 C93 0.92 0.84 R7 0.92 0.84 C83 0.91 0.84 C93 0.92 0.85 C93 0.92 0.84	18 M1		0.907				0.773						0.823
M3 0.886 0.786 M4 0.919 0.8645 M5 0.897 0.805 M6 0.907 0.822 C1 0.961 0.922 C3 0.967 0.933 C4 0.966 0.939 C5 0.969 0.931 C6 0.966 0.933 C7 0.966 0.933 C8 0.965 0.933 C9 0.967 0.935 R1 0.051 0.933 R2 0.965 0.939 R4 0.956 0.939 R4 0.951 0.935 R4 0.952 0.922 R5 0.962 0.913 R4 0.939 0.939 R5 0.931 0.941 R6 0.932 0.922 R4 0.913 0.842 R5 0.924 0.845 Eco53 0.931 0.842 Eco54 0.936 0.824 Eco57 0.925 0.824 Eco58 0.936 0.842 Eco57 0.922 0.854 Eco58 0.936 0.842 Eco59 <td>M2</td> <td></td> <td>0.905</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0.819</td>	M2		0.905										0.819
M4 0.019 0.815 M5 0.807 0.815 M6 0.007 0.822 C1 0.61 0.822 C2 0.96 0.924 C3 0.967 0.925 C4 0.965 0.939 C6 0.969 0.939 C7 0.966 0.939 C8 0.965 0.939 C9 0.967 0.935 C8 0.965 0.939 C9 0.967 0.931 C8 0.965 0.931 R1 0.951 0.905 R2 0.955 0.901 R4 0.962 0.923 R5 0.959 0.913 R6 0.913 0.842 R6 0.923 0.842 R5 0.924 0.842 ExoS1 0.921 0.842 ExoS2 0.913 0.842 ExoS4 0.914 0.832 ExoS5 0.913 0.842 ExoS4 0.923 0.842 ExoS5 0.914 0.842 ExoS4 0.924 0.842 ExoS5 0.914 0.842 ExoS4<	M3		0.886										0.786
MS 0.897 0.885 M6 0.907 0.822 C1 0.961 0.924 C2 0.96 0.921 C3 0.967 0.935 C4 0.965 0.939 C5 0.969 0.933 C6 0.969 0.933 C7 0.966 0.933 C8 0.965 0.935 R1 0.951 0.905 R2 0.956 0.905 R4 0.955 0.902 R4 0.962 0.902 R5 0.905 0.914 R6 0.923 0.914 R8 0.924 0.923 Eos51 0.924 0.935 Eos52 0.914 0.935 Eos54 0.924 0.935 Eos54 0.924 0.935 Eos55 0.914 0.935 Eos54 0.914 0.835 Eos55 0.924 0.835	M4		0.919										0.845
no 0.00 0.02 C1 0.96 0.921 C2 0.96 0.921 C3 0.967 0.932 C4 0.966 0.933 C5 0.969 0.933 C7 0.966 0.933 C8 0.967 0.933 C9 0.967 0.933 C8 0.966 0.933 C9 0.967 0.933 R1 0.951 0.935 R2 0.952 0.913 R3 0.955 0.913 R4 0.955 0.913 R5 0.923 0.913 R8 0.962 0.924 EcoS1 0.92 0.844 EcoS2 0.923 0.814 EcoS4 0.914 0.835 EcoS5 0.914 0.835 EcoS6 0.914 0.835 EcoS6 0.914 0.835 EcoS8 0.929 0.844 EcoS9 0.929 0.844 EcoS9 0.914 0.835 EcoS9 0.921 0.812 EcoS9 0.922 0.814 EcoS9 0.922 0.814 <	M5 M6		0.897										0.805
C2 0.96 0.92 C3 0.967 0.92 C4 0.965 0.92 C5 0.969 0.93 C6 0.969 0.93 C7 0.966 0.93 C8 0.965 0.93 C9 0.965 0.93 R1 0.951 0.935 R2 0.956 0.91 R4 0.956 0.92 R5 0.955 0.91 R6 0.955 0.91 R8 0.962 0.92 R8 0.962 0.92 Ses4 0.962 0.92 R8 0.92 0.92 Ses5 0.91 0.824 Ses5 0.92 0.82 Ses5 0.914 0.854 Ses5 0.915 0.82 Ses5 0.915 0.82 Ses5 0.92 0.84 Ses5 0.92 0.85 Ses5 0.92 0.8	C1	0.961	0.907										0.924
C3 0.967 0.963 0.932 C4 0.969 0.932 C5 0.969 0.933 C7 0.966 0.933 C8 0.967 0.935 R1 0.956 0.905 R2 0.956 0.923 R3 0.956 0.925 R4 0.956 0.925 R5 0.962 0.925 R6 0.955 0.913 R7 0.962 0.925 R5 0.962 0.914 R6 0.925 0.925 R5 0.962 0.921 R6 0.921 0.942 R7 0.971 0.942 0.942 R6 0.921 0.943 EcoS1 0.921 0.845 EcoS2 0.913 0.842 EcoS4 0.914 0.845 EcoS6 0.909 0.825 EcoS6 0.921 0.845 EcoS6 0.922 0.851 EcoS6 0.922 0.851 </td <td>C2</td> <td>0.96</td> <td></td> <td>0.921</td>	C2	0.96											0.921
C4 0.965 0.969 0.944 C5 0.969 0.933 C8 0.965 0.933 C9 0.967 0.935 R1 0.951 0.935 R2 0.956 0.944 R3 0.962 0.925 R4 0.962 0.925 R4 0.962 0.931 R5 0.955 0.913 R6 0.955 0.913 R8 0.962 0.925 EcoS1 0.921 0.935 EcoS1 0.921 0.943 EcoS5 0.959 0.914 EcoS5 0.914 0.824 EcoS5 0.914 0.825 EcoS5 0.914 0.825 EcoS6 0.914 0.833 EcoS1 0.915 0.813 EcoS1 0.914 0.833 EcoS1 0.924 0.842 EcoS1 0.919 0.844 EcoS1 0.924 0.854 EcoS1 0.922 0.853 EcoS2 0.924 0.854 EcoS1 0.922 0.855 EcoS1 0.924 0.854 EcoS2 0.924	C3	0.967											0.936
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R70.9710.942R80.9620.925EcoS10.920.846EcoS20.9180.842EcoS30.9230.851EcoS40.9240.854EcoS50.9140.852EcoS60.9150.838EcoS90.9010.812EcoS90.9240.854EcoS90.9010.812EcoS90.9200.864EcoS90.9200.882EroS40.9200.882EcoS90.9360.877ErnS10.9220.851ErnS50.9190.826ErnS50.9260.858ErnS60.9200.854ErnS70.9220.854ErnS60.9240.854ErnS70.9220.854ErnS60.9240.854ErnS70.8640.9747	R6					0.955							0.913
ns 0.962 0.92 0.944 EcoS1 0.918 0.842 EcoS2 0.918 0.842 EcoS3 0.923 0.851 EcoS4 0.924 0.854 EcoS5 0.914 0.835 EcoS6 0.909 0.826 EcoS7 0.915 0.838 EcoS8 0.901 0.812 EcoS9 0.929 0.864 EcoS10 0.929 0.864 EcoS10 0.926 0.872 EnvS1 0.822 0.851 EnvS4 0.929 0.844 EnvS4 0.929 0.851 EnvS4 0.926 0.828 EnvS4 0.921 0.851 EnvS4 0.922 0.851 EnvS4 0.922 0.851 EnvS6 0.924 0.844 EnvS6 0.924 0.854 EnvS6 0.926 0.851 EnvS6 0.924 0.854	R7					0.971							0.942
EcoS2 0.918 0.82 EcoS3 0.923 0.851 EcoS4 0.924 0.854 EcoS5 0.914 0.855 EcoS6 0.909 0.826 EcoS8 0.901 0.812 EcoS8 0.901 0.812 EcoS9 0.929 0.864 EcoS9 0.929 0.864 EcoS9 0.929 0.851 EroS1 0.936 0.872 EroS2 0.922 0.851 EroS3 0.926 0.853 EroS4 0.921 0.851 EroS5 0.926 0.854 EroS4 0.921 0.854 EroS5 0.922 0.851 EroS4 0.922 0.851 EroS5 0.924 0.844 EroS5 0.922 0.851 EroS6 0.922 0.851 EroS6 0.924 0.854 EroS7 0.925 0.854 EroS6 0.924 0.854 EroS6 0.924 0.854 EroS7 0.926 0.854 EroS6 0.926 0.854 EroS6 0.926 0.854 EroS6	K8 EcoS1					0.962			0.92				0.925
EcoS3 0.923 0.851 EcoS4 0.924 0.851 EcoS5 0.914 0.835 EcoS6 0.909 0.826 EcoS7 0.915 0.835 EcoS8 0.901 0.812 EcoS9 0.901 0.812 EcoS9 0.901 0.812 EcoS9 0.929 0.864 EcoS10 0.922 0.851 EroS3 0.922 0.851 EroS4 0.922 0.851 EroS5 0.922 0.851 EroS4 0.922 0.854 EroS5 0.922 0.854 EroS4 0.922 0.854 EroS5 0.922 0.854 EroS5 0.922 0.854 EroS5 0.922 0.854 EroS6 0.922 0.854 EroS5 0.924 0.854 EroS6 0.924 0.854 EroS7 0.925 0.854 EroS6 0.926 0.854 EroS7 0.926 0.854 EroS6 0.926 0.854 EroS7 0.926 0.854 EroS6 0.926 0.854 EroS7	EcoS2								0.918				0.842
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1000 0.901 0.838 EcoS7 0.901 0.812 EcoS8 0.901 0.812 EcoS9 0.929 0.864 EcoS10 0.936 0.877 EmvS1 0.882 0.777 EmvS2 0.922 0.851 EmvS4 0.919 0.844 EmvS5 0.922 0.855 EmvS6 0.924 0.854 EmvS7 0.924 0.854 EmvS7 0.924 0.854 EmvS7 0.924 0.854 SocS1 0.864 0.747	EcoS5 EcoS6								0.914				0.835
EcoS8 0.901 0.812 EcoS9 0.929 0.864 EcoS10 0.936 0.877 ErwS1 0.882 0.777 ErwS2 0.922 0.851 ErwS4 0.919 0.844 ErwS5 0.922 0.855 ErwS4 0.922 0.855 ErwS6 0.924 0.854 ErwS7 0.924 0.854 SocS1 0.864 0.747	EcoS7								0.909				0.838
EcoS9 0.929 0.864 EcoS10 0.936 0.877 EmS1 0.882 0.777 EmS2 0.922 0.851 EmS3 0.926 0.888 EmS4 0.919 0.844 EmS5 0.922 0.851 EmS6 0.922 0.851 EmS6 0.924 0.854 EmS7 0.905 0.854 SoS1 0.864 0.747	EcoS8								0.901				0.812
EcoS10 0.936 0.877 EnvS1 0.882 0.777 EnvS2 0.881 0.922 0.851 EnvS3 0.926 0.854 0.926 0.854 EnvS4 0.922 0.851 0.922 0.854 EnvS5 0.922 0.854 0.922 0.854 EnvS6 0.924 0.854 0.854 EnvS7 0.864 0.747 0.747	EcoS9								0.929				0.864
EnvS1 0.882 0.77 EnvS2 0.922 0.851 EnvS3 0.926 0.858 EnvS4 0.919 0.844 EnvS5 0.922 0.855 EnvS6 0.924 0.854 EnvS7 0.864 0.747	EcoS10								0.936	0.000			0.877
EnvS3 0.926 0.858 EnvS4 0.919 0.844 EnvS5 0.922 0.855 EnvS6 0.924 0.854 EnvS7 0.905 0.864 SocS1 0.864 0.747	EnvS1 EnvS2									0.882			0.777
EnvS4 0.919 0.844 EnvS5 0.922 0.85 EnvS6 0.924 0.854 EnvS7 0.905 0.818 SocS1 0.864 0.747	EnvS3									0.926			0.858
EnvS5 0.922 0.85 EnvS6 0.924 0.854 EnvS7 0.905 0.818 SocS1 0.864 0.747	EnvS4									0.919			0.844
EnvSb 0.924 0.854 EnvS7 0.905 0.818 SocS1 0.864 0.747	EnvS5									0.922			0.85
Lavs / 0.905 0.818 SocS1 0.864 0.747	EnvS6									0.924			0.854
0.001 0.777	SocS1									0.905	0.864		0.818
SocS2 0.892 0.795	SocS2										0.892		0.795
SocS3 0.88 0.774	SocS3										0.88		0.774
Soc54 0.875 0.766	SocS4										0.875		0.766
SeeSS 0.767 0.752 SeeSS 0.767 0.752	SocS5										0.767		0.752
3030 0.88/ 0./80 SocS7 0.854 0.730	SocS7										0.887		0.729
Soc88 0.882 0.778	SocS8										0.882		0.778
SocS9 0.869 0.755	SocS9										0.869		0.755
SocS10 0.873 0.763	SocS10										0.873		0.763
SocS11 0.88 0.775	SocS11										0.88	0.070	0.775
Quany (OW1) 0.9/9 0.99 ''ndharibity' (OM2) 0.071 0.042	roductivity (OM2)											0.979	0.959
Morak (OM3) 0.972 0.945	Morale (OM3)											0.972	0.945
Delivery (OM4) 0.974 0.949	Delivery (OM4)											0.974	0.949
Cost (OM5) 0.97 0.941	Cost (OM5)	07.7	ot -	o		0.5.5	co =	02.5				0.97	0.941
76 01 Vartanke δ / . 3 δ 1.0 94.4 90.4 86.2 60./ 95.2 84.4 82.6 / 6.5 92.7 Extraction Method: Principal Commonent Analysis, Rotation Method: Varinax with Kaiser Normalization Rotation Rotatio	70 OI Variance Extraction Method: Princ	8/.5	81.6 Analysis Rotati	94.4 ion Method: Var	90.4 imax with Kaisar	86.2 Normalization	00.7 Rotation converse	93.2 re in 25 iterations	84.4	82.6	/0.5	92.7	

4. Results

An exploratory analysis was conducted before structural equation modeling [11]. In testing for the suitability of data, the correlation matrix indicated a coefficients value ≥ 0.70 . The findings in Table 11 suggest that all constructs are more correlated with their items compared to the other constructs. It demonstrates that the overall model meets the conditions of discriminant validity required. And thus, the measurement model is valid and reliable. Kaiser-Meyer-Olkin value was 0.984, well above the recommended value of 0.60, which indicates that that the sampling is adequate. Bartlett's Test of Sphericity indicates a value of 0.000, supporting the notion of factorability, as illustrated in Table 3.

The principal component analysis was conducted to perform exploratory analysis [35]. The results show eleven factors with an eigenvalue > 1, explaining the variance respectively, as illustrated in Table 4. All loadings are above 0.50, therefore none of the 85 items were removed [61].

Table 4 illustrate components of agility and sustainability. For example, Component 1 represents competency for agility (CEAG) that includes labeled items C1-C9, Component 2 represents material handling for agility (MHAG) that includes labeled items M1-M6. The sustainability components include 3 categories (economic, social, and environmental) as illustrated in Table 4 (8, 9, and 10 respectively). For example, factor loading 8 represents the economic performance of sustainability (EcoS) that includes item EcoS1-EcoS10. Component 11 represents operational performance metrics labeled OPM.

4.1. Psychometric properties

A test for reliability and validity of the data was conducted [20,31]. The result indicates that Chronbach's alpha value is 0.979 for agility, 0.987 for sustainability, and 0.986 for operational performance, as illustrated in Table 5. Chronbach's alpha coefficient value indicates a very strong consistency and reliability, the coefficient value is well above the required 0.70 [31]. Convergent validity was tested using average variance extracted (AVE), composite reliability (CR), and item loading [52]. Table 5 indicates that values (AVE, item loading, and CR) for all constructs are above the 0.5 recommended threshold [31], therefore indicating convergent validity of the model presented. Moreover, since the dependant and independent variables were obtained from the same source, a procedural approach was utilized to minimize common method bias. Most of the respondents to the survey were highly skilled and knowledgeable senior managers, thus, this minimizes the common method bias. More so, we reduced common bias by separating the measures over the length of the survey instruments, in that way, we guaranteed that participants' responses remained anonymous [68].

4.1.2. Discriminant validity

The purpose of discriminatory validity is to check how many constructs differ from each other using the same measurement model. This test is applied by comparing the values of the square root of the AVE in the diagonal with the correlations among the reflective construct [31]. Table 6, indicates that all constructs are strongly related to their items compared to other items associated with other constructs. This result suggests that the model satisfies the recommendations of discriminant validity, therefore the model is valid and reliable.

4.2. Parceling method

A parceling method that transforms construct from high order,

multidimensional into first-order latent factor was applied [18]. The process reduces the number of indicators (observed variables) in the model to a composite score (averaged into subsets called parcels) was used [2]. The parcels are used as indicators of the latent construct [55]. In parceling Sustainability and Agility indicators, we used the weighted sum scores approach. The score for each parcel is created by multiplying the scaled score for each item assigned to the parcel by the item's factor loading before summing all weighted scores [55]. This approach is recommended for creating parcels from multidimensional scales. Since different factor loading values are applied to each item, this allows for items with the highest loadings to have the largest effect on the score [55]. Table 7, illustrates the measurement model result after applying parceling.

4.3. Structural model

The structural model analysis examines goodness of fit (GoF) and the endogenous variable coefficient (R^2). The validation requires that both values are greater than 0.1 [31]. Fig. 3, illustrates the resulting structural model (PLS algorithm). The R^2 for operational performance is 0.964, indicates that the proposed construct explains 96% of the operational performance variance. Sustainability performance R^2 is 0.845. The structural model for the GoF value is 0.812, which indicates a good model fit and is appropriate for evaluating path significance ([31].

Testing results for the hypothesis with associated standardized path coefficient, T-statistics, and P-value are presented in Table 8. Hypotheses H1 (i.e. relationship between Agile performance and operational performance), H2 (i.e. the relationship between Agile performance and sustainability performance), H3 (i.e. the relationship between Sustainability and operational performance), and H4 (i.e. Sustainability mediates the relationship between agility and operational). The first three hypotheses are all supported at a significance value (*P*) of p < 0.001, p < 0.001, and p < 0.05 respectively. H4 for the indirect effect (sustainability as a mediator indicated a value path value of 0.072 (value needs to be greater than 0.7). Sobel test was conducted to investigate partial mediation. The Sobel test presented in Table 9 indicated partial mediation. Therefore, the results determined that agility and sustainability performance positively affect operational performance metrics in the US automotive manufacturing industry.

According to Fornell and Cha [29]; Byrne [11]; Furr [31], variable act as a mediator is it positively contribute between predictor and criterion variables. Geyi et al., [35], indicate that to achieve full mediation the path coefficient of the direct effect must be greater than the sum of the multiplication of the indirect effect path coefficient. In testing for the mediation effect of sustainability performance on the impact of agility on operational performance and since the direct effect result is higher than the indirect (as illustrated in Fig. 3 and Table 8) we conclude that sustainability has a partial mediation effect on the relationship between agility and operational performance metrics.

4.4. Measurement of an agility performance index

For computing the overall value of Agility (index), we utilized formulas proposed by Fornell et al. [30]; Lin et al. [56]; Routroy et al. [72] (illustrated in equation 1).

$$AGI = \frac{\sum_{i=1}^{n} w_i \bar{x}_i - \sum_{i=1}^{n} w_i}{9 \sum_{i=1}^{n} w_i} \times 100$$
(1)

 w_i represent the weight of item *i*, and \overline{x}_i the average value of measurement item *i*. A 1-9 scale questioner (pairwise comparison) was provided to participants to compare the various agility constructs/categories, as

Table 5.

Measurment model result (PLS).

Latent variable	Inicator	Outer Weight	Loading	Communality	AVE	CB	Rho A	Cronbach's Alpha
	inicator	Outer Weight	Loading	Communanty	71VL	CIC	1010_71	cronbach 3 Aipha
Agility Perfromance	D1	0.040	0.000	0.050	0.89	0.983	0.986	0.979
Process Planning	P1 P2	0.240	0.963	0.958				
	P2 P3	0.237	0.903	0.902				
	P4	0.234	0.965	0.955				
	P5	0.235	0.966	0.958				
	P6	0.237	0.966	0.964				
	P7	0.236	0.967	0.960				
Work Place and People	W1	0.226	0.946	0.932				
	W2	0.226	0.951	0.936				
	W3	0.226	0.950	0.935				
	W4	0.225	0.949	0.933				
	W5	0.226	0.950	0.936				
	WO MZ	0.226	0.949	0.935				
Quality	01	0.220	0.948	0.933				
Quanty	02	0.234	0.944	0.949				
	03	0.235	0.947	0.952				
	Q4	0.235	0.942	0.950				
	Q5	0.235	0.948	0.954				
	Q6	0.236	0.951	0.958				
	Q7	0.235	0.945	0.951				
Technology	T1	0.134	0.777	0.752				
	T2	0.138	0.760	0.754				
	13	0.141	0.761	0.754				
	14 TE	0.132	0.757	0.751				
	15 T6	0.134	0.759	0.752				
	T7	0.129	0.757	0.750				
	T8	0.124	0.755	0.748				
Matreial Handling	M1	0.199	0.830	0.786				
	M2	0.197	0.832	0.783				
	M3	0.199	0.829	0.787				
	M4	0.204	0.849	0.807				
	M5	0.200	0.837	0.796				
	M6	0.201	0.834	0.789				
Competency / Efficiency	CI	0.231	0.938	0.950				
	C2	0.230	0.933	0.949				
	C4	0.230	0.940	0.951				
	C5	0.231	0.945	0.957				
	C6	0.230	0.943	0.954				
	C7	0.230	0.943	0.953				
	C8	0.232	0.942	0.956				
	C9	0.231	0.940	0.954				
Responsivness	R1	0.233	0.940	0.931				
	RZ D2	0.235	0.948	0.938				
	R4	0.230	0.952	0.947				
	R5	0.234	0.946	0.939				
	R6	0.234	0.945	0.939				
	R7	0.238	0.960	0.952				
	R8	0.234	0.951	0.940				
Sustainability Perfromance					0.98	0.992	989	0.987
Economical	EcoS1	0.420	0.922	0.862				
	EcoS2	0.424	0.903	0.864				
	EcoS4	0.425	0.917	0.800				
	EcoS5	0.429	0.915	0.858				
	EcoS6	0.409	0.910	0.829				
	EcoS7	0.416	0.910	0.844				
	EcoS8	0.418	0.892	0.850				
	EcoS9	0.429	0.919	0.874				
	EcoS10	0.430	0.933	0.894				
Environmental	EnvS1	0.414	0.896	0.833				
	EnvS2	0.399	0.906	0.807				
	Env53	0.392	0.899	0.793				
	Envo4 EnvS5	0.393	0.901	0.790				
	EnvS6	0.385	0.892	0.777				
	EnvS7	0.387	0.856	0.780				
Social	SocS1	0.400	0.867	0.815				
	SocS2	0.397	0.886	0.810				
	SocS3	0.399	0.878	0.814				

(continued on next page)

Table 5. (continued)

Latent variable	Inicator	Outer Weight	Loading	Communality	AVE	CR	Rho_A	Cronbach's Alpha
	SocS4	0.397	0.869	0.816				
	SocS5	0.368	0.856	0.751				
	SocS6	0.366	0.872	0.747				
	SocS7	0.376	0.850	0.764				
	SocS8	0.381	0.872	0.778				
	SocS9	0.387	0.866	0.788				
	SocS10	0.380	0.867	0.779				
	SocS11	0.380	0.866	0.771				
Operational Perfromance					0.95	0.992	0.989	0.987
	Quality	0.206	0.979	0.979				
	Productivity	0.205	0.971	0.971				
	Morale	0.207	0.972	0.972				
	Delivery	0.208	0.974	0.974				
	Cost	0.203	0.970	0.970				

Table 6.

Correlation between the latent variables.

	Agility	OperationalPerfMetrics	Sustainability
Agility	0.981		
OperationalPerfMetrics	0.944	0.973	
Sustainability	0.914	0.917	0.988

illustrated in Appendix A.

The weights are determined through the analytics hierarchy process [10]. The process uses a pairwise comparison method and the main advantages of this method are that it generates ratio data that can provide and prioritize construct/categories based on importance [31]. The matrix illustrated in Appendix A contains numerical values that determine the importance of each factor on the y-axis (i) as compared to the x-axis (j) based on the respondent judgment (matrix was completed by 25 managers interviewed). Determining the importance of each factor can range between 1-9 or the inverse of 1/i, interpretation, and sample is illustrated in Appendix A. The weights calculated from the hierarchy analysis are illustrated in Table 10. The agility index was found to be 78.6 points on a scale of 1-100.

Table 7.

Measurment model results (parceling).

5. Discussion and managerial implications

5.1. The effect of agility practices on operational performance metrics

The results of this study indicate that agility performance significantly impacts operational performance metrics in the US automotive manufacturing industry. Therefore, it can be assumed that the higher level of agility implementation practices, the greater the improvements in operational performance metrics. The result presented in Tables 4, 5, 7, and 9, indicates that each group of agility dimensions (i.e. CEAG, MHAG, PPAG, QUAG, REAG, TCAG, and WPAG) has a different impact. Some dimensions are more significant than others. Table 7, indicates that the loading results of specific dimensions had higher significance than others. For example, ranking loading by impact from highest to lowest respectively shows that PPAG (highest), REAG, WPAG, QUAG, CEAG, MHAG, TCAG (lowest). A correlation matrix was also conducted to test the relationship between all dimensions of the model, illustrated in Table 11. The correlation matrix shows a strong relationship between all model dimensions, significant at the 0.01 level. The highest correlation between Agility and operational performance indicators was between PPAG (Process planning) and OM4 (Delivery) and the lowest was between TCAG (Technology)and OM3 (Morale), as illustrated in Table 10. Further inspection of the data and hypothesis tested indicates that agility performance practices explained more than 80 percent of the variance in operational performance. This result shows that agility

	Items	Loading ^a	AVE ^b	CR ^c	Rho_A	Cronbach's Alpha ^d
Agility Performance			0.891	0.983	0.986	0.979
(Competency/Efficiency)	CEAG	0.965				
(Material Handling)	MHAG	0.937				
(Process Planning)	PPAG	0.992				
(Quality_	QUAG	0.968				
(Responsiveness)	REAG	0.985				
(Technology)	TCAG	0.765				
(Work Place and People)	WPAG	0.976				
Sustainability Performance			0.975	0.992	989	0.987
(Economical)	EcoS	0.991				
(Environmental)	EnvS	0.981				
(Social)	SocS	0.991				
Operational Performance			0.947	0.992	0.989	0.987
(OM5)	Cost	0.97				
(OM4)	Delivery	0.974				
(OM3)	Morale	0.972				
(OM2)	Productivity	0.971				
(OM1)	Quality	0.979				

^a All item loadings > 0.5 Indicates Indicator reliability

^b All average Variance Extracted (AVE) > 0.5 indicates convergent reliability

^c All composite reliability (CR) > 0.7 indicates internal consistency

 $^{\rm d}$ All Cronbach's Alpha > 0.7 indicates indicator reliability.



Fig. 3.. Structural model (PLS algorithm results).

Table 8.			
Results of hypothesis	testing and	mediation	analysis.

Hypotheses	Path	Path Coefficient	Std Error	T Statistics	P Values	Result
	Direct Effect	0.01000	0.000	00 (())	0.000	a 1
HI	Agility -> OperationalPerfMetrics	0.910**	0.030	30.664	0.000	Supported
H2	Agility -> Sustainability	0.919**	0.010	94.585	0.000	Supported
H3	Sustainability -> OperationalPerfMetrics	0.914*	0.032	2.430	0.015	Supported
	Indirect Effect					
H4	Agility -> OperationalPerfMetrics	0.072*	0.029	2.444	0.015	Supported (partial)

* *P* < 0.05,

* P < 0.001

Table 9. Sobel test.

Direct Value with mediator	0.91
Direct Value without mediator	0.982
IV -> Med Beta	0.919
Med -> DV Beta	0.078
IV -> Med Standard error	0.01
Med -> DV Standard error	0.032
*Sobel test statistics:	2.436
One tailed probability:	0.007
**Two Tailed Probability:	0.0148

* Should be greater than 1.96,

** Should be less than .05

Table 10.	
Results of pairwise comparison matrix for Agility factors $n = 25$.	

Index Indicator	Weight (wi)	Indicator Mean (xi)	WiXi	Ranking
CEAG	0.224	1.570	0.352	3
MHAG	0.039	0.276	0.011	6
PPAG	0.247	1.730	0.427	2
QUAG	0.085	0.592	0.050	5
REAG	0.087	0.609	0.053	4
TCAG	0.027	0.191	0.005	7
WPAG	0.290	2.032	0.590	1

practices/dimensions are likely to get more attention, especially during a period of uncertainty and ambiguity in the marketplace.

5.2. The effect of agility practices on sustainability practices

The impact of agility on sustainability was more significant than the impact of agility on operational performance. Fig. 3, indicates that the loadings path for agility practices to performance metrics was 0.910 and the loading path for agility practices to sustainability performance was 0.919. This result indicates that agile practices have a strong effect on sustainability. The results indicate that higher agility implementation will lead to a higher positive impact on sustainability practices. These results agree with previous research conducted by Gunasekaran et al. [43]. According to Geyi et al. [35], theoretical and practical work regarding the impact of agility on performance metrics, as well as the impact of agility on sustainability performance is rare. What is new in this research is not just the impact of agility on sustainability but also the depth and breadth of agility performance studied since no previous work was as comprehensive in detailing agility dimensions from an automotive manufacturing perspective. In the model studied the agility practices accounted for more than 80 percent of the variance in performance metrics and sustainability. Data suggests that economic, social, and environmental sustainability performance loadings were very similar to each other. According to Gupta [44], climate change directly impacts the scarcity of resources and force manufacturers to focus more on advancements in technology to reduce environmental and social impact. Ciccullo et al. [16], indicates that the main driver of success in

Table 11. Correlation matrix.

	SocS	WPAG	QUAG	TCAG	MHAG	CEAG	REAG	EcoS	EnvS	OM1	OM2	OM3	OM4	OM5	PPAG
SocS	1	.827**	.896**	.659**	.838**	.861**	.914**	.981**	.954**	.861**	.871**	.881**	.892**	.859**	.893**
WPAG	.827**	1	.926**	.735**	.873**	.967**	.965**	.879**	.845**	.948**	.932**	.935**	.941**	.933**	.961**
QUAG	.896**	.926**	1	.608**	.885**	.963**	.970**	.937**	.874**	.949**	.943**	.968**	.964**	.945**	.984**
TCAG	.659**	.735**	.608**	1	.827**	.617**	.685**	.680**	.662**	.644**	.658**	.624**	.652**	.628**	.700**
MHAG	.838**	.873**	.885**	.827**	1	.824**	.891**	.873**	.834**	.837**	.855**	.865**	.867**	.836**	.913**
CEAG	.861**	.967**	.963**	.617**	.824**	1	.974**	.911**	.843**	.971**	.953**	.962**	.963**	.957**	.974**
REAG	.914**	.965**	.970**	.685**	.891**	.974**	1	.953**	.916**	.952**	.949**	.962**	.966**	.943**	.982**
EcoS	.981**	.879**	.937**	.680**	.873**	.911**	.953**	1	.955**	.905**	.912**	.920**	.926**	.897**	.938**
EnvS	.954**	.845**	.874**	.662**	.834**	.843**	.916**	.955**	1	.837**	.846**	.858**	.869**	.831**	.870**
OM1	.861**	.948**	.949**	.644**	.837**	.971**	.952**	.905**	.837**	1	.940**	.938**	.944**	.942**	.959**
OM2	.871**	.932**	.943**	.658**	.855**	.953**	.949**	.912**	.846**	.940**	1	.927**	.929**	.928**	.954**
OM3	.881**	.935**	.968**	.624**	.865**	.962**	.962**	.920**	.858**	.938**	.927**	1	.940**	.925**	.969**
OM4	.892**	.941**	.964**	.652**	.867**	.963**	.966**	.926**	.869**	.944**	.929**	.940**	1	.926**	.972**
OM5	.859**	.933**	.945**	.628**	.836**	.957**	.943**	.897**	.831**	.942**	.928**	.925**	.926**	1	.952**
PPAG	.893**	.961**	.984**	.700**	.913**	.974**	.982**	.938**	.870**	.959**	.954**	.969**	.972**	.952**	1

** Correlation is significant at the 0.01 level (2-tailed).

sustainability implementation depends on the organizational strategy. Our results show that the highest loadings achieved in agility practices/dimensions are related to workplace organization (strategic planning), Efficiency, and responsiveness at the same time the sustainability practices indicate the highest loading is achieved with dimensions related to social, economic, environmental dimensions respectively. For example, proper workplace and people planning in agility will directly result in issues such as improvement in employee safety, morale, quality, competitiveness, and reduction in waste. Treacy et al. [83], from a sustainability perspective, such agility improvements will result in improving different dimensions at different levels of sustainability (i.e. economic, social, environmental). The correlation matrix indicates that all agility and sustainability dimensions have a strong relationship with each other, significant at the 0.01 level (2-tailed). The strongest correlation was between PPAG (Process planning) and EcoS (Economic sustainability) and the lowest is between TCAG (technology) and SocS (Social sustainability), as illustrated in Table 11.

5.3. The effect of sustainability practices on operational performance metrics

The impact of sustainability on operational performance was positive and significant. These results confirm previous work conducted by Lin et al. [56]; Gunasekaran et al. [43]; Geyi et al. [35]. According to Esfabbodi et al. [27] implementation of sustainability practices will lead to significant improvement in cost and efficiency. The results of this research indicate that sustainability performance not only leads to improvements in cost and efficiency, but it also leads to significant improvement in morale, productivity, and delivery. Sustainability implementation leads to improvements in waste reduction (i.e. improvement in transportation, material, waiting, motion, etc.) which in turn lower overall cost. The correlation matrix illustrated in Table 11 indicates that items of sustainability and operational performance are all significantly correlated. The highest correlation is between EcoS (Economic sustainability) and OM4 (Delivery) and the lowest is between EnvS (Environmental sustainability) and OM5 (Cost). Implementation of social, environmental, and economic sustainable initiatives will result in improvements such as a reduction in non-value added work, improvement of employee skills, empowerment of employees, improvement in emission reduction, and improvement in union-management relations, therefore increasing organizational profitability. The results presented

in this research provide robust empirical evidence that implantation of sustainability practices will significantly improve operational performance (cost, quality, delivery, morale, and productivity).

5.4. The mediating role of sustainability performance

This research confirms the mediation effect of sustainability performance on the relationship between agility and operational metrics. Previous work that considered sustainability and agility only focused on specific dimensions as well as different industry and mediation dimensions such as supply chain. In comparison, none of the previous research presented considered such a model. For example, Hong et al. [47] and Geyi et al. [35] focused on agility (supply chain) performance being the mediator between sustainability and operational performance. This research contradicts Hong et al. [47] regarding the relationship between agility and sustainability and in comparison to Gevi et al. [35], it indicates that sustainability plays a partial mediator role. In addition to the Sobel test conducted to confirm partial mediation, Fig. 3 shows that path loading from agility to operational performance is 0.910, path loading from agility to sustainability is 0.919, and from the direct effect of sustainability on operational performance is 0.078. Multiplying the direct path from agility to performance will result in 0.071 (i.e. 0.919 \times 0.078), which is less than the direct path from agility to operational performance which is 0.910, this will lead to the conclusion that the mediation impact is partial. Explained variation of 0.845 for sustainability practices and 0.964 for operational metrics. These results agree with previous work conducted by Lin et al. [57]; Gunasekaran et al. [43]; Gupta [44], regarding the drawback of sustainability implementation in certain dimensions and the cost associated with such implementation will negatively impact operational performance short term. When sharing this result with practitioners they indicated that part of the reason why sustainability does not yield a positive impact on performance is driven by the following issues

- No collaboration between employees, union and management and in some cases between upper and lower management,
- No involvement of stakeholders and customers,
- No alignment between agility objectives and sustainability,
- Lack of technology and skilled employees,

- Lack of commitment to initiative related to sustainability-driven mainly by cost and return of investment from a short term perspective.
- Complexity and uncertainty in the market forces management to focus on chasing short term objectives, neglecting long term objectives.

5.5. Theoretical and Managerial Implications

The manufacturing industry around the world is redefining systems and processes to eliminate waste and create more sustainable manufacturing operations. By adopting new and innovative philosophies such as agility and sustainability, manufacturing companies are ensuring competitiveness and longevity. Benefits driven by adopting such philosophies extend beyond the manufacturing facility to benefit all stakeholders ([44]). For example, adopting agility and sustainability dimensions will not only lead to an improvement in productivity, but it can also decrease the negative impact on the environment, economy, and society, therefore benefiting the community, employees, and customers.

This study improves the understanding of agility and sustainability practices by exploring the effect both on each other as well as on operational performance practices adopted by the manufacturing industry at the US automotive companies. The finding provided in this paper confirms that agility practices have an impact on operational performance and sustainability performance. Implementing agility, the seven groups of agility factors (includes 52 dimensions) will lead to an improvement in the three sustainability factors (include 28 dimensions) and also increase the operational performance metrics (i.e. quality, productivity, morale, delivery, and cost). This study confers to the broader literature in our discipline by providing empirical evidence on the effect of a set of sustainable and agile practices on operational performance metrics. This study is the first (in breadth and width) that identifies a comprehensive list of agile dimensions/categories (52 elements identified under seven groups) utilized in the US manufacturing industry. It also, identify the critical role that sustainability can play in supporting the impact of agility on operational performance.

This study presents an insight into how manufacturing organizations can deal with agility and sustainability implementation. Market uncertainties, economic downturns, complexity, and ambiguity will require manufacturing organizations to reduce waste, cost, and other types of inputs. Economic, social, and environmental sustainability implementation will lead to an improvement in competitiveness and significant performance improvement. To optimize operational performance, managers need to implement agility and sustainability practices concurrently. Practitioners need to understand the impact of each element within agility as well as sustainability practices and their impact on each other. For certain factors has more or less impact on operational performance. Understanding such impact will allow managers to shift focus based on objectives required. For example, higher implementation of PPAG and REAG will lead to a significantly higher increase in quality compared to delivery. An agility index based on the seven categories (52 elements) was presented. This index can be used by the automotive companies as a benchmark showing how significant are the agility factors. Moreover, the index gives the manager the priority of what to implement and when to implement it.

Sharing these results with practitioners several issues were pointed out by those managers:

1- Adoption of agility dimensions need to be comprehensive.

- 2- Adoption of sustainability dimensions cannot be driven by short term objectives. Since managers hesitate to invest in sustainability elements due to a low return on investment.
- 3- Adoption of improved, efficient, and continuous relationships among all stakeholders.
- 4- Adoption of an upgraded training system/program for all employees. Keeping in mind that advancement in technology is related to upgrading and improving issues such as people skills, materials and usage, reduction of waste, and alternative energy usage. And that in turn connect all dimensions of sustainability and agility to improve performance.
- 5- The sustainment of this adoption (agility and sustainability dimensions) need a commitment to every member of the organization (including union).

The results presented in this study improve the knowledge of agility and sustainability practices utilized by the US automotive industry. We provide empirical evidence of agility as a driver of operational performance, as well as a clear indication of a significant strong positive relationship between agility and sustainability performance. The findings demonstrate how sustainability and agility implementation (each separate) will result in improvements in operational performance, and when combined their impact on operational performance will improve results in higher improvement. Sustainability is necessary for maximizing the impact of agility on organizational performance metrics. This research offer manager an insight into agility dimensions and how the automotive industry in the US can categorize the elements/factors within agility performance. The interactions between agility, sustainability, and operational performance were demonstrated. Therefore, providing practitioners with a template that can be utilized to prioritize factors implementations based on desired operational performance outcomes and helps managers identify areas that need more attention in the future.

Although operational performance metrics involve more variables (multidimensional), in this paper we were limited to the top 5 items identified as the top priority for manufacturing facility managers. Future research can investigate how agility and sustainability impact other metrics such as supply chain efficiency, employee utilization, environment, reliability, flexibility, etc. The agility index presented in this research provides practitioners with a tool to determine and priorities drivers of agility based on their impact on operational performance. This study focused on primary data obtained from automotive industryrelated facilities (i.e. manufacturing and assembly, Powertrain, and components) in the US. Which does not reflect all automotive or manufacturing industry in the US or around the world. Further research should cover other types of manufacturing industries to get a more robust conclusion (for the US and other countries).

Declaration of Competing Interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.orp.2020.100171.

Appendix

Appendix A: Determining Index and Pairwise comparison

* CR >0.10 go back to step 2

2,4,6,8	These are intermediate scales between 2 adjacent judgments
Reciprocals	If requirement "i" has lower value than i

If 'I" is higher than "j" type integer, If "I" is lower than "j" type 1 divided by the reciprocal #

Table A: For "i" and "j" Value (use above notes), fill in highlighted area

)			
	Factors	CEAG	MHAG	PPAG	QUAG	REAG	TCAG	WPAG
	CEAG	1.00	5.00	1.00	3.00	3.00	6.00	1.00
	MHAG	0.20	1.00	0.14	0.50	0.33	2.00	0.13
;	PPAG	1.00	7.00	1.00	6.00	3.00	7.00	0.50
I	QUAG	0.33	2.00	0.17	1.00	1.00	5.00	0.33
	REAG	0.33	3.00	0.33	1.00	1.00	4.00	0.25
	TCAG	0.17	0.50	0.14	0.20	0.25	1.00	0.13
	WPAG	1.00	8.00	2.00	3.00	4.00	8.00	1.00
						/		

Only fill in the highlighted blocks the reverse is =1/i

Table B: Normalized value for the score in Table A

											Percentage of
Factors	CEAG	MHAG	PPAG	QUAG	REAG	TCAG	WPAG	Score	Sum	Sum/7	Influence
CEAG	0.247934	0.188679	0.208955	0.204082	0.238411	0.181818	0.3	0.224268	1.569879	0.224268	22%
MHAG	0.049587	0.037736	0.029851	0.034014	0.02649	0.060606	0.0375	0.039398	0.275783	0.039398	4%
PPAG	0.247934	0.264151	0.208955	0.408163	0.238411	0.212121	0.15	0.247105	1.729735	0.247105	25%
QUAG	0.082645	0.075472	0.034826	0.068027	0.07947	0.151515	0.1	0.084565	0.591955	0.084565	8%
REAG	0.082645	0.113208	0.069652	0.068027	0.07947	0.121212	0.075	0.08703	0.609213	0.08703	9%
TCAG	0.041322	0.018868	0.029851	0.013605	0.019868	0.030303	0.0375	0.027331	0.191317	0.027331	3%
WPAG	0.247934	0.301887	0.41791	0.204082	0.317881	0.242424	0.3	0.290303	2.032118	0.290303	29%

References

- Adeleye EO, Yusuf YY. Towards agile manufacturing: models of competition and performance outcomes. Int J Agile Syst Manage 2006;1(1):93–110.
- [2] Aluja A, Blanch A. Replicability of first-order 16PF-5 factors: an analysis of three parceling methods. Personal Individ Differ 2004;37(1):667–77.
- [3] Govindan K, Seuring S, Zhu Q, Azevedo SG. Accelerating the transition towards Sustainability dynamics into supply chain relationship management and governance structures. J Clean Prod 2016;112:1813–23.
- [4] Baehr ME, Renck R. The definition and measurement of employee morale. Adm Sci Q 1958:157–84.
- [5] Beske-Janssen P, Johnson MP, Schaltegger S. 20 years of performance measurement in sustainable supply chain management–what has been achieved? Supply Chain Manag. 2015;20(6):664–80.
- [6] Blau G. Testing the generalizability of a career commitment measure and its impact on employee turnover. J Vocat Behav 1989;35(1):88–103.
- [7] Blome C, Schoenherr T, Eckstein D. 'The impact of knowledge transfer and complexity on supply chain flexibility: a knowledge-based view. Int J Prod Econ 2014;147:307–16.
- [8] Bolwijn P, Boorsma T, Van Breukelen QH, Brinkman S, Kumpe T. Flexible manufacturing, integrating technological and social innovation. Amsterdam: Elsevier; 1986.
- [9] Bottani E. Profile and enablers of agile companies: an empirical investigation. Int J Prod Econ 2010;125(2):251–61.
- [10] Brunelli M. Introduction to the analytics hierarchy process. New York: Springer, 2015.
- [11] Byrne BM. Structural equation modeling with AMOS: basic concepts, applications, and programming. Routledge; 2016.
- [12] Carter CR, Rogers DS. A framework of sustainable supply chain management: moving toward new theory. Int J Phys Distrib Logist Manag 2008;38(5):360–87.
- [13] Chen L, Zhao X, Tang O, Price L, Zhang S, Zhu W. Supply chain collaboration for sustainability: a literature review and future research agenda. Int J Prod Econ 2017;194:73–87.
- [14] Chin TA, Tat HH. Does gender diversity moderate the relationship between supply chain management practice and performance in the electronic manufacturing services industry? Int J Logist Res Appl 2015;18(1):35–45.
- [15] Chin TA, Tat HH, Sulaiman Z. 'Green supply chain management, environmental collaboration and sustainability performance. Procedia CIRP 2015;26:695–9.
- [16] Ciccullo F, Pero M, Caridi M, Gosling J, Purvis L. Integrating the environmental and social sustainability pillars into the lean and agile supply chain management

paradigms: a literature review and future research directions. J Clean Prod 2018; 172:2336–50.

- [17] Clason DL, Dormody TJ. Analyzing data measured by individual likert-type items. J Agric Educ 1994;35(4):31–5.
- [18] Coffman DL, MacCallum RC. Using parcels to convert path analysis models into latent variable models. Multivar Behav Res 2005;40(2):235–59.
- [19] Conforto EC, Salum F, Amaral DC, Silva SL, de Almeida LFM. Can agile project management be adopted by industries other than software development. Proj Manage J 2014;45(3):21–34. https://doi.org/10.1002/pmj.21410.
- [20] DeVellis RF. Scale development: theory and applications. UK: Sage Publications; 2016.
- [21] DJSI, 2016. Dow Jones Sustainability Indices. http://www.Sustainability-indices. com/images/.
- [22] Dyllick T, Hockerts K. Beyond the business case for corporate sustainability. Bus Strategy Environ 2002;11(2):130–41.
- [23] El-Khalil R. Lean manufacturing alignment with respect to performance metrics multinational corporations case study. Int J Lean Six Sigma 2020. Vol. ahead-ofprint No. ahead-of-print, https://doi.org/10.1108/IJLSS-10-2017-0118.
- [24] El-Khalil R, Darwish Z. Flexible manufacturing systems performance in U.S. automotive manufacturing plants: a case study. Prod Plan Control 2019;30(1): 48–59.
- [25] Environmental Protection Agency (2019) EPA Publication Number: 100K20001. (n.d.). Retrieved from https://www.epa.gov/newsroom/epa-year-review-2019.
- [26] Esfahbodi A, Zhang Y, Watson G. Sustainable supply chain management in emerging economies: trade-offs between environmental and cost performance. Int J Prod Econ 2016;181(Part B):350–66.
- [27] Esfahbodi A, Zhang Y, Watson G, Zhang T. Governance pressures and performance outcomes of sustainable supply chain management–an empirical analysis of UK manufacturing industry. J Clean Prod 2017;155:66–78.
- [28] Faulkner W, Badurdeen F. Sustainable Value Stream Mapping (Sus-VSM): methodology to visualize and assess manufacturing Sustainability performance. J Clean Prod 2014;85. 8e18.
- [29] Fornell C, Cha J. Partial least squares. Adv Methods Market Res 1994;407(3): 52–78.
- [30] Fornell C, Johnson M, Anderson E, Cha J, Bryant B. The American customer satisfaction index: nature, purpose, and findings. J Market 1996;60(4):7–18.
- [31] Furr M. Psychometrics. Thousand Oaks, California, USA: Sage Publications; 2018.
 [32] Garetti M, Taisch M. Sustainable manufacturing: trends and research challenges. Prod Plan Control 2012;23(2–3):83–104.
- [33] Gehani RR. Time-based management of technology: a taxonomic integration of tactical strategic roles. Int J Oper Prod Manage 1995;15(2):19–35.

- [34] Geng R, Mansouri SA, Aktas E. The relationship between green supply chain management and performance: a meta-analysis of empirical evidences in Asian emerging economies. Int J Prod Econ 2017;183:245–58.
- [35] Geyi DG, Yusuf Y, Menhat S, Abubakar T. Agile capabilities as necessary conditions for maximising sustainable supply chain performance: An empirical investigation. Int J Prod Econ 2020;140(1):531–43.
- [36] Goldman SL, Nagel RN. Management, technology and agility: the emergence of a new era in manufacturing. Int J Technol Manage 1993;8(1/2):18–38.
- [37] Goldman SL, Nagel RN, Preiss K. Agile competitors and virtual organizations: strategies for enriching the customer. New York, NY: Van Nostrand Reinhold; 1995.
- [38] Gordon J, Sohal S. Assessing manufacturing plant competitiveness-An empirical field study. Int J Oper Prod Manag 2001;21(1/2):233–53.
- [39] Gunasekaran A. Agile manufacturing: enablers and an implementation framework. Int J Prod Res 1998;36(5):1223–47.
- [40] Gunasekaran A. Agile manufacturing: a framework for research and development. Int J Prod Econ 1999;62(1/2):87–106.
- [41] Gunasekaran A. Design and implementation of agile manufacturing systems. Int J Prod Econ 1999;62(1/2):1–6.
- [42] Gunasekaran A, Yusuf Y. Agile manufacturing: a taxonomy of strategic and technological imperatives. Int J Prod Res 2002;40(6):1357–85.
- [43] Gunasekaran A, Yusuf Yahaya Y, Adeleye Ezekiel O, Papadopoulos Thanos, Kovvuri Dharma, Asabe Dan, et al. Agile manufacturing: an evolutionary review of practices. Int J Prod Res 2019;57:5154–74. https://doi.org/10.1080/ 00207543.2018.1530478.
- [44] Gupta K. Innovation in manufacturing for sustainability. Switserland: Springer; 2019.
- [45] Hart SL. A natural-resource-based view of the firm. Acad Manag Rev 1995;20(4): 986–1014.
- [46] Helleno AL, Moraes AJI, Simon AT. Integrating Sustainability indicators and lean manufacturing to assess manufacturing processes: application case studies in Brazilian industry. J Clean Prod 2017;153:405–16.
- [47] Hong J, Zhang Y, Ding M. Sustainable supply chain management practices, supply chain dynamic capabilities, and enterprise performance. J Clean Prod 2018;172: 3508–19.
- [48] Hormozi AH. Agile manufacturing: the next logical step. Benchmarking 2001;8 (2):132–43.
- [49] Ismail HS, Snowden SP, Poolton J, Ried IR, Arokiam I. Agile manufacturing framework and practice. Int J Agile Syst Manage 2006;1(1):11–28.
- [50] Jain NK, Jain VK. Computer aided process planning for agile manufacturing environment. In: Gunasekaran A, editor. Agile manufacturing: the 21st century competitive strategy. Oxford: Elsevier; 2001. p. 515–34.
- [51] Jin-Hai L, Anderson AR, Harrison RT. The evolution of agile manufacturing. Bus Process Manage J 2003;9(2):170–89.
- [52] Katiyar R, Meena LP, Barua KM, Tibrewala R. Impact of sustainability and manufacturing practices on supply chain performance: Finding from an emerging economy. Int J Prod Econ 2018;197:303–16.
- [53] Kusiak A, He DW. Design for agile assembly: an operational perspective. Int J Prod Res 1997;35(1):44–7.
- [54] Kusiak A, He DW. Design for agility: a scheduling perspective. Robot Comput-Integr Manuf 1998;14:415–42.
- [55] Landis RS, Beal DJ, Tesluk PE. A comparison of approaches to forming composite measures in structural equation models. Organ Res Methods 2000;3(2):186–207.
- [56] Lin CT, Chiu H, Chu P. Agility index in the supply chain. Int J Prod Econ 2006;100 (2):285–99.
- [57] Lin CT, Chiu H, Tseng YH. Agility evaluation using fuzzy logic. Int J Prod Econ 2006;101(2):353–68.
- [58] Lu RXA, Lee PKC, Cheng TCE. Socially responsible supplier development: construct development and measurement validation. Int J Prod Econ 2012;140 (1):160–7.
- [59] Bevilacqua M, Ciarapica FE, Giacchetta G. Development of a sustainable product lifecycle in manufacturing firms: a case study. Int J Prod Res 2007;45(18–19): 4073–98. https://doi.org/10.1080/00207540701439941.
- [60] Mani V, Gunasekaran A, Papadopoulos T, Hazen B, Dubey R. Supply chain social sustainability for developing nations: evidence from India. Resour Conserv Recycl 2016;111:42–52.
- [61] Marshall AP, Fisher MJ, Brammer J, Eustace P, Grech C, Jones B, et al. Assessing psychometric properties of scales: a case study. J Adv Nurs 2007;59(4): 398–406.
- [62] Meade LM, Sarkis J. Analyzing organizational project alternatives for agile manufacturing processes: an analytical network approach. Int J Prod Res 1999;37 (2):241–61.
- [63] Naylor JB, Naim MM, Berry D. Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. Int J Prod Econ 1999;62 (1–2):107–18.
- [64] Neely A, Gregory M, Platts K. Performance measurement system design: a literature review and research agenda. Int J Oper Prod Manag 2005;25(12): 1228–63.
- [65] Norman G. Likert scales, levels of measurement and the "laws" of statistics. Adv Health Sci Educ 2010;15:625–32.
- [66] Pagell M, Shevchenko A. Why research in sustainable supply chain management should have no future. J Supply Chain Manag 2014;50(1):44–55.
- [67] Paulraj A, Chen IJ, Blome C. 'Motives and performance outcomes of sustainable supply chain management practices: a multi-theoretical perspective. J Bus Ethics 2017;145:239–58.

- [68] Podsakoff PM, MacKenzie SB, Lee J-Y, Podsakoff NP. Common method biases in behavioural research: a critical review of the literature and recommended remedies. J Appl Psychol 2003;88(5):879–903.
- [69] Porter ME. Competitive advantage: creating and sustaining superior performance: with a new introduction. Free Press; 2004.
- [70] Pritchard RD. Productivity measurement and improvement: organizational case studies. Greenwood Publishing Group; 1995.
- [71] Rodrigues Vaz C, Rauen T, Lezana A. Sustainability and innovation in the automotive sector: a structured content analysis. Sustainability 2017;9:1–23.
 [72] Routroy A. Potdar KP. Shankar A. Measurement of manufacturing agility: a ca
- [72] Routroy A, Potdar KP, Shankar A. Measurement of manufacturing agility: a case study. Meas Bus Excell 2015;19(2):1–22.
- [73] Sahin F. Manufacturing competitiveness: different systems to achieve the same results. Prod Inventory Manage J 2000;41(1):56–65.
- [74] Sarkis J, Zhu Q, Lai K. An organizational theoretic review of green supply chain management literature. Int J Prod Econ 2011;130(1):1–15.
- [75] Sharifi H, Zhang Z. A methodology for achieving agility in manufacturing organizations: an introduction. Int J Prod Econ 1999;62:7–22.
- [76] Sharifi H, Zhang Z. Agile manufacturing in practice. Application of a methodology. Int J Oper Prod Manage 2001;21(5/6):772–94.
- [77] Sharp JM, Irani Z, Desai S. Working towards agile manufacturing in the UK industry. Int J Prod Econ 1999;62:155–69.
- [78] Sheridan JH. Where's the agility game plan? Ind Week 1996;245(14):502.
- [79] Sink DS. Productivity management: planning, measurement and evaluation, control and improvement (p. 518). New York, NY: Wiley; 1985.
- [80] Stalk G, Hout TM. Competing against time: how time-based competition is reshaping global markets. New York, NY: The Free Press; 1990.
- [81] Stefanelli NO, Jabbour CJC, Jabbour ABL, de S. Green supply chain management and environmental performance of firms in the bioenergy sector in Brazil: an exploratory survey. Energy Pol 2014;75:312–5.
- [82] Tidd J, Bessant J, Pavitt K. Managing innovation. Chichester: Wiley; 1997.[83] Treacy R, Humphreys P, McIvor R, Lo C. ISO14001 certification and operating
- performance: a practice-based view. Int J Prod Econ 2019;208:319–28. [84] U.S. Bureau of Economic Analysis (BEA), (2019). Retrieved from https://www.
- bea.gov/data/gdp/gross-domestic-product.[85] U.S. Department of Commerce. (2019, April). Retrieved from https://www.
- commerce.gov/data-and-reports/economic-indicators. [86] Vachon S, Klassen RD. Environmental management and manufacturing
- performance: the role of collaboration in the supply chain. Int J Prod Econ 2008; 111(2):299–315.
- [87] Van Assen MF. Agile-based competence management: the relation between agile manufacturing and time-based competence management. Int J Agile Manage Syst 2000;2(2):142–55.
- [88] Vanalle RM, Ganga GMD, Godinho Filho M, Lucato WC. Green supply chain management: an investigation of pressures, practices, and performance within the Brazilian automotive supply chain. J Clean Prod 2017;151:250–9.
- [89] Vázquez-Bustelo D, Avella L, Fernández E. Agility drivers, enablers and outcomes. Int J Oper Prod Manage 2007;27(12):1303–32. https://doi.org/10.1108/ 01443570710835633.
- [90] Vinodh S. Improvement of agility and sustainability: A case study in an Indian rotary switches manufacturing organisation. J Clean Prod 2010;18:1015–20. https://doi.org/10.1016/j.jclepro.2010.02.018.
- [91] Vinodh S, Sundararaj G, Devadasan SR. Measuring organisational agility before and after implementation of TADS. Int J Adv Manuf Technol 2010;47(5–8): 809–18.
- [92] Vokurka R, Fliedner G. The journey toward agility. Ind Manage Data Syst 1998;98 (4):165–71.
- [93] Walker PH, Seuring PS, Sarkis PJ, Klassen PR. Sustainable operations management: recent trends and future directions. Int J Oper Prod Manag 2014;34 (5):1–11.
- [94] WCED SWS. World commission on environment and development. Our Common Future 1987;17:1–91.
- [95] Womack JP, Jones DT, Roos D. The machine that change the world. New York, NY: Simon and Schuster; 1990.
- [96] Wong CWY, Lai K-H, Shang K-C, Lu C-S, Leung TKP. Green operations and the moderating role of environmental management capability of suppliers on manufacturing firm performance. Int J Prod Econ 2012;140(1):283–94.
- [97] World Bank, World Development Indicators. (2019). Retrieved from https://data. worldbank.org/indicator/NY.GDP.MKTP.CD?most_recent_year_desc=true.
- [98] Youn S, Yang MG, Hong P, Park K. Strategic supply chain partnership, environmental supply chain management practices, and performance outcomes: an empirical study of Korean firms. J Clean Prod 2013;56:121–30.
- [99] Youssef MA. Agile manufacturing: a necessary condition for competing on global markets. Ind Eng 1992:177–80. December.
- [100] Yusuf Y, Gunasekaran A, Papadopoulos T, Auchterlounie W, Hollomah D, Menhat M. Performance measurement in the natural gas industry: a case study of Ghana's natural gas supply chain. Benchmarking 2018;25(8):2913–30. https://doi.org/10.1108/BIJ-11-2017-0301.
- [101] Yusuf YY, Adeleye EO. A comparative study of lean and agile manufacturing with a related survey of current practices in UK. Int J Prod Res 2002;40(17):4545–62.
- [102] Yusuf YY, Gunasekaran A, Musa A, Dauda M, El-Berishy NM, Cang S. 'A relational study of supply chain agility, competitiveness and business performance in the oil and gas industry. Int J Prod Econ 2014;147:531–43.
- [103] Yusuf YY, Gunasekaran A, Musa A, El-Berishy NM, Abubakar T, Ambursa HM. The UK oil and gas supply chains: an empirical analysis of adoption of sustainable measures and performance outcomes. Int J Prod Econ 2013;146(2):501–14.

R. El-Khalil and M.A. Mezher

- [104] Yusuf YY, Sarhadi M, Gunasekaran A. Agile manufacturing: the drivers, concepts and attributes. Int J Prod Econ 1999;62:33–43.
- [105] Zhu Q, Sarkis J. Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. J Oper Manag 2004;22(3):265–89.
- [106] Zhu Q, Sarkis J, Lai K. Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices. J Purch Supply Manag 2013;19:106–17.