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From Data Sciences to Decisions: How Analytics, Sensing, Process Integration, Human Resource Flexibility, and Technology Orientation Lift Manufacturing Operations Under a Data-Driven Shop-Floor Culture

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ABSTRACT

Decision making process of the companies improved through analytical capability, sensing capability, process integration, human resource flexibility, and technology orientation which leads to enhanced operational performance. Therefore, research aimed to test the influence of analytical capability, sensing capability, process integration, human resource flexibility, and technology orientation on operational performance with the moderating influence of data-driven culture. Cross-sectional quantitative data were employed from 315 transportation and engineering employees. The depicted results show that analytical capability, sensing capability, process integration, human resource flexibility, and technology orientation each have a significant and positive impact on the operational performance. Moreover, the data-driven culture moderates positively to promote the transportation and engineering company's operational performance. Study results emphasize the significance of cultivating a decision-making making data-driven culture in manufacturing settings to transform sensor data into actionable decisions, enhance operational excellence, and improve responsiveness to dynamic market conditions. The results contribute theoretically by extending the dynamic capability theory and practically by guiding managers to raise a strong data-driven environment that leverages analytics, sensing, and technology for superior operational performance that could support to better operational decisions.

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1. Introduction

Operational performance (OP) becomes an important for the company's long term success because it directly impacts the company's productivity and competitive advantage (Al-Qubaisi & Ajmal, 2018). OP directly affects to the companies in compromising their ability through effectively managing their resources, and products that increase the customers' expectations in terms of their cost with compromising cost (Kenyon, 2025). In other ways, OP also enhances the internal process efficiency through reducing waste management and improving cost management, which increases companies sustainability in the competitive market (Oteri et al., 2023). Additionally, OP also serves as a critical link between organizational strategy and execution, which is ensuring that strategic goals are translated into tangible outcomes such as increased market share, customer satisfaction, and innovation capacity (Al Najjar & Qandeel, 2025). Furthermore, OP also increases the firm's ability to adopt the internal and external pressures, such as technological disruptions, fluctuating demand, and supply chain uncertainties, which enhances the long-term sustainability(Zhou et al., 2024). In the context of modern industries driven by data analytics and digital transformation, superior OP not only improves the decision-making process but also raises continuous improvement of the companies (Song et al., 2022). Literature supported that the OP of the companies is being increased when the companies have a stronger decision-making process (Wong & Ngai, 2025). It has been highlighted in the literature that when firms improve their decision-making process then their OP significantly improves because effective decisions in the organizations are totally based on accurate insights and timely information, which leads in the organizations to increased efficiency and productivity (Carmeli et al., 2009). Therefore, to increase decision-making capability, various factors such as analytical capability, sensing capability, human resource flexibility, technology orientation, and process integration play a vital role, which increase the company's overall OP (Ansari & Ghasemaghaei, 2023; Liu et al., 2024; Raj et al., 2025; Su et al., 2022; Wong & Ngai, 2025). Analytical capability helps companies to collect, process, and interpret data to make informed operational decisions, improving cost control, production scheduling, and quality management (Kamble & Gunasekaran, 2020). In other perspectives, sensing capability helps companies in detecting the emerging market trends, customer preferences, and environmental changes, which helps to companies in handling proactive adjustments in the operations which increase the competitiveness and OP of the companies (Zhou et al., 2025). Human resource flexibility supports effective decision-making by providing the ability to reallocate and adapt resources based on fluctuating production needs or supply disruption (Rehman & Jajja, 2023). Technology orientation strengthens the OP through promoting the use of digital tools, automation, and innovation (Zhou et al., 2025). Lastly, process integration ensures smooth coordination across departments and supply chain partners, enabling to companies in synchronized decisions which increases the company's overall operational consistency (Östlund & Gustafsson, 2024).

Collectively, these factors empower firms to make better, faster, and data-driven decisions, leading to superior OP. Therefore, the study mainly focused on improving operational efficiency through data data-driven culture. Companies improve their decision-making capabilities when they have a better data-driven culture, which leads to improved OP (Östlund & Gustafsson, 2024). In the companies where the company's decisions are being guided by the data, except intuitions, then operational strategies become more precise and adaptable as per the market-changing conditions (Constantiou & Kallinikos, 2015). A strong data-driven culture enhances analytical capability by promoting the use of advanced analytics, predictive modeling, and performance metrics to identify process inefficiencies and optimize resource utilization (Wong & Ngai, 2025). It also reinforces sensing capability by enabling real-time monitoring of market signals, customer behaviors, and environmental shifts through data intelligence systems, allowing faster and more accurate responses. Ridwan that could lead to improve the OP (Ridwan, 2025). Similarly, human resource flexibility benefits from data-driven insights that inform decisions on production planning, workforce deployment, and inventory management are leading to provide agile and cost-effective operations. Technology orientation thrives in a data-centric environment, as digital tools and automation rely on data for continuous improvement and innovation (Tafoya, 2025). Furthermore, process integration also becomes a more efficient when is being supported through a culture which is data sharing and transparency across departments, enhancing coordination and reducing decision latency (Paiva et al., 2021). Without a robust data-driven culture, these capabilities may not be fully leveraged, resulting in fragmented decision-making and suboptimal OP (Gade, 2021). This is the reason; data data-driven culture acts as an important enabler, which amplifies the positive effect of these capabilities on OP.

Therefore, the study focused on using data data-driven culture as a moderating variable to increase OP. Despite the growing body of literature emphasizing the importance of analytical capability, sensing capability, human resource flexibility, technology orientation, and process integration, various gaps exist in the literature. For instance, most of the prior studies have primarily examined their effect on the OP with limited attention on the moderating mechanism, which could strengthen or weaken these relationships (Ansari & Ghasemaghaei, 2023; Liu et al., 2024; Raj et al., 2025; Su et al., 2022; Wong & Ngai, 2025). Existing findings are often inconsistent (Ansari & Ghasemaghaei, 2023; Benzidia et al., 2021; Gangwani & Bhatia, 2024; Manafe et al., 2024; Raj et al., 2025; Yu et al., 2021). This relationship emphasis that further research needs to addressed with moderating variable. In this regard, data driven culture could be used a moderating variable because it could become a better enabler of OP, yet prior research has largely overlooked its moderating influence on how these organizational capabilities translate into improved performance (Almazmomi et al., 2022; Chatterjee et al., 2024). While, is this study data driven culture has been used a moderating to increase the company's decision-making optimization to improve OP. Furthermore, prior studies have also been conducted on other sectors, with limited attention on transportation and engineering manufacturing companies, which heavily rely on data, technology, and integrated processes for OP (Almazmomi et al., 2022). The technology and engineering industry faces various challenges in production variability, and high equipment maintenance cost (Giannopoulos & Moschovou, 2023). To reduce this challenge, prior researchers highlighted that analytical and sensing capabilities enable real-time monitoring of machinery and logistics systems; human resource flexibility ensures adaptability to fluctuating production schedules, which increases the company's OP (Alonge et al., 2023). On the other hand, technology integration in transportation raises innovations in their production system, which increases the company's OP (Tseng & Liao, 2015). Furthermore, process integration also enhances coordination within organizations between engineering design, production, and transportation functions (Drachuk et al., 2021). Therefore, investigating how a data-driven culture moderates these relationships in the transportation and engineering manufacturing context not only addresses existing research gaps but it also offers valuable insights for firms aiming to achieve data-empowered operational excellence. Therefore, the study objective is to test the effect of analytical capability, sensing capability, human resource flexibility, technology orientation, and process integration on OP through the data-driven culture of the transportation and engineering sector. Study with the objective contributed in prior literature through contributing literature in the existing studies through extending the understanding of how the decision-making process improves organizational capabilities, and interacting with a data-driven culture to enhance OP, especially in the transportation and engineering manufacturing sectors (Haider, 2024). Study with the moderating effect of data-driven culture, research addresses a significant gap in the prior literature, where most of the prior studies were focused on direct effects. This approach advances dynamic capability theory by demonstrating that the effectiveness of operational capabilities is not static but is also contingent upon the firm's cultural orientation toward data usage and evidence-based decision-making (Karami, 2023). Practically, the findings emphasize that companies in transportation and engineering manufacturing should cultivate a data-driven culture to fully leverage their analytical and technological resources for improving OP. On the other hand, managers should invest in digital infrastructure, employee data literacy, and cross-departmental data sharing to ensure informed, agile, and coordinated decision-making, which could enable companies to increase their responsiveness according to market fluctuations, minimize operational inefficiencies, and achieve sustainable competitive advantage in increasingly data-intensive industrial environments

2. Literature Review

2.1 Analytical Capability and Operational Performance

Analytical capability represents the companies' ability to drive larger data in the meaningful way that supports to companies in increasing decision-making process to improve OP (Akter et al., 2021). In other words, it also represents the companies' ability to transform the raw data into actionable insights, which could increase the process optimization and cost efficiency (Palaniappan, 2025). In other words, operationally analytical capability always allows firms to identify inefficiencies and optimize supply chain activities, which helps to improve the company's operational performance (OP) (Alonge et al., 2023). The importance of analytical capability in improving OP lies in its role as a foundation for data-driven decisions. Firms with strong analytical capabilities can optimize resource allocation, improve process visibility, and enhance productivity (Adesina et al., 2024). In manufacturing and service sectors, analytics help firms adapt to uncertainty by identifying performance bottlenecks and proposing strategic improvements (Wolniak, 2024b). In other perspectives, analytical capability also strengthens the competitive advantage through continuous improving the decision-making process (Wolniak, 2024a). They also identified that companies with a stronger analytical capability always increase productivity and improve their cost efficiency. Chaudhuri et al. further explained that analytics-driven organizations outperform competitors operationally (Chaudhuri et al., 2024). However, some studies found limited or insignificant effects, especially when analytics are not aligned with organizational strategy or culture (Alaskar, 2023). These prior studies have shown that analytical capability increases the OP, and accordingly hypothesis is,

H1: Analytical capability significantly influences to operational performance.

2.2 Sensing Capability and Operational Performance

Sensing capability consisted of the firm's ability to detect and anticipate the business changes according to environment of the business (Song et al., 2022). It enables organizations to identify the opportunities and threats that are guiding them in adjusting resources and processes proactively (Ahmad, 2024). In other words, sensing capability also allows firms to monitor demand fluctuations, supplier dynamics, and technology advancements, which helps them to maintain a company's OP (Song et al., 2022). Equally, sensing capability is also important for improving the OP by enhancing responsiveness and adaptability (Wong & Ngai, 2025). Firms with strong sensing capabilities can anticipate disruptions and reconfigure processes to minimize negative impacts on performance (Ahmad, 2024). This agility supports operational continuity and helps achieve customer satisfaction through reliable delivery and quality consistency (Stank et al., 2022). Rehman & Jajja, empirically found that sensing capabilities significantly enhance a firm's ability to manage operations efficiently under uncertain conditions (Rehman & Jajja, 2023). In another study, it is found that sensing capability alone does not guarantee improved operational outcomes unless combined with integrating and reconfiguring capabilities (Zungu & Laryea, 2025). In this regard, while sensing is important for the environmental performance but it is also important to improve the OP and accordingly hypothesis is,

H2: Sensing capability significantly influences to operational performance.

2.3 Human Resource Flexibility and Operational Performance

Human resource flexibility represents the organization's ability to utilize organizational resources for various purposes along with a minimum cost (Martinez-Sanchez et al., 2021). It encompasses flexibility in labor, equipment, and processes, which allows firms to in adapting quickly changes as a per the market demand and production requirements (Siagian et al., 2021). Furthermore, human resource flexibility is also vital for managing variability and maintaining efficiency under uncertainty (Alzoraiki et al., 2024). Another study also found that human resource flexibility is an important indicator for OP lies in its potential to balance efficiency and responsiveness. Firms with flexible resources can handle fluctuations in customer demand, supply chain disruptions, and production changes without compromising performance (Östlund & Gustafsson, 2024). This flexibility leads to better utilization of assets and improved cost-effectiveness, contributing to sustained operational excellence (Nyangoma et al., 2024). Manzoor empirically found that human resource flexibility positively impacts OP (Manzoor et al., 2022), especially in the current dynamic markets. While other studies reported that excessive flexibility may reduce operational efficiency due to higher coordination costs and resource redundancy (Yang et al., 2024). Therefore, the effectiveness of human resource flexibility depends on maintaining a balance between adaptability and cost control. Prior studies highlighted that human resource flexibility is an integral factor to improve OP, and accordingly hypothesis is,

H3: Human resource flexibility significantly influences to operational performance**.**

2.4 Technology Orientation and Operational Performance

Technology orientation consisted of the company’s ability in designing a strategic formulation for adopting and utilizing new technology for improving the OP (Nugroho et al., 2022). It shown the reflections of companies' openness towards the technology changes and their ability in using technology to improve OP (Lepore et al., 2023). From another perspective, companies who have better orientation in the technology they have stronger process automation, enhances data accuracy, and supports efficient production and logistics (JADOUN, 2024). Equally, technology-oriented companies are also often early adopters of systems that improve quality, reduce costs, and enhance decision-making (Zhou et al., 2025). Such firms integrate digital tools to optimize workflows and resource allocation, directly contributing to operational excellence. Adiguzel et al. empirical studies that technology-oriented firms achieve higher OP (Adiguzel et al., 2025). In the same vein, Savitri et al. study also found that technology orientation enhances adaptability (Savitri et al., 2021), which leads to improving the OP. Conversely, Obiki-Osafiele et al. found that excessive focus on technology without adequate human and process alignment can lead to inefficiencies or increased operational costs (Obiki-Osafiele et al., 2024), which could decrease the company’s OP. Thus, technology orientation’s effectiveness depends on strategic integration with operational processes in increasing the company’s OP, and accordingly hypothesis is,

H4: Technology orientation significantly influences to operational performance**.**

2.5 Process Integration and Operational Performance

Process integration involved coordinating various internal and external processes to ensure smooth information and material flow across organizational boundaries (Hettich & Kreutzer, 2021). It consisted of integrating various internal and external stakeholders through better collaborative systems and shared information platforms (Li et al., 2022). Furthermore, process integration also ensures coherence between planning, procurement, production, and distribution functions, which leads towards a greater OP (Althabatah et al., 2023). Process integration also able to help the organization in increasing their faster decisions making which increases the visibility across the value chain (Wyciślak, 2024). It also raises collaboration and ensures alignment between operational activities and strategic objectives, resulting in enhanced performance outcomes (Kissimoto et al., 2023). Olayinka empirical study also found that process integration significantly improves efficiency (Olayinka, 2021), responsiveness, and quality performance. While other studies highlighted various challenges, such as coordination costs, data sharing reluctance, and incompatibility between partners, that limit benefits (Susha et al., 2023). These studies highlight that process integration increases the OP, but its success totally depends on mutual trust, information quality, and technological compatibility among partners, and accordingly hypothesis is,

H5: Process integration significantly influences to operational performance**.**

2.6 Moderating Effect of Data Driven Culture

Previously discussed that analytical, sensing capability, human resource flexibility, technology integration, and process integration are integral factors to improve the OP, but the prior studies on these relationships are still have inconsistent findings. This is enforcing that further relationship could be tested with other moderating variables, like as data-driven culture. As an analytical capability, which consisted of an organization's ability to collect, interpret, and utilize data to make informed, better operational decisions. However, its impact on OP can be significantly enhanced when supported by a strong data-driven culture (DDC) (Östlund & Gustafsson, 2024). A better DDC helps to promote effective decision-making which are based on empirical based rather than on intuitions, where the data analytical insights are integrated into day-to-day operations (Östlund & Gustafsson, 2024). When organizations cultivate a DDC, employees at all levels are encouraged to trust and apply analytical outputs, which ensures that analytical capability translates into measurable operational gains such as reduced costs, better resource allocation, and improved productivity. In contrast, in firms lacking such a culture, analytical tools may remain underutilized and which could reduce the OP (Chaudhuri et al., 2024). Furthermore, sensing capability allows to the companies in responding a proactively as per the environmental changes which could improve the flexibility and OP (Bhatia, 2021). A better data driven culture always helps to improve the sensing capability through embedding evidence-based monitoring and forecasting mechanisms in the organizations (Iyer, 2025). When DDC is high, sensing activities are guided by data analytics, enabling timely recognition of customer needs and operational inefficiencies. Employees in data-oriented cultures are more likely to use predictive analytics and data visualization tools to interpret patterns, thereby improving decision accuracy Hurbean et al. (Hurbean et al., 2024).

On the other hand, companies with the low DDC, then the companies relied more on intuitions or fragmented information which could lead to delayed responses. Consequently, DDC enhances improves the sensing capability to enhance OP through enabling organizations to transform sensed information into rapid, data-backed strategic actions. Furthermore, human resource flexibility, which reflects the firm's ability to reconfigure the resources efficiently to increase OP (Larabi, 2025). As the human resource flexibility could alone contribute towards the performance improvements but it effectiveness could be more magnified through the improvement of DDC (Thummala & Saxena, 2024). Authors argued that DDC always helps to facilitate the real-time data, which enables managers to the mangers in making evidence-based decisions on resource reallocation and utilization (Thummala & Saxena, 2024). For example, companies with stronger DDC can use data analytics to forecast capacity constraints, manage inventories dynamically, and allocate labor or technology assets effectively. This alignment between flexibility and data insight enhances overall operational efficiency and responsiveness (Thummala & Saxena, 2024).Conversely, companies without the DDC orientation, resources that are flexible might not be used optimally due to delayed or inaccurate information. These prior studies emphasized that DDC could improve the human resource flexibility to improve the OP, and accordingly hypothesis is, Technology integration which emphasizes a company's tendency in adopting an advanced technologies for increasing OP (Ganbold et al., 2021).As, the technology integration could improve the OP through improving the process efficiency while its impact could be improve when the companies have strong DDC (Atieh et al., 2025). A better DDC ensures that technological tools are not just implemented but they also systematically used to gather and operational data to increase the OP (Adepoju et al., 2022). Organizations with high DDC are better positioned to integrate technologies into daily operations which could lead to superior coordination, reduced downtime, and higher process optimization (Chukwunweike et al., 2024).In other words, technology integration could not improve OP without supporting culture often results in underutilization and poor return on investment. These studies emphasized that strong DDC could improve the infrastructure of technology through embedding data-centric thinking across technological processes and decision frameworks.

Lastly, process integration also comprises to create coordination in the internal and external business processes to increase the OP (Anwar et al., 2025). As the process integration directly increases the OP through reducing redundancy and its influence could become more substantial under a strong DDC. The DDC always facilitates the data that is transparent which is being exchanges across departments which is ensuring that integrated processes are continuously monitored and optimized (Орлов, 2024). When an organization have better data driven culture, process integration efforts are guided by real-time performance metrics, predictive analytics, and cross-functional data insights. This synergy minimizes operational bottlenecks, improves process visibility, and enhances OP (Balogun et al., 2025). Conversely, low DDC environments often experience fragmented data practices that undermine integration benefits. Therefore, DDC serves as a crucial moderator that strengthens the positive impact of process integration on OP. Accordingly, study has following hypothesis below,

H6: Analytical capability significantly influences to operational performance with moderating effect of data driven culture.

H7: Sensing capability significantly influences to operational performance with moderating effect of data driven culture.

H8: human resource flexibility significantly influences to operational performance with moderating effect of data driven culture.

H9: Technology orientation significantly influences to operational performance with moderating effect of data driven culture.

H10: process integration significantly influences to operational performance with moderating effect of data driven culture.

3. Research Methods

The research objective was to test the influence of sensing capability, human resource flexibility, technology integration, and process integration on the operational performance of transportation and engineering companies. Moderating effect of data-driven culture also used. Study with this objective, used the quantitative deductive approach where data collected in numbers. A key strength of the quantitative research approach is its ability to produce generalizable results through statistical analysis (Ghanad, 2023). On the other hand, data collected through the survey instrument where data collected in a distributed questionnaire at one time, and here cross cross-sectional research design is more suitable for the current study. A key strength of the cross-sectional research design is its ability to quickly improve the picture of variables at one point in time, allowing efficient comparison across groups. Therefore, researchers employed the cross-sectional design for the current study.

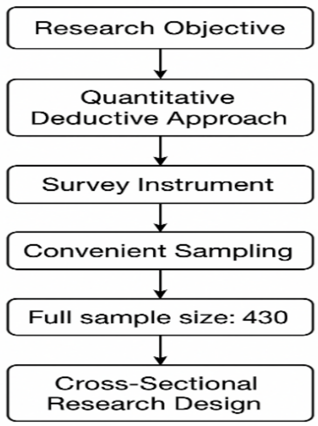

Figure 1: Research Process

3.1 Questionnaire and Sampling Technique

The population of the study was the employees of transportation and engineering manufacturing companies. Questionnaires were distributed among 430 employees of transportation and engineering manufacturing companies using a convenience sampling technique. Convenient sampling technique is a strong because it is quick, inexpensive, and easy to implement. It allows researchers to gather data rapidly from readily available participants (Golzar et al., 2022). From these 430 responses, 330 questionnaires were returned, and among those, 315 were valid for analysis; that is enough response rate for a social sciences study. Respondents distributed questionnaires were adopted from the prior studies where it was already used and tested. Sensing capability comprises four items from (Wong & Ngai, 2025). Data-driven culture is measured by four items (Wong & Ngai, 2025). Operational performance was tested after using seven items from (Wong & Ngai, 2025). Analytical capability was measured using five items (Wong & Ngai, 2025). Process integration was measured from seven items (Irfan et al., 2020). Human resource flexibility also comprised seven items adopted from (Úbeda-García et al., 2017). Technology orientation was measured using four items adopted from (Nassani et al., 2023). Research instrument ranked on above five-point Likert scale and variables are predicted in Figure.2 below.

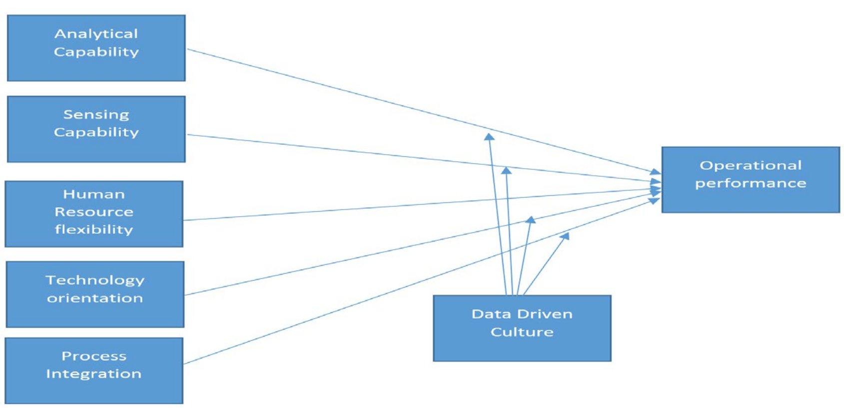

Figure 2: Research Framework

4. Data Analysis and Results

This section shown the demographic results of the 315 respondents from transportation and engineering companies show a workforce dominated by males (66.7%), which is reflecting the traditionally male-oriented nature of these sectors. Majority of the respondents are belonging to middle age of 35 years age group (44.4%), which is indicating a relatively active and productive workforce. From education perspectives, most of the respondents have bachelor's degree (47.6%), suggesting that the industry relies heavily on employees with formal technical and professional qualifications. Work experience levels vary, though a substantial portion (38.1%) have 1–5 years of experience, which is demonstrating a mix of early-career and moderately experienced employees. The sample is evenly spread across transportation (50.8%) and engineering (49.2%) sectors, which is providing a balanced representation of both industries for meaningful analysis. Above result are in Table.1 below.

Table 1: Demographic Profile

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	210	66.7%
	Female	105	33.3%
Age (Yrs)	18 to 25	60	19.0%
	26 to 35	140	44.4%
	36 to 45	80	25.4%
	Above 45	35	11.1%
Education Level	Diploma	70	22.2%
	Bachelor's Degree	150	47.6%
	Master's Degree	80	25.4%
	Other	15	4.8%
Work Experience (Yrs)	<1 year	25	7.9%
	1 to 5	120	38.1%
	6 to 10	100	31.7%
	Above 10 years	70	22.2%
Sector	Transportation	160	50.8%
	Engineering	155	49.2%

4.1 Measurement Model

The study employed Partial Least Squares (PLS)-Structural Equation Modeling (SEM) using Smart PLS 4. The analysis was conducted in two models: measurement and structural. The measurement model results highlight that the survey fulfilled the requirements of the measurement model. Hair et al. highlighted that composited reliability (CR) values must be higher than 0.70. Furthermore, the average variance extracted (AVE) values for the constructs are above the recommended minimum of 0.50 (Hair et al., 2019). In other words, Hair et al. also recommended that factor loadings must also be greater 0.50 (Hair et al., 2019), and results showed that values are greater than the recommended values, which indicates that the measurement model exhibits acceptable reliability and convergent validity in Table 2 and Figure 3. Furthermore, variance inflation factor (VIF) values are also less than 5 which shown that there is no issue of multicollinearity (Hair et al., 2019).

Table 2: Convergent Validity

Construct	VIF	CR	AVE
Sensing Capability	2.321	0.891	0.682
Analytical Capability	2.192	0.902	0.693
Process Integration	1.772	0.883	0.664
Human resource flexibility	1.890	0.924	0.713
Technology Orientation	1.780	0.903	0.692
Data-Driven Culture	1.651	0.912	0.722
Operational Performance	1.733	0.934	0.702

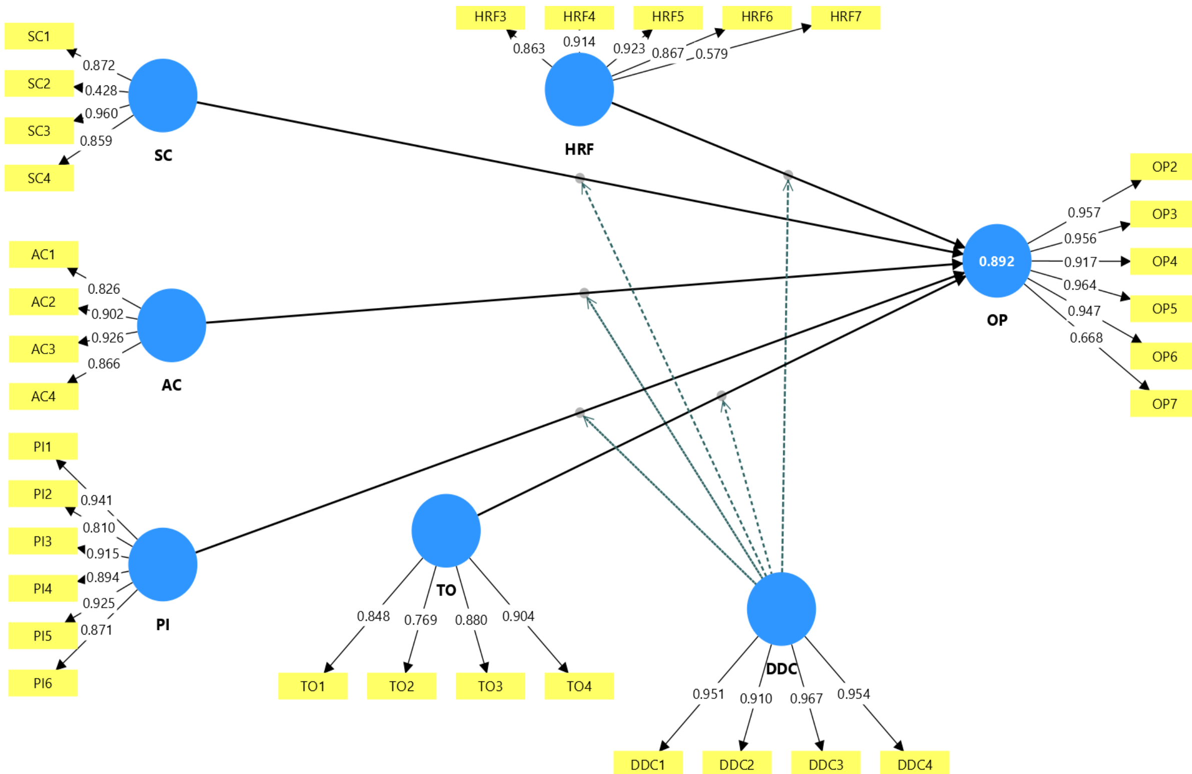

Figure 3: Loadings

4.2 Discriminant Validity

The Fornell–Larcker criterion results demonstrate satisfactory discriminant validity among all constructs. According to Fornell and Larcker, the square root of AVE must be greater than the diagonal values (Fornell & Larcker, 1981), which shows the constructs' discriminant validity. Table 3 diagonal values are higher than the values below, which highlights discriminant validity.

Table 3: Discriminant Validity

Construct	SC	DDC	OP	AC	PI	HRF	TO
SC	0.825						
DDC	0.612	0.849					
OP	0.581	0.632	0.837				
AC	0.553	0.573	0.602	0.831			
PI	0.492	0.542	0.564	0.512	0.812		
HRF	0.523	0.553	0.595	0.533	0.507	0.843	
TO	0.504	0.532	0.573	0.522	0.486	0.543	0.831

4.3 Hypothesis Results

4.3.1 Direct Effect Results

The regression results (Table 4) through the structural model showed that analytical capability has positive significant ($\beta = 0.312$, $p < 0.001$) impact on operational performance. Sensing capability also shows a positive and significant ($\beta = 0.278$, $p = 0.002$) effect on operational performance. Human resource flexibility also demonstrates a positive and significant ($\beta = 0.241$, $p = 0.006$) on operational performance. Moreover, technology orientation exhibits a positive and significant ($\beta = 0.334$, $p < 0.001$) effect on operational performance. Lastly, process integration also has a positive and significant effect ($\beta = 0.296$, $p = 0.001$) on operational performance. Above all, these findings reinforced that enhancing these capabilities leads to superior operational performance in the automotive and transportation manufacturing sector.

Table 4: Direct Effects Results

Independent Variable (Code)	β (Beta)	Std. Error	T-Statistic	P-Value	Decision
AC	0.312	0.084	3.714	0.000***	Supported
SC	0.278	0.091	3.054	0.002**	Supported
RF	0.241	0.088	2.739	0.006**	Supported
TO	0.334	0.079	4.228	0.000***	Supported
PI	0.296	0.086	3.442	0.001**	Supported

Note: AC = Analytical Capability, SC = Sensing Capability, RF = human resource flexibility, TO = Technology Orientation, PI = Process Integration, OP = Operational Performance

4.3.2 Moderating Effect

Further structural model results (Table 5) and (Figure 4) showed that data driven culture (DDC) significantly (β = 0.421, p = 0.000) moderates between analytical capability and OP which is indicating that when firms combine strong analytical capabilities with a data-driven culture. The interaction of sensing capability and DDC also has a positive and significant (β = 0.387, p = 0.000) effect on operational performance which is suggesting that a DDC environment enhances firms' ability to sense market and technological trends more accurately and act proactively. Similarly, human resource flexibility interacting with DDC also exhibits a positive and significant (β = 0.359, p = 0.000) effect on operational performance which is highlighting that data-supported resource allocation and reconfiguration strengthen production adaptability and efficiency. Moreover, technology orientation with DDC also shows the strongest positive and significant moderating (β = 0.445, p = 0.000) effect on operational performance which is indicating that a data-driven culture strengthens the impact of technological innovation and automation on performance. Finally, Process Integration with DDC also has a positive and significant (β = 0.398, p = 0.000) effect on operational performance which is emphasizing that data-driven integration of production, logistics, and supply chains enhances coordination and operational synergy.

Table 5: Moderating Effects

Hypothesis	Interaction Term (Code)	β (Beta)	Std. Error	T-Statistic	P-Value	Decision
H6	AC × DDC->OP	0.421	0.072	5.847	0.000***	Supported
H7	SC × DDC->OP	0.387	0.079	4.899	0.000***	Supported
H8	RF × DDC->OP	0.359	0.083	4.325	0.000***	Supported
H9	TO × DDC->OP	0.445	0.068	6.544	0.000***	Supported
H10	PI × DDC->OP	0.398	0.075	5.307	0.000***	Supported

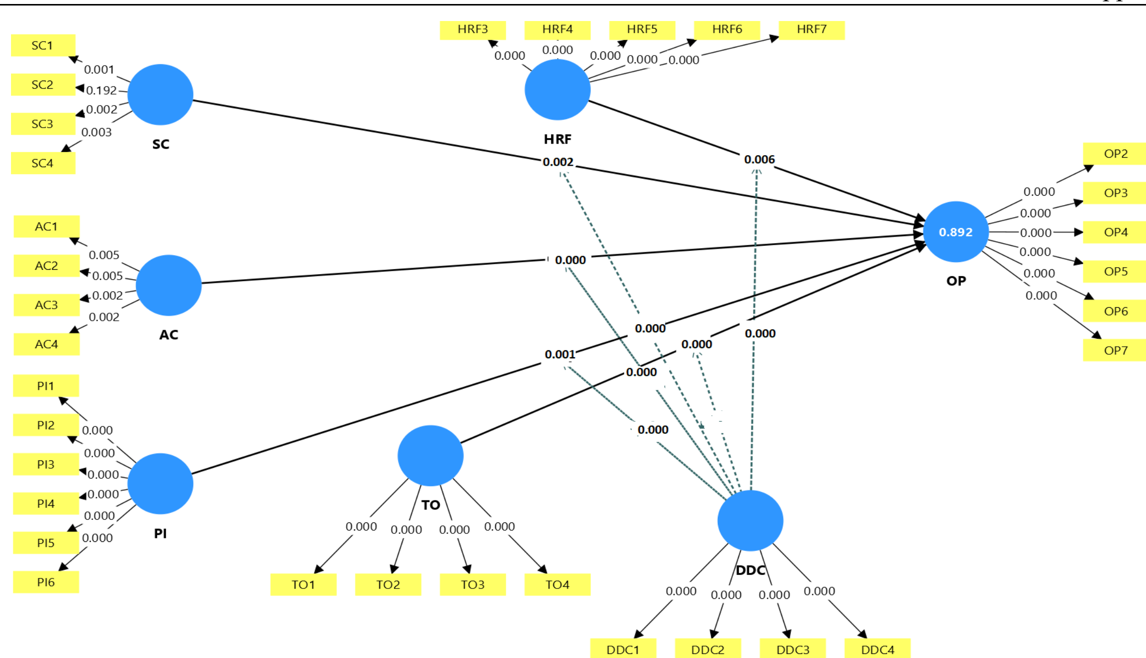

Figure 4: Structural Models

5. Discussion

The result indicated that analytical capability positively and significantly effects to the OP of transportation and engineering companies. These results shown that analytical ability of data is the manufacturing sector enables companies to optimize their production planning and controlling their cost. The study results is supported with the finding of Al Bashar et al. where they found that analytics capability improves production efficiency and enhances process reliability in manufacturing (Al Bashar et al., 2024). These findings indicated that transportation and engineering manufacturing companies should invest in analytical tools and employee training to strengthen their data interpretation capabilities. Implementing predictive analytics and AI-driven performance dashboards can help firms anticipate production bottlenecks and enhance OP. Further results highlight that sensing capability also exhibited a positive significant influence on the OP of transportation and engineering manufacturing companies. This result highlights that companies with the market dynamic sensing is being respond more effectively which is increasing the OP of transportation and engineering companies. This finding is supported with Hakeem, who emphasized that sensing is a key component of dynamic capabilities that drive performance in rapidly changing environments (Hakeem, 2023). These findings shown that transportation companies should establish continuous market monitoring systems and foster cross-functional communication to strengthen sensing abilities.

Collaborating with technology suppliers and maintaining close relationships with logistics partners can further enhance responsiveness to market changes. Moreover, human resource flexibility also exhibited a positive and significant influence on the OP which shows the significance of adaptable resource allocation to improve the manufacturing system. Literature supported the evidence that transportation companies operational could be improved when the companies have flexibility in utilizing labor, machinery, and materials ensures continuity during production shifts or supply disruptions Kanike (Kanike, 2023). The results is supported with the study of Gayed and El Ebrashi, who found that flexible resource allocation improves firms' resilience and adaptability in uncertain market environments (Gayed & El Ebrashi, 2023). The results shown that organization should adopt a better manufacturing system and should develop a multi-skilled team to quickly adjust production schedules when facing demand fluctuations that could increase companies' competitive advantage. In addition to the previous, technology orientation also exhibited a significant positive influence on the OP. This result emphasizes the strongest positive impact on the OP. These results emphasize that the increasing advancement in technology in the transportation company is increasing efficiency, productivity, and competitiveness. In transportation and engineering manufacturing, adopting technologies such as IoT-enabled sensors, robotics, and computer-aided manufacturing improves process accuracy and reduces operational costs. The result is supported by the finding of Adiguzel et al., who reported that technology-oriented firms outperform competitors in operational and innovation metrics (Adiguzel et al., 2025). These findings highlighted that managers should prioritize technology-driven strategies, integrating smart manufacturing and Industry 4.0 solutions that will ensure sustained operational excellence and global competitiveness. In addition to the previous, lastly process integration also exhibited a positive significant influence on the OP. These results highlighted that transportation and engineering manufacturing companies have better coordination in different production stages which is increasing the companies OP through reducing the operational delays. This result is highlighting that within the transportation and engineering companies, process integration ensures that design, production, and logistics units operate cohesively, resulting in higher output quality and shorter delivery cycles. Guo et al. found the same results where they found that integrated processes enable synchronized operations to improve the OP (Guo et al., 2021). These findings enforced that companies should strengthen digital connectivity across departments through enterprise resource planning systems to increase the OP. On the other hand, the moderating effect between the analytical capability and OP is also significantly moderated by DDC. This supports the findings of Sitorus and Meilani who emphasize that integrating data analytics with organizational culture enhances performance (Sitorus & Meilani, 2024). These findings highlight that firms should invest in analytics platforms and staff training to strengthen evidence-based operations.

Further, the moderation of DDC is also significantly moderated in the relationship between sensing capability and OP of transportation and engineering companies. This result highlights that DDC improves the ability to anticipate technological and market changes. Teixeira et al. supported the same results, where they reported that data-driven sensing is key to agility (Teixeira et al., 2023). These findings highlight that companies should use big data and IoT tools to enhance market and operational awareness. On the other hand, human resource flexibility also exhibited a positive and significant influence on the OP, with the moderating effect of DDC, which suggested that data-enabled flexibility enhances adaptability in allocating materials, labor, and machinery. Turi et al. also showed that data use strengthens resource agility to increase OP (Turi et al., 2023). This result indicates that organizations should adopt digital tools for real-time resource allocation and process adjustment. Furthermore, technology orientation also has a significant effect on OP, with a moderating effect of data-driven culture, which implies that data-driven cultures amplify the benefits of automation and innovation. Teixeira et al. also found that technology adoption yields higher performance when guided by data insights (Teixeira et al., 2023). These results show that organizations should integrate data analytics with technology evaluation to optimize innovation outcomes. Finally, process integration also exhibits a positive and significant effect on OP with the moderating effect of data-driven culture, which means that data-driven coordination among production and logistics enhances efficiency and synchronization. Bamakan et al. similarly observed that data-enabled integration strengthens supply chain performance (Bamakan et al., 2021). These findings show that using ERP and IoT-based platforms to connect production, procurement, and logistics for better process alignment. Previous findings have shown that DDC culture is a significant moderator which is enabling transportation and engineering manufacturing firms to achieve greater efficiency, adaptability, and competitive advantage through data-supported decision-making (Singh et al., 2023). DDC also used a moderating variable in the following studies Atiningsih & Izzaty, where it is also found a significant moderating effect which is showing the significance of this moderating effect variable (Atiningsih & Izzaty, 2021). This moderating effect shows the significance of DDC as a moderating variable for the current study.

5.1 Contributions

5.1.1 Theoretical Implications

The study has contributions in various ways. Theoretically, at first, this research contributed literature by extending the dynamic capability through empirically validating that analytical capability, sensing capability, human resource flexibility, technology orientation, and process integration significantly influence OP, especially with the moderating effect of data-driven culture (DDC). Prior studies were conducted on the direct effects of capabilities, but the present study advances theory by showing how a DDC strengthens the link between these internal capabilities and performance outcomes. This contribution enriches theoretical understanding by positioning DDC as an enabling mechanism that transforms firm-level capabilities into superior operational results, especially in technology-intensive and data-reliant industries like transportation and engineering manufacturing. Second, this research also contributed in the extant literature through introducing a DDC as a moderating construct which plays a significant role that has rarely been empirically tested in this sector. Earlier studies treated DDC as a direct determinant of performance or innovation outcomes, but this research demonstrates its interactive influence in amplifying the effects of analytical and technological capabilities. The contribution lies in identifying DDC as a critical contextual factor that enhances decision-making precision, responsiveness, and adaptability. This finding expands theoretical boundaries and encourages future researchers to explore cultural and behavioral moderators in operations management models. Lastly, study contributed a literature through developing an integrated decision-making model which increase the conceptual understanding of how technological, analytical, and cultural dimensions jointly increases OP. The contribution of this model is that it offers a theoretical pathway for future studies to explore the synergy between human, technological, and cultural resources in achieving data-enabled operational performance in the decision-making process. Furthermore, it sets a foundation for comparative studies across industries and regions, which is offering rich theoretical implications for digital transformation and Industry 4.0 research.

5.1.2 Practical Implications

At first, research has contributed findings to help to managers in emphasizing that a strong DDC is important to improve the decision-making process which could enhance the benefits of analytical and sensing capabilities. Managers in transportation and engineering manufacturing firms should also implement a training program to enhance data literacy, promoting evidence-based decision-making, and using analytics platforms for real-time monitoring that could strengthen OP. At second, research also contributed through offering the actionable ways via improving decision making process through integrating data-driven tools across supply chain, production, and maintenance systems that could guide companies on how to operationalize data-driven decision-making to reduce costs, minimize downtime, and ensure continuous production flow. This is particularly relevant for engineering manufacturing firms where real-time data supports machine calibration, process automation, and timely supply chain coordination. Third, research also contributed through providing strategic direction for organizational leaders in their decision making to align technological orientation with data governance and process integration. Managers should establish clear data management frameworks, encourage cross-departmental data sharing, and integrate digital systems that allow seamless communication across production, logistics, and design units. This contribution shows that a well-established data-driven culture not only improves operational accuracy but also fosters innovation and strategic agility, enabling firms to respond faster to customer demands and market changes. Lastly, this study has contributed to policy and industry practice by highlighting the need for institutional support in promoting data-driven manufacturing ecosystems. Policymakers, industry associations, and government agencies should encourage digital transformation by providing financial incentives, training programs, and collaborative platforms for data analytics adoption. The contribution here lies in demonstrating that nurturing a data-driven mindset across the sector will strengthen national competitiveness, enhance technological innovation, and support sustainable industrial growth in transportation and engineering manufacturing domains.

6. Conclusion and Future Directions

Research aimed to test the influence of analytical capability, sensing capability, process integration, human resource flexibility, and technology orientation on operational performance with the moderating influence of data-driven culture. Cross-sectional quantitative data were employed from 315 transportation and engineering employees. The depicted results show that analytical capability, sensing capability, process integration, human resource flexibility, and technology orientation each have a significant and positive impact on the operational performance. Moreover, the data-driven culture moderates positively to promote the transportation and engineering company's operational performance. Study results emphasize the significance of cultivating a decision-making data-driven culture in manufacturing settings to transform sensor data into actionable decisions, enhance operational excellence, and improve responsiveness to dynamic market conditions. The results contribute theoretically by extending the dynamic capability theory and practically by guiding managers to foster a strong data-driven environment that leverages analytics, sensing, and technology for superior operational performance that could support to better operational decisions. The study has various limitation that needs to be addressed in further study. Firstly, study focused on transportation and engineering sectors, where findings could not be generalized on other manufacturing companies, like the textile sector. To further study generalizability, it is suggested that further study need to be addressed on other manufacturing sector. Secondly, the study limited on cross sectional research design which limited the study scope. Further research needs to be addressed on longitudinal research design to increase the study scope. Thirdly, the study limited on moderating effect while ignored mediating effect of innovation culture which could increase the OP of the organizations. Therefore, further research might be conducted with both of moderated and mediating model to increase the predictive power of research framework.

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