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The Role of Agile Manufacturing in Cost Management and Enhancing Differentiation Strategy

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Abstract: This study aims to investigate the impact of applying Agile Manufacturing principles on rationalizing cost management and enhancing the differentiation strategy in Iraqi economic units, focusing on the Wasit Spinning and Weaving Factory as a case study. To achieve this goal, a descriptive–analytical approach was adopted using a closed, five-point Likert questionnaire developed from rigorously validated academic scales; 55 questionnaires were distributed to factory employees, five incomplete responses were discarded, and a statistically valid sample of 50 was analyzed. Content validity was confirmed by an expert panel, and reliability reached Cronbach's $\alpha = 0.932$, indicating high internal consistency. Data were processed with SPSS (version 28) using descriptive statistics, a one-sample t-test, and correlation and regression analyses. The results showed that implementing Agile Manufacturing contributes, at a high level of significance ($p < 0.001$), to reducing operating, logistics, and development costs while simultaneously strengthening differentiation elements such as response speed, product customization, and brand image; the tests also revealed notable homogeneity in respondents' views, underscoring the reliability of the conclusions. Accordingly, the study recommends developing digital infrastructure and linking production lines to Internet-of-Things technologies, alongside integrating Lean and Six Sigma methodologies within the Agile Manufacturing framework to maximize their combined effect on cost and quality.

Keywords: Agile Manufacturing; Cost Management; Differentiation Strategy, Costing-System Design, Target costing.

Introduction

As global competition intensifies and business environments become increasingly volatile and uncertain, the ability to reconcile rapid cost reduction with enhanced differentiation has become a strategic imperative that business units can no longer ignore. The accelerated evolution of digital technologies—especially Internet-of-Things applications, real-time data analytics, and flexible automation—has demonstrated that traditional approaches to manufacturing and cost management are no longer sufficient to secure competitive sustainability. In this context, **Agile Manufacturing**

emerges as a dynamic model that enables companies to sense swift shifts in consumer demand and reconfigure their production resources with high flexibility, all while maintaining a satisfactory balance between quality and cost. Although Western literature extensively explores the relationship between agile manufacturing and cost management, Arabic research—particularly studies addressing applied dimensions in the manufacturing sector—remains limited. This gap is especially pronounced in Iraq's textile industry, which faces dual pressures: the need to lower costs to compete with low-priced imported products and the obligation to maintain quality and variety that meet local consumer preferences and support self-sufficiency policies.

Drawing on the foregoing, this study seeks to bridge a knowledge gap by analyzing the impact of adopting Agile Manufacturing principles at the Wasit Spinning and Weaving Factory—one of Iraq's oldest national industrial pillars—on two pivotal dimensions: cost management and differentiation strategy. The choice of this factory is particularly significant because it exemplifies a state-owned economic unit striving to reconcile the imperatives of industrial reform with the challenges of a free-market environment..

Section One — Research Methodology

Research Problem

Growing global competition compels firms to strike a balance between cost reduction and differentiation from rivals. Yet enterprises often face multiple hurdles when implementing agile-manufacturing strategies: high initial costs can undermine competitive capability, while misalignment between agility initiatives and cost-management systems may erode margins. Accordingly, the core problem addressed in this study is to understand how Agile Manufacturing affects production-cost control and how this strategy can be leveraged to secure a competitive advantage through differentiation.

Research Objective

This study aims to analyse the role of Agile Manufacturing in cost management and in strengthening firms' differentiation strategies. Specifically, it explores how contemporary production technologies and practices can simultaneously lower costs and raise product quality, thereby enhancing corporate competitiveness in modern markets.

Research Hypothesis

The study rests on the central hypothesis that applying Agile-Manufacturing practices improves cost management and positively reinforces differentiation strategy. By refining production processes and boosting efficiency, firms can achieve a blend of high quality and competitive pricing, ultimately elevating customer satisfaction and market distinctiveness.

Research Significance

The theoretical and practical importance of this work lies in bridging an Arab-language knowledge gap through an empirical analysis linking Agile Manufacturing with cost management and differentiation. First, it enriches academic discourse on manufacturing strategies by clarifying their joint influence on cost control and competitive uniqueness. Second, it offers clear, actionable insights for economic units seeking to optimise production efficiency and deliver distinctive products, enabling them to compete effectively in modern market environments.

Research Method

A descriptive-analytical design was adopted. Data were collected using a closed, five-point Likert questionnaire developed from rigorously validated academic scales and administered to 53 employees at the "Wasit Spinning and Weaving Factory". Five incomplete responses were discarded, leaving a valid sample of 50 participants. Content validity was confirmed by an expert panel, reliability reached Cronbach's $\alpha \geq 0.80$, and an exploratory factor analysis verified

construct coherence. Data were processed using SPSS v28 for descriptive statistics and one-sample t-tests to examine the relationships among Agile Manufacturing, cost management, and differentiation strategy.

Data Sources

Primary data were obtained exclusively from the aforementioned questionnaire and were supplemented by semi-structured interviews with production and cost supervisors to validate and interpret the findings. Secondary data comprised a critical review of peer-reviewed studies on Agile Manufacturing, cost management, and differentiation strategy.

Section Two — The Impact of Agile Manufacturing on Cost Management and the Enhancement of Differentiation Strategy

2.1 Emergence and Evolution of Agile Manufacturing

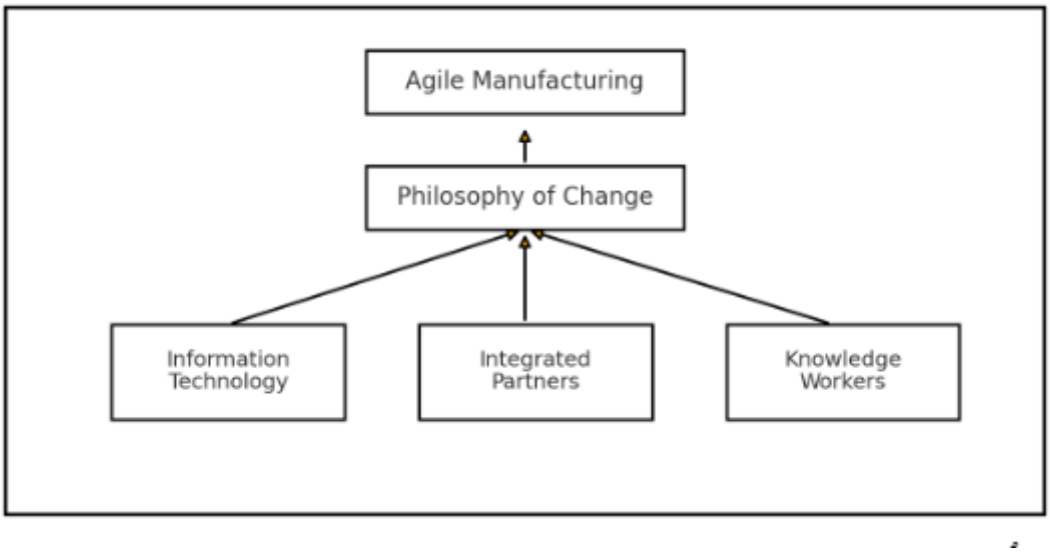
Recent advances in manufacturing technologies have driven industrial organisations to adopt contemporary standards and to search for new philosophies capable of meeting ever-increasing customer requirements. One of the most prominent outcomes of this search is **mass customisation**, widely regarded as a leading approach in the field. These developments have fundamentally reshaped how products are designed and produced, moving beyond traditional inputs toward the broad application of modern ideas. The contemporary industrial literature underscores the necessity of adapting to such changes, noting that manufacturing strategies over the past two centuries have redefined production concepts by prioritising flexibility and innovation. This interplay of ideas highlights the importance of responding rapidly to human needs through advanced means of rapid market response (Kidd, 1994, p. 23).

Agile Manufacturing is defined as a production system rooted in dynamic-capabilities theory; it enables firms to adapt instantaneously to market volatility and complex customer demands while maintaining cost stability and product quality. The approach rests on four core pillars: (1) rapid demand sensing, (2) the ability to reconfigure production resources, (3) comprehensive informational integration, and (4) empowering work teams to make real-time decisions (Mohaghegh, Åhlström, & Blasi, 2023).

2.2 Components of Agile Manufacturing

Agile Manufacturing comprises **three principal components**, each requiring specific organisational actions. Together, these components aim to drive holistic change and continuous improvement in an organisation’s resources and capabilities, as illustrated in Figure ( ) (Kovach et al., 2005, p. 3).

Figure 1. Components of Agile Manufacturing



Kovach, J., Stringfellow, P., Turner, J., & Cho, B. R. (2005). *The House of Competitiveness: The Marriage of Agile Manufacturing, Design for Six Sigma, and Lean Manufacturing with Quality Considerations*. *Journal of Industrial Technology, 21*(3), 1–10.

2-2-1 Information Technology

Information technology (IT) refers to the use of computers, networks, and other technologies—together with the documents and data they handle—for creating, managing, storing, and processing information (Krajewski & Ritzman, 2005, p. 512). Effective manufacturing therefore requires seamless IT integration to deliver appropriate solutions across production domains. Such integration relies on relevant data presented in a way that increases system efficiency, facilitates decision-making, and enables economic units to deploy resources more effectively (e.g., data-mining technologies).

2-2-2 Integrated Partners

A comprehensive programme for engaging and motivating people encompasses all elements that heighten their interaction, reshape their mind-sets, and foster their individual growth. This involves identifying needs, providing targeted training, and monitoring workplace factors that influence performance, thereby improving individual outcomes. Empowerment is the granting of authority to make decisions and to contribute to improved results; Krajewski and Ritzman (1999, p. 186) highlight its managerial importance, while Turban et al. (1999, p. 132) show how empowerment strengthens relationships and develops skills, ultimately advancing economic units.

2-2-3 Knowledge Workers in IT

Knowledge workers are individuals who process knowledge and develop solutions through their skills and expertise. They constitute an essential part of organisations, playing a vital role in managing and directing information in ways that support the strategic objectives of economic units (Shoham & Hasgall, 2005, p. 226).

Cost Management

Cost management is a foundational concept in modern managerial thought because it is directly linked to an organisation’s ability to achieve operational efficiency and maintain sustainable profitability in competitive environments (Ríos-Quispe, 2023). It is defined as the organisational activity concerned with planning, estimating, monitoring, and controlling the costs associated with

production and service delivery so as to maximise organisational value and minimise unnecessary expenditure (Klimecka-Tatar, 2017).

Comprehensive cost management is a cradle-to-grave process that systematically supervises and controls expenditures across every phase of the product life-cycle—from concept and design, through production and distribution, to use and end-of-life disposal. Techniques such as value-chain analysis are employed to maximise product value in line with customer requirements. Planning and control decisions therefore rest on precise cost measurements and clearly defined resource needs, enabling managers to classify and reallocate production costs to raise efficiency. Cost data must be viewed not merely as a control variable but as a strategic domain that explicitly considers life-cycle implications. Robust cost management thus supports well-informed quality decisions and performance improvements (Harrison et al., 2004), while enhancing competitiveness by delivering reliable decision-support information, cutting unnecessary expenditure, and optimising resource utilisation (Anwar & Abdullah, 2021).

Contemporary Directions in Cost Management

Driven by global competition, rapid digital advances, and mounting environmental and social obligations, the field of cost management is undergoing radical transformation. Key intellectual and practical issues—ranging from digitalization to sustainability—include (Horngren et al., 2021):

Focus Area	Contemporary Evolution
Cost Estimation	Transition from traditional regression models to machine-learning algorithms that process real-time sensor data, raising the accuracy of fixed and variable coefficients and enabling instant cost forecasts.
Cost Drivers	Process-mining analytics extract workflow patterns and identify resource-intensive activities, while IoT technologies capture second-by-second energy and material consumption, allowing regular driver recalibration.
Cost–Volume–Profit (CVP)	Shift from static tables to interactive “What-If” dashboards linked directly to ERP systems, enabling leaders to test profit resilience against market shocks or exchange-rate fluctuations.
Costing-System Design	Cloud platforms integrate environmental and social costs alongside financial ones and embed ESG metrics in the chart of accounts to ensure regulatory compliance and reliable sustainability reporting.
Target Costing	Incorporated into agile sprints that feed instant customer feedback into development cycles; perceived-value models guide the creation of low-carbon products within cost and price constraints.
Life-Cycle Costing	“Cradle-to-cradle” indicators include carbon fees and recycling costs at the design stage, providing a competitive edge in green supply chains and curbing unforeseen downstream expenses.
Capacity Management	Digital twins simulate production lines to detect bottlenecks before they arise, while flexible-workforce models let firms adjust swiftly to demand changes without inflating fixed costs.
ABC/ABM	AI enhances activity classification and locates robotic-process-automation (RPA) opportunities, shortening financial close times and supplying accurate contribution-margin reports by product, service, or customer.
Cost-Based Pricing	Price-optimisation algorithms integrate real-time market data to generate dynamic prices that preserve margins—especially in sectors with volatile demand such as transport and logistics.
Customer Profitability Analysis	Large databases estimate customer lifetime value (CLV) and link it to multi-channel service costs, informing pruning or focus decisions and improving marketing-resource allocation.

Differentiation Strategies

Differentiation strategies are a primary means of distinguishing products and services from those of competitors (Chen & Hua, 2017). Boehe and Barin Cruz (2010) identify four common forms of product and service differentiation: design, functionality/performance, quality, and innovation. The overarching goal is to create competitive advantage by distinguishing an offering on attributes valued by customers, thus boosting business sales. Successful implementation requires a precise understanding of the competitive landscape to convince customers of the benefits of sustainable products or services. Quality has become a decisive factor in meeting unique customer needs, while product design encompasses all aspects affecting appearance, feel, and function; well-designed products combine functional and aesthetic advantages that benefit consumers (Mahin et al., 2024).

Porter (1985) defines differentiation as an economic unit's ability to develop products or services with unique characteristics valued by customers, making them hard to imitate and thereby strengthening the unit's market position.

Core Elements of a Differentiation Strategy

Innovation, quality, design, after-sales service, and customisation constitute an integrated system that converts differentiation from a theoretical construct into a tangible competitive edge. By leveraging these pillars simultaneously, economic units create unique value that is difficult for competitors to replicate, enhancing customer loyalty and long-term profitability:

1. Innovation — A field study of Indonesia's telecommunications-tower industry shows that combining differentiation strategy with innovation mitigated competitive intensity and significantly improved financial and operational performance, confirming that sustained investment in new products and ideas bolsters long-run profitability (Pradipta et al., 2023).
2. Superior Quality — A causal analysis of Kenyan edible-oil plants found that differentiation strategies based on performance, conformity, and reliability produced significant gains in sales and profit margins, demonstrating that quality is a competitive asset rather than an added cost (Mwazunai, 2023).
3. Distinctive Design — A recent review in the cosmetics sector revealed that roughly 73 % of purchase decisions occur at the point of sale and that design elements—such as colour, shape, and texture—elevate perceived value and generate enduring brand loyalty, making attractive packaging a key driver of market differentiation (Srivastava et al., 2022).
4. After-Sales Service — A 2024 study of public-sector employees in Delhi-NCR observed a positive link between response speed, technician competence, and customer satisfaction and loyalty, positioning after-sales service as a strategic differentiator that prevents customer defection (Pandey, 2024).
5. Customization (Mass Customization) — A theoretical model in *Marketing Letters* indicates that firms adopting full or partial customization can expand markets and improve profits, provided they manage interactive costs effectively; by precisely meeting customer preferences, customization avoids direct price wars (Jost, 2023).

An applied study covering 72 industrial projects showed that integrating Agile Manufacturing principles with Industry 4.0 technologies—such as robotics, additive manufacturing, IoT, and big-data analytics—increased energy efficiency on production lines by an average of 15–25 %, while markedly improving decision speed and process quality (Arana Landín et al., 2023).

Achieving a Differentiation Strategy through Agile Manufacturing

Cost management is inextricably linked to a firm's ability to embrace **agile manufacturing**. Schuh et al. (2019) proposed a systematic framework for managing fixed costs and reducing "sticky" costs, thereby allowing production lines to be reconfigured rapidly without incurring excessive financial burdens. In a field application, a Bain & Company case report showed that integrating Lean Six Sigma principles reduced a plant's direct costs by 15 % while markedly increasing operational flexibility (Bain & Company, 2020). Jagtap et al. (2022) likewise demonstrated at a UK food factory that implementing SMED cut setup times and lowered direct-labour costs by roughly 10 %.

Agile manufacturing does more than pare down expenses; it also enables competitive differentiation by supporting the quick launch of customized products in response to market opportunities. Recent studies confirm that standard-cost methodologies adapted to agile environments—such as TADS-ABC—can trim development and production costs by 8–11 % through improved product design and material utilization (Ding et al., 2021). Managing both fixed and variable costs is therefore pivotal. Schuh et al. (2019) showed that addressing sticky costs can cut operating expenses by up to 10–15 % without sacrificing product quality, while Ali and Wasim (2022) found that agile practices in small and medium-sized enterprises lowered average production costs by 8–11 % through better scheduling and reduced downtime.

Beyond cost savings, agile manufacturing equips firms to deliver finely tailored products and services that bolster differentiation. Mohaghegh et al. (2023) argue that the flexibility inherent in this approach enhances continuous-innovation capacity, enabling the release of unique offerings and faster responses to new market opportunities while sustaining cost and quality efficiency.

As a cornerstone of modern cost management and differentiation strategies, agile manufacturing—and the advanced technologies it integrates—allows companies to achieve greater efficiency and flexibility, thereby reducing costs and improving quality. According to Krajewski and Ritzman (1999), agile manufacturing boosts productivity and curbs waste, improving profit margins. Advanced agile techniques help minimize losses and raise process effectiveness, strengthening cost-management capability. Agile manufacturing not only lowers costs but also elevates product quality; the ability to design and build high-quality products gives firms a market edge. Porter (1985) notes that differentiation strategies hinge on delivering added value to customers—something unique product features can fulfil. Effective agility lets firms offer high-quality products at competitive prices, enhancing market appeal. Shammot (2011) likewise identifies quality as a decisive differentiator, observing that agile practices improve design and performance, facilitating effective differentiation.

Moreover, agile manufacturing fosters continuous product innovation—an essential component of differentiation (Kotler & Keller, 2011). In sum, agile manufacturing plays a vital role in cost management and in refining differentiation strategies by enabling firms to cut expenditures, enhance product quality, and strengthen market competitiveness. Economic units should therefore invest in modern manufacturing technologies and continuous employee training to realise these benefits fully (Kaliappen & Hilman, 2013; Olsen & Connolly, 2000).

Key Dimensions for Achieving a Differentiation Strategy under Agile Manufacturing

In an industrial environment marked by complexity and intense competition, **agile manufacturing** is the linchpin for accelerating market responsiveness and cost reduction while preserving product quality and enabling innovation. The following seven pillars are central to realising a robust differentiation strategy through agile manufacturing:

1. Understanding Market Needs: Competitive success hinges on deep analysis of consumer behaviour and the alignment of products and services with actual customer requirements,

thereby bolstering loyalty and securing sustained performance advantages (Na, Kang, & Jeong, 2019).

2. Developing Unique Products via Open Innovation: Combining internal and external ideas through an open-innovation approach speeds up product-development cycles and launches innovative solutions that set the firm apart from rivals (Arvaniti, Dima, Stylios, & Papadakis, 2022).
3. Optimizing Manufacturing Processes with IoT and Artificial Intelligence: Digital technologies such as the Internet of Things (IoT) and AI facilitate real-time monitoring and data analytics, raising operational efficiency and cutting waste (Kalsoom et al., 2021).
4. Sustainable Quality through an ISO 9001 Quality-Management System Implementing ISO 9001 standards enhances product reliability and process consistency, positively affecting customer satisfaction and corporate reputation (Cződörová & Gnap, 2023).
5. Investing in Training and Development to Elevate Employee Performance Systematic training programmed build a culture of continuous learning, supporting innovation and boosting organizational efficiency (Hussain et al., 2023).
6. Effective Marketing of Value-Based Differentiation: Emphasizing corporate social responsibility and brand image strengthens consumer attachment to the product's added value and cultivates long-term loyalty (Jia et al., 2023).
7. Rapid Responsiveness to Change to Enhance Competitive Agility: Swift operational flexibility allows firms to adapt to new market opportunities and challenges, supporting the launch of sustainable products and ensuring strategic resilience (Zhao, Alli, & Me, 2023).

Agile manufacturing is thus a cornerstone for fostering continuous innovation capacity: Yusuf et al. (1999) note that operational flexibility enables the rapid release of products with unique features while maintaining cost and quality efficiency, thereby underpinning a differentiation strategy in global markets. An applied study of 72 industrial projects further shows that integrating agile-manufacturing principles with **Industry 4.0** technologies—such as robotics, additive manufacturing, IoT, and big-data analytics—boosted energy efficiency on production lines by an average of **15–25 %** and significantly improved decision-making speed and process quality (Arana Landín et al., 2023).

Section Three - Practical Part

In the preceding chapter, we examined the nature of Agile Manufacturing and its contribution to cost management and the enhancement of differentiation strategy. This chapter introduces the **Wasit Spinning and Weaving Factory**, the field site for the present study. The factory is one of the key industrial units belonging to Iraq's State Company for Textile and Leather Industries, established by Cabinet Decision No. 306 (2015) through the merger of several state-owned enterprises specializing in cotton, wool, textiles, carpets, and ready-made garments. Located in the city of Al-Kut, Wasit Governorate, the plant was originally built under the 1959 Iraqi–Soviet agreements as a dedicated spinning-and-weaving facility, drawing on transferred technology to localize the textile industry.

The factory produces cotton yarn and converts it into various fabrics and textiles to meet domestic demand and supply government entities. Since its inception, it has served as an important economic and social engine by providing employment and adding value to Iraqi cotton. Despite the operational challenges that have confronted the textile sector over the decades, the plant remains a cornerstone for developing Iraq's manufacturing base and supporting national self-sufficiency.

To test the study's hypothesis, a questionnaire was designed with **three dimensions**: the first represents the independent variable, while the remaining two are dependent variables. Each dimension contains ten questions. The questionnaire was administered to a sample of scholars and specialists in accounting working within Iraqi economic units. A total of **53** questionnaires were distributed, as shown in Table 1.

Table 1. Distributed and Received Questionnaires

Questionnaires distributed	Questionnaires received	Excluded / missing	Response rate
53	50	3	94 %

Source: Prepared by the researcher using SPSS software.

Statistical methods. Data were analysed with **SPSS**, one of the standard statistical packages. The procedures included:

- **Construct validity** tests for each dimension of the questionnaire.
- **Cronbach's alpha** to assess reliability: values approaching 1.0 indicate strong internal consistency, whereas values near 0 signal weak consistency.
- **One-sample *t*-tests** to decide whether to accept or reject the research hypotheses by comparing calculated *t* values with the 0.05 significance level—both for the overall sample and for each questionnaire item.
- Additional descriptive statistics (arithmetic mean and standard deviation).

A **five-point Likert scale** was used to code responses, and frequency distributions were computed for every item. The subsequent tables (not reproduced here) show the strength of the correlation between each questionnaire statement and the total score of its corresponding dimension.

Table 2 - Internal-Consistency Validity for Dimension 1 (Role of Agile Manufacturing in Cost Management)

No.	Item	Correlation Coefficient	Significance (sig.)
1	Agile manufacturing reduces operating costs by improving resource utilisation.	0.684	.000
2	Implementing agile-manufacturing principles lowers scrap and waste rates in the production process.	0.765	.000
3	Agile manufacturing provides greater flexibility in cost planning than traditional methods.	0.791	.000
4	Agile manufacturing cuts inventory costs by adopting make-to-order production.	0.602	.000
5	Agile manufacturing improves product quality, thereby reducing rework costs.	0.672	.000
6	Agile manufacturing enhances the efficient use of labour and production equipment.	0.312	.000
7	Applying agile manufacturing helps lower the cost of new-product development.	0.751	.014
8	Agile manufacturing improves the accuracy of actual-cost measurement compared with traditional systems.	0.761	.000
9	Agile manufacturing enables the reduction of logistical costs (transport and storage).	0.765	.000
10	Agile manufacturing enhances standard-cost systems and managerial accounting.	0.732	.000

Source: Prepared by the researcher using SPSS software.

Pearson correlation results indicate strong homogeneity between the items in the "Agile Manufacturing and Cost Management" dimension and the overall variable. Eight items show strong to very strong correlations (r = 0.60–0.79) with high statistical significance at the 0.01 level, reflecting a consistent perception among respondents that applying agile-manufacturing principles—especially waste reduction, improved planning, and lower logistical and administrative costs—fundamentally supports cost management.

Item 6, by contrast, exhibits only a weak-to-moderate correlation (r = 0.312) with significance at 0.05, suggesting diverging views on how far better utilization of labor and equipment actually reduces costs compared with the other indicators. Overall, the findings confirm the conceptual validity of this scale dimension, although Item 6 may warrant rephrasing or the addition of practical examples to improve clarity and alignment with the construct.

Table 3-Internal-Consistency Validity for Dimension 2 (Role of Agile Manufacturing in Enhancing Differentiation Strategy)

No.	Item	Correlation Coefficient	Significance (sig.)
1	Agile manufacturing helps develop customized products that match customer needs.	0.775	.000
2	Agile manufacturing offers a high response speed to market changes.	0.761	.000
3	Agile manufacturing enhances the ability to launch new products faster than competitors.	0.538	.000
4	Agile manufacturing raises product quality and thus achieves higher customer satisfaction.	0.673	.000
5	Agile manufacturing enables companies to offer innovative products on a continuous basis.	0.516	.000
6	Agile manufacturing builds a positive brand image through flexibility and quality.	0.724	.000
7	Agile manufacturing delivers unique products that secure a sustainable competitive advantage.	0.448	.000
8	Agile manufacturing strengthens the firm's ability to adapt to changing customer requirements.	0.724	.000
9	Agile manufacturing helps balance low cost with high value for customers.	0.768	.000
10	Agile manufacturing improves the company's competitive position in global markets.	0.737	.000

Source: Prepared by the researcher using SPSS software.

Pearson correlation values indicate that the items within the "Agile Manufacturing and Differentiation Strategy" dimension are all significantly associated with the overall construct, as every significance level is **p < 0.001**, thereby reinforcing the reliability of the scale. The strongest relationships appear in items (1), (2), and (9), where **r** ranges from **0.761** to **0.775**; this reflects respondents' recognition that product customisation, rapid market response, and balancing cost with delivered value constitute the core of competitive differentiation. Other strong links are found in items (6), (8), and (10) (**r ≈ 0.724–0.737**), suggesting that cultivating a positive brand image, adapting to customer requirements, and bolstering global standing are tangible outcomes of adopting agile manufacturing. By contrast, items (3) and (5) show moderately high correlations (**r ≈ 0.516–0.538**), hinting at slight variability in how participants rate agile manufacturing's role in accelerating product launches or fostering continuous innovation. The weakest association

appears in item (7) (**r = 0.448**), which may warrant rephrasing or enrichment with illustrative examples to clarify how agile manufacturing contributes to delivering unique products. Overall, the results show that most items effectively capture the differentiation concept linked to agile manufacturing, though reviewing lower-correlation statements is advisable to improve homogeneity and raise the explanatory power of the measure..

Cronbach's Alpha Reliability Test

The **Cronbach's Alpha test** was conducted to determine the reliability of the scale, that is, the stability and internal consistency of the questionnaire items. The statistical analysis yielded a Cronbach's Alpha value of **0.932**, indicating that the questionnaire results are highly dependable and can confidently be used to achieve the study's objectives. Table 4 presents the relevant statistic.

Table 4. Cronbach's Alpha Test

Reliability Statistics	
Cronbach's Alpha	**0.932**
Number of items	**20**

Source: Prepared by the researcher using SPSS software.

One-Sample *t*-Test

A one-sample *t*-test was applied to every questionnaire item. An item is deemed **positive**—that is, respondents agree with its content—if the calculated *t* value exceeds the tabulated value (2.01) **or** the *p*-value is below 0.05 **and** the relative importance exceeds 60 %. Conversely, an item is considered **negative** if its calculated *t* is below 2.01 **or** the *p*-value exceeds 0.05 **and** its relative importance is below 60 %. The study's principal hypothesis states that **implementing Agile-Manufacturing practices improves cost management and positively enhances differentiation strategy, thus allowing firms to combine high quality with competitive prices, raising customer satisfaction and strengthening market position**.

Table 5. Descriptive Statistics for the Study Variables

Item	Mean	Std. Dev.	Std. Error
Dimension 1 — Role of Agile Manufacturing in Cost Management			
X1	4.1400	0.35051	0.04957
X2	4.0600	0.23990	0.03393
X3	4.1200	0.32826	0.04642
X4	4.0600	0.23990	0.03393
X5	4.1200	0.32826	0.04642
X6	4.1000	0.30305	0.04286
X7	4.1600	0.37033	0.05237
X8	4.1200	0.32826	0.04642
X9	4.0600	0.23990	0.03393
X10	4.1200	0.32826	0.04642
Dimension 2 — Role of Agile Manufacturing in Enhancing Differentiation Strategy			
Y1	4.1800	0.38809	0.05488

Y2	4.1600	0.42185	0.05966
Y3	4.0800	0.27405	0.03876
Y4	4.1200	0.32826	0.04642
Y5	4.0600	0.23990	0.03393
Y6	4.1600	0.37033	0.05237
Y7	4.1000	0.30305	0.04286
Y8	4.1600	0.37033	0.05237
Y9	4.1000	0.30305	0.04286
Y10	4.2000	0.40406	0.05714

Source: Prepared by the researcher using SPSS software.

The descriptive statistics reveal a strong, consistent endorsement of agile-manufacturing benefits across the sample. All item means lie well above the neutral midpoint of 3.00 on the five-point Likert scale, confirming overall agreement among respondents. Within the cost-management dimension, the statement that agile manufacturing reduces new-product development costs (X7) registers the highest average score (4.16), while the items concerning waste reduction, make-to-order inventory, and logistical savings (X2, X4, X9) show the lowest—but still favourable—means (4.06). In the differentiation dimension, the assertion that agile manufacturing bolsters the firm's global competitive standing (Y10) achieves the top mean (4.20), whereas the item on continuous innovation (Y5) records the lowest mean in that set (4.06). Standard deviations remain modest (0.24–0.42) and are paired with small standard errors (< 0.06), indicating a high degree of response homogeneity and reinforcing the reliability of these conclusions.

Table 6. One-Sample *t*-Test for Dimension 1 (Cost Management)

Item	*t*	*df*	*Sig.* (2-tailed)	Mean Difference	95 % CI (Lower–Upper)
X1	83.519	49	0.000	4.14000	4.0404 – 4.2396
X2	119.670	49	0.000	4.06000	3.9918 – 4.1282
X3	88.749	49	0.000	4.12000	4.0267 – 4.2133
X4	119.670	49	0.000	4.06000	3.9918 – 4.1282
X5	88.749	49	0.000	4.12000	4.0267 – 4.2133
X6	95.667	49	0.000	4.10000	4.0139 – 4.1861
X7	79.431	49	0.000	4.16000	4.0548 – 4.2652
X8	88.749	49	0.000	4.12000	4.0267 – 4.2133
X9	119.670	49	0.000	4.06000	3.9918 – 4.1282
X10	88.749	49	0.000	4.12000	4.0267 – 4.2133

Source: Prepared by the researcher using SPSS software.

All ten items differ significantly from the reference value (0) at $\mathbf{p < 0.001}$. Given that zero represents the lowest point on the scale, these findings confirm strong agreement that agile manufacturing contributes to cost management across every item. Future tests might adopt a more meaningful benchmark (e.g., 3 = neutral) to gauge the positive bias more precisely, but the current data clearly reveal robust support for the cost-management role of agile manufacturing.

Table 7. One-Sample *t*-Test for Dimension 2 (Differentiation Strategy)

Item	*t*	*df*	*Sig.* (2-tailed)	Mean Difference	95 % CI (Lower–Upper)
Y1	76.161	49	0.000	4.18000	4.0697 – 4.2903
Y2	69.730	49	0.000	4.16000	4.0401 – 4.2799
Y3	105.274	49	0.000	4.08000	4.0021 – 4.1579
Y4	88.749	49	0.000	4.12000	4.0267 – 4.2133
Y5	119.670	49	0.000	4.06000	3.9918 – 4.1282
Y6	79.431	49	0.000	4.16000	4.0548 – 4.2652
Y7	95.667	49	0.000	4.10000	4.0139 – 4.1861
Y8	79.431	49	0.000	4.16000	4.0548 – 4.2652
Y9	95.667	49	0.000	4.10000	4.0139 – 4.1861
Y10	73.500	49	0.000	4.20000	4.0852 – 4.3148

Source: Prepared by the researcher using SPSS software.

All items in the differentiation dimension differ significantly from zero at **p < 0.001**, confirming unanimous agreement that agile manufacturing strengthens differentiation. Means range from 4.06 (Y5) to 4.20 (Y10), reflecting a clear orientation toward high agreement. Confidence intervals are narrow owing to low variance, underscoring response homogeneity. **Overall Conclusion** Because every study variable attained a significance level of **0.000 < 0.05**, the research hypothesis is supported: **adopting Agile-Manufacturing techniques indeed improves cost management and positively reinforces differentiation strategy by enhancing production efficiency, reducing costs, and raising product quality.** This, in turn, elevates customer satisfaction and secures competitive distinctiveness.

Section Four - Conclusions and Recommendations

Conclusions

1. Statistical tests confirm that Agile-Manufacturing principles cut operating, logistical, and development costs, proving their cost-efficiency.
2. High mean scores on the differentiation dimension show that agile manufacturing's flexibility, rapid response, and product customization directly build a lasting competitive edge.
3. A Cronbach's-α of 0.932 evidences strong internal consistency and high measurement reliability.
4. Low standard deviations indicate pronounced response homogeneity, boosting the findings' credibility and limiting bias.
5. The comparatively weak correlation for labor-and-asset utilization suggests this aspect needs clearer definition or illustrative examples in future research.
6. Acceptance of the main hypothesis demonstrates that agile manufacturing simultaneously improves cost management and strengthens differentiation, raising customer satisfaction and competitive capability.

Recommendations:

1. Integrate production lines with Internet-of-Things technologies and real-time data sensing to detect and eliminate waste instantly.
2. Implement structured training and empowerment programmes to build employees' digital-analytics skills and agile-equipment maintenance capabilities, accelerating decision-making and innovation.

3. Establish comprehensive KPIs that track workforce productivity and asset efficiency, linking results to incentives for cost reduction and greater flexibility.
4. Embed Lean and Six Sigma methodologies within the agile-manufacturing framework to address waste and variability concurrently and maximise their combined impact on process quality.
5. Forge open-innovation partnerships with suppliers and customers to speed customised product development and enhance perceived value.
6. Re-test statistical models using a neutral midpoint (Likert = 3) and examine moderating variables—such as plant size and automation level—to identify conditions that maximise agile manufacturing's effects on cost and differentiation.

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