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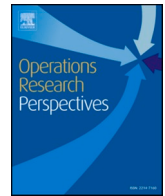
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The mediating impact of sustainability on the relationship between agility and operational performance

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ABSTRACT

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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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

Table 1.
Constructs and their indicators, sources.

Latent Variable/ construct	Indicators/Manifest variables	Reference
Agility "Agility Group/ category (AG)"		
Process Management/ Planning (PPAG)	<p>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.</p> <p>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.</p> <p>P3: The ability to have an organizational structure that promotes innovation, training and education.</p> <p>P4: The ability to gain union/management buy-in regarding new processes and planning.</p> <p>P5: The ability to allocate/determine/accomplish cost goals and objectives.</p> <p>P6: The ability to involve early different agents in the product development process and concurrent execution of functions/activities.</p> <p>P7: The ability to form strategic alliances based on core/complementary competencies.</p>	<p>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)</p>
Work place & team (WPAG)	<p>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.</p> <p>W2: The ability to relocate employees quickly to respond to any changes in demand.</p> <p>W3: The ability to enhance employees belonging (morale) and gain their trust which can positively affect their productivity.</p> <p>W4: The ability to guide employee decisions through acquired knowledge where rapid and sudden decision is needed (Knowledge Management).</p>	<p>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)</p>

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Table 1. (continued)

Latent Variable/ construct	Indicators/Manifest variables	Reference
Quality (QUAG)	W5: The ability to have a range of tasks that an operator can perform within the manufacturing system.	Gunasekaran [[40], 1998] and Gunasekaran and Yusuf [42]
	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.	
	Q1: The ability to implement automation.	
	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)	
Technologies (TCAG)	Q5: The ability to eliminate problems at their source (Kaizen).	Gunasekaran [1998][40], Gunasekaran and Yusuf [42] Group technology Gunasekaran [39,40], Gunasekaran and Yusuf [42] and Yao and Carlson (2003)
	Q6: The ability to implement lean production system (7 wastes, standardization, 5s..).	
	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 decouple processes in order to isolate problem source.		
T6: The ability to use software and computer-controlled machinery to automate a manufacturing process (Computer aided manufacturing).		
T7: The ability of a system to run virtually unattended for a long enough period.		
T8: The ability to quickly fabricate a scale model of a		

Table 1. (continued)

Latent Variable/ construct	Indicators/Manifest variables	Reference		
Material Handling/ Delivery (MHAG)	physical part or assembly using three-dimensional computer aided design data (Rapid prototyping).	Gunasekaran [1998] [40], Gunasekaran and Yusuf [42], Venugopal and Saleeshya (2019), Flidner and Vokurka (1997) and Yao and Carlson (2003)		
	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, 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.			
Competency/ Efficiency (CEAG)	M6: The ability to implement automated guided vehicle systems (AGVs); automated storage and retrieval systems (AS/RS).	Gunasekaran [1998] [40], Gunasekaran and Yusuf [42], Sahin [73], Meade and Sarkis [62] and Parkinson (1999) The ability/ease to increase.		
	C1: The ability to implement a systematic determination 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 of the system to produce different part types without incurring a major setup.			
	C7: The ability to produce products with different dimensions and shapes (new design).			
	C8: The ability to operate profitably at different throughput levels.			
	C9: 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.			
	Responsiveness (REAG)			Gunasekaran [1998] [40], Cho et al. (1996), Gunasekaran and Yusuf [42], Jin-Hai et al. [51], Goldman and Nagel [36], Yao and Carlson (2003) and Geyi et al. (2019)

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Table 1. (continued)

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.	
	SEC1:Improved market share	[102,103]; Golicic and Smith (2013); Paulraj et al. [67]
	SEC2: Improved company image.	
	SEC3: Improved company's image in market place.	
SEC4: Increase profitability.		
SEC5: Decreasing in material purchasing cost.		
SEC6: Decrease in utility bills.		
SEC7: Decrease in waste treatment fees.		
SEC8: Decrease in waste discharge fees.		
SEC9: Reduction of environmental accident cases.		
SEC10: Improved product quality.		
SEN1: Reduce CO2 emissions	[27,67,96,106]; Blome et al. [7]	
SEN2: Reduction of wastewater		
SEN3:Reduction of solid wastes		
SEN4: Reduction of energy consumption		
SEN5: Decrease in production of toxic, hazardous, or harmful substances		
SEN6: Decrease in material usage		
SEN7: Improved compliance with environmental standards		
SSO1: The firm has very good relations with the community and stakeholders	Paulraj et al. [67]; Jennings (2013); Krause et al. (2009); Chin et al. [15]; Sarkis et al. (2010); Klassen and Vereecke (2012)	

Table 1. (continued)

Latent Variable/ construct	Indicators/Manifest variables	Reference
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 ensures product safety	
	Quality: Improvement in Quality (OM1).	[102,106]; Ren et al., 2003; Blome et al., 2013; Eckstein et al. (2015)
Productivity: Improvement in Productivity (OM2).		
Morale: Improvement in employee Morale (OM3)		
Delivery: Improvement in product Delivery (OM4).		
Cost: Improvement in overall Cost (OM5).		

their performance against defined objectives and detect discrepancies [100]. Beske-Janssen et al. [5] stated that any performance measurement 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).

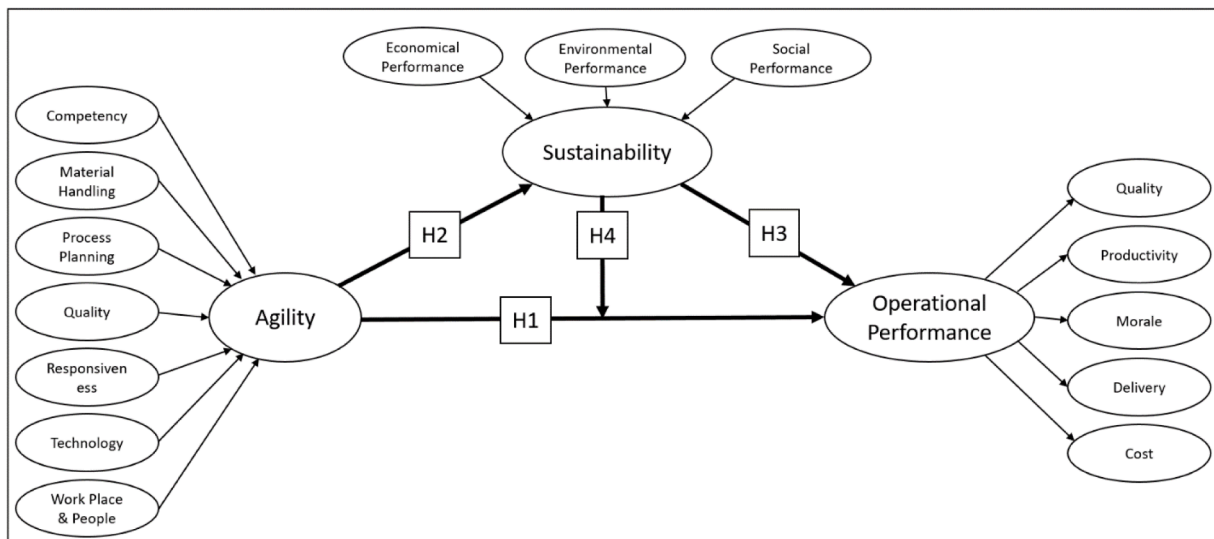


Fig. 1.. Conceptual framework and hypotheses.

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 automation. 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,

Table 2. Respondent's demographics and facilities information

Relevant Dimension	Type/Issue measured and ratio		
Type of manufacturing Facility	Assembly	Powertrain	Component
Managerial position	41% Production	28% Engineering	31% Other (Comptrollers, Material handling, Facility, HR..etc)
Manager Level of Education	53% BS/BA	30% Masters	17% DBA/PhD
Participants work experience	21% 5 years or less	77% 6-15years	2% Above 15 years
Gender by the type of facility (Female/Male/Other)	0% 40% F/60% M	21% Powertrain	79% Component
Revenues/Size	Small (annual sales less than \$100 million)	Mid-size (\$100-\$999 million)	Large (\$1 Billion plus)
Age of the Firm	0% 15 Years or less	33% 16 - 20 years	66% Above 25 Years
Number of employees	4% 1000 or less	8% 1001-5000	88% 5000 and above
Agility implementation history	0% 5 Years or less	40% 6-10 years	60% 10 years +
Sustainability implementation history	48% 5 Years or less	27% 6-10 years	25% 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 where 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 Sampling Adequacy.		0.984
Bartlett's Test of Sphericity	33158.1	2455.5
	3570	677.23
	0.000	0.000

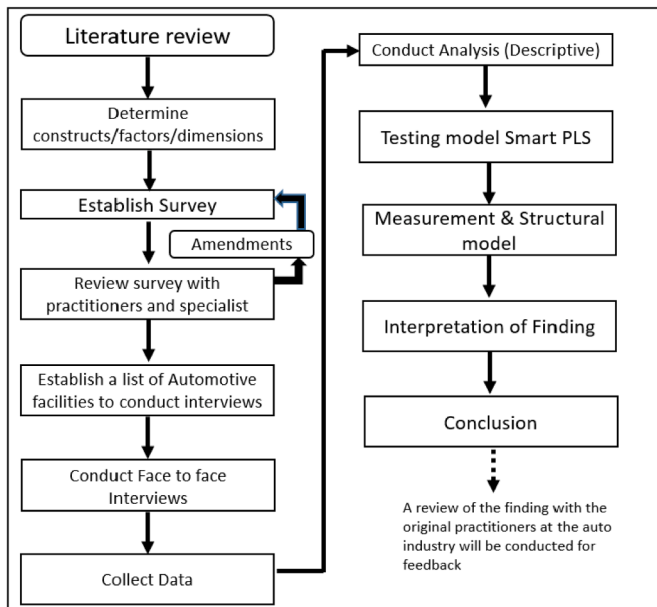


Fig. 2.. Research methodology.

Table 4.
Exploratory factor Analysis: Factor loadings for explanatory Variables (SPSS).

Items	Factor loadings											Extracted Communalities h2
	1 CEAG	2 MHAG	3 PPAG	4 QUAG	5 REAG	6 TCAG	7 WPAG	8 EcoS	9 EnvS	10 SocS	11 OPM	
P1			0.97									0.94
P2			0.97									0.941
P3			0.97									0.941
P4			0.971									0.942
P5			0.974									0.949
P6			0.972									0.944
P7			0.974									0.948
W1								0.969				0.938
W2								0.971				0.944
W3								0.971				0.943
W4								0.969				0.94
W5								0.972				0.944
W6								0.967				0.936
W7								0.969				0.939
Q1				0.97								0.941
Q2				0.969								0.939
Q3				0.973								0.947
Q4				0.965								0.932
Q5				0.972								0.945
Q6				0.978								0.956
Q7				0.971								0.943
T1						0.763						0.582
T2						0.767						0.589
T3						0.767						0.588
T4						0.793						0.628
T5						0.814						0.662
T6						0.779						0.607
T7						0.776						0.603
T8						0.773						0.598
M1		0.907										0.823
M2		0.905										0.819
M3		0.886										0.786
M4		0.919										0.845
M5		0.897										0.805
M6		0.907										0.822
C1	0.961											0.924
C2	0.96											0.921
C3	0.967											0.936
C4	0.965											0.932
C5	0.969											0.94
C6	0.969											0.939
C7	0.966											0.934
C8	0.965											0.932
C9	0.967											0.935
R1					0.951							0.905
R2					0.956							0.914
R3					0.962							0.925
R4					0.962							0.925
R5					0.959							0.919
R6					0.955							0.913
R7					0.971							0.942
R8					0.962							0.925
EcoS1							0.92					0.846
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							0.936					0.877
EnvS1								0.882				0.777
EnvS2								0.922				0.851
EnvS3								0.926				0.858
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
SocS2									0.892			0.795
SocS3									0.88			0.774
SocS4									0.875			0.766
SocS5									0.767			0.752
SocS6									0.887			0.786
SocS7									0.854			0.729
SocS8									0.882			0.778
SocS9									0.869			0.755
SocS10									0.873			0.763
SocS11									0.88			0.775
Quality (OM1)											0.979	0.959
Productivity (OM2)											0.971	0.942
Morale (OM3)											0.972	0.945
Delivery (OM4)											0.974	0.949
Cost (OM5)											0.97	0.941
% of Variance	87.3	81.6	94.4	90.4	86.2	60.7	93.2	84.4	82.6	76.5	92.7	

Extraction Method: Principle Component Analysis, Rotation Method: Varimax with Kaiser Normalization, Rotation convergence in 25 iterations

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 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).

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

w_i represent the weight of item i , and \bar{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.
Measurement model result (PLS).

Latent variable	Indicator	Outer Weight	Loading	Communality	AVE	CR	Rho_A	Cronbach's Alpha
Agility Performance					0.89	0.983	0.986	0.979
Process Planning	P1	0.240	0.963	0.958				
	P2	0.237	0.965	0.962				
	P3	0.236	0.966	0.959				
	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				
	W6	0.226	0.949	0.935				
	W7	0.226	0.948	0.935				
Quality	Q1	0.235	0.942	0.949				
	Q2	0.234	0.944	0.949				
	Q3	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				
	T3	0.141	0.761	0.754				
	T4	0.132	0.757	0.751				
	T5	0.134	0.759	0.752				
	T6	0.128	0.757	0.750				
	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	C1	0.231	0.938	0.950				
	C2	0.230	0.935	0.949				
	C3	0.232	0.943	0.958				
	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				
	R2	0.235	0.948	0.938				
	R3	0.236	0.952	0.947				
	R4	0.235	0.951	0.944				
	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 Perfomance					0.98	0.992	989	0.987
Economical	EcoS1	0.420	0.922	0.862				
	EcoS2	0.424	0.903	0.864				
	EcoS3	0.425	0.917	0.866				
	EcoS4	0.429	0.913	0.874				
	EcoS5	0.422	0.906	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				
	EnvS3	0.392	0.899	0.793				
	EnvS4	0.395	0.901	0.798				
	EnvS5	0.392	0.902	0.794				
	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	Indicator	Outer Weight	Loading	Communality	AVE	CR	Rho_A	Cronbach's Alpha
Operational Performance	SocS4	0.397	0.869	0.816	0.95	0.992	0.989	0.987
	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				
	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.

Measurement model results (parceling).

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

^d All Cronbach's Alpha > 0.7 indicates indicator reliability.

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

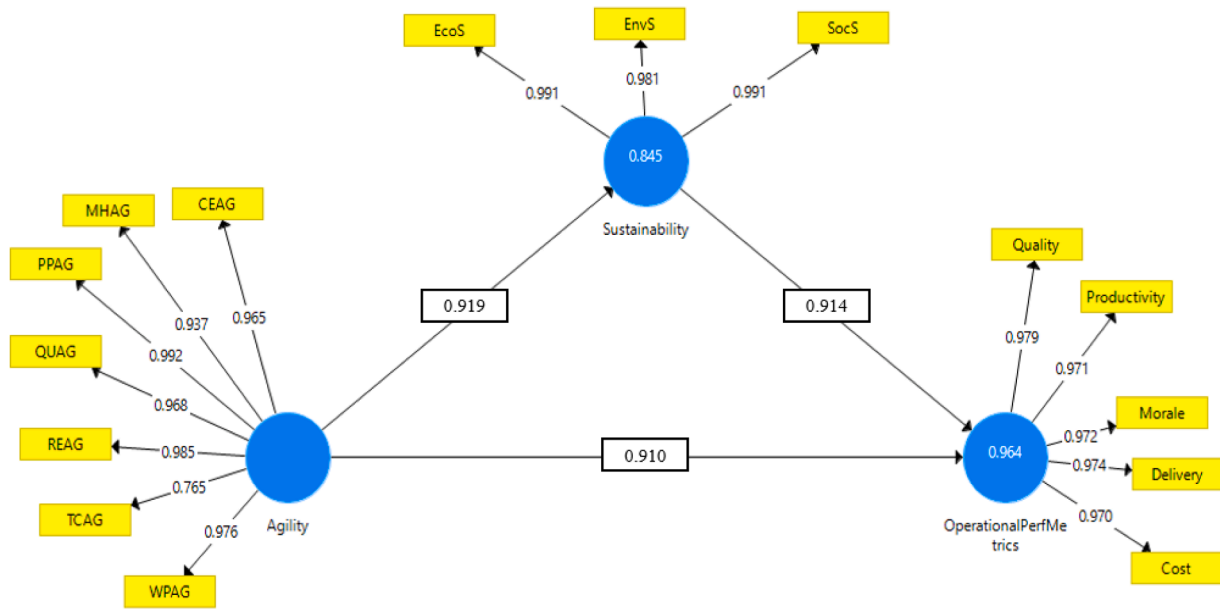


Fig. 3.. Structural model (PLS algorithm results).

Table 8. Results of hypothesis testing and mediation analysis.

Hypotheses	Path	Path Coefficient	Std Error	T Statistics	P Values	Result
<i>Direct Effect</i>						
H1	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
<i>Indirect Effect</i>						
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 Esfahbodi 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 Geyi 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. 0.919×0.078), 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 industry-related 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](https://doi.org/10.1016/j.orp.2020.100171).

Appendix

Appendix A: Determining Index and Pairwise comparison

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

* CR >0.10 go back to step 2

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

		j							
		CEAG	MHAG	PPAG	QUAG	REAG	TCAG	WPAG	
i	Factors	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
		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

Factors	CEAG	MHAG	PPAG	QUAG	REAG	TCAG	WPAG	Score	Sum	Sum/7	Percentage of 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%

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