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TECHNOLOGY-ENABLED MANUFACTURING MANAGEMENT AND COMPETITIVENESS: ASSESSING THE IMPACT OF DIGITAL INTEGRATION, INNOVATION, AND ADVANCED TECHNOLOGIES

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Original research

A B S T R A C T

The study aimed at technology adoption and competitiveness of manufacturing firms. The specific objectives of the study were to determine the effect of networking integration on cost competitiveness; assess the effect of digital marketing on market share; assess the effect of product development on customer satisfaction; and determine the effect of technology advancement on cost competitiveness. The study adopted the survey research design. A purposive sampling was triangulated with snowball sampling technique to arrive at 342 respondents. The study used well-structured questionnaire, and the reliability of the instrument was determined with Cronbach alpha test. The study used Structural Equation Model. Regression weight was applied to test hypotheses. Findings revealed that networking integration had a significant positive effect on cost competitiveness, digital marketing had no significant positive effect on market share, product development had a significant positive effect on customer satisfaction, and technology advancement had a significant positive effect on cost competitiveness. The study concluded that technology promotes competitiveness in today's business environment. The study recommended that firms prioritize networking integration by fostering strategic partnerships and collaborative networks in order to enhance competitiveness.

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1. INTRODUCTION

Firms often take decision regarding the technology to adopt. This affects the manner in which the firms improve their performance and competitiveness. Technology adoption is the use and application of new technologies aimed at enhancing the performance and competitiveness of a firm. This includes the use of automation technologies, digital technologies, and modern production technologies. When a firm adopts the technologies, it can improve its performance by increasing efficiency and output while reducing costs. This depends on the manner in which the technologies are implemented in the daily running of the business (Mubarak et al., 2021; Ouyang et al., 2020). A firm can adopt technologies to improve efficiency, and the quality of products. That is, the adoption of technologies is a

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crucial factor for a firm aimed at enhancing performance and competitiveness.

Technology adoption research in the field of manufacturing has also improved over the years. From past research, it has been noted that the adoption of technology by firms enhances productivity and helps the firm to respond to changes in the market (Asche et al., 2018; Tofail et al., 2018). In developed regions, the government has formulated policies that enhance research and development, as well as the adoption of modern technology by firms (Marques et al., 2019; Park, 2017). The adoption of modern technology, including artificial intelligence and robotics, has helped firms to enhance production and even come up with new products (European Commission, 2020). From recent research, it has been noted that the adoption of technology has helped firms to enhance communication, as well as the development of production systems (Reiman et al., 2021; Sgarbossa et al., 2020). Key areas have been noted, including networking systems, digital platforms, technological change, product development, and technology advancement. Though studies are done on developed countries, fewer studies are done on African countries. In Africa, firms are using technology to improve production efficiency and product quality (Esho & Verhoef, 2020).

In Nigeria, big firms are using modern technology to improve efficiency, but small and medium-sized firms are facing challenges in adopting modern technology. One of the areas is networking integration, which is helpful for communication in production and supply chains. A well-integrated networking system helps firms avoid delays and improve cost competitiveness. Conversely, a poorly integrated networking system raises operational costs (Sahoo & Lo, 2022). The Southeast region of Nigeria features manufacturing firms within a very competitive environment – market expansion is key here. Digital marketing features significantly within such processes. Firms can use the web to promote their offerings and increase both customers and market share (Bala & Verma, 2018; Nanda et al., 2021). The downside is that many firms do not take full advantage of such digital tools and methods, limiting their competitiveness and visibility within such markets. Technological change is an important element within manufacturing activity. Such changes as automation or modern methods make for increased speed and less manual work within operations (Ryalat et al., 2023; Tyagi et al., 2021). The big drawback is the very fast rate of such change, making productivity and performance difficult to maintain within many manufacturing firms.

Product development is also an aspect to be considered for competitiveness. Organizations that use modern technology in product development are able to satisfy their customers. This is due to the fact that products become reliable and marketable (Pallant et al., 2020; Tan et al., 2020). The limited use of technology in product development makes it difficult for organizations to satisfy their customers. Considering technology advancement, which involves constant improvement in tools and techniques, is important for desired competitiveness. Organizations take advantage of advanced technology to reduce production costs. This makes them competitive in the market (Muñoz et al., 2019; Prashar et al., 2022).

However, despite the benefits associated with the use of this aspect of technology, there is still a gap in the adoption by manufacturing firms. This means that if the firms do not improve in the respective areas, they may lose their competitiveness and the ability to meet the needs of the market. This therefore presents a gap in the understanding of the impact of various aspects of technology adoption on competitiveness..

2. LITERATURE REVIEW

2.1 Theoretical foundation

This study is anchored on technology-organization-environment (TOE) framework and dynamic capabilities theory (DCT). The TOE Framework is useful because it explains adoption as a function of technological readiness, organizational capacity, and environmental pressure (Arifia, 2024; Malik et al., 2021). The study back up with DCT because adoption translates into competitiveness. The theories provide complementary lenses for understanding both the adoption and the competitive consequences of digital manufacturing technologies. The TOE framework posits that the adoption of technological innovations within firms is shaped by three contextual dimensions: the technological context (the availability and characteristics of relevant technologies, such as networked production systems and digital design tools), the organizational context (firm-level resources, structure, and readiness to absorb new technologies), and the environmental context (external competitive pressures, industry dynamics, and market demands that push firms toward digitalization) (Malik et al., 2021; Shahadat et al., 2023).

In this study, TOE explains why and under what conditions manufacturing firms adopt digital manufacturing capabilities such as networking integration, digital marketing platforms, product development tools, and broader technological advancement associated with Industry 4.0 practices. However, TOE alone does not account for how adopted technologies translate into sustained competitive advantage, which is where DCT becomes essential. DCT argues that firms achieve competitive advantage not merely by possessing resources or technologies, but by their capacity to sense opportunities, seize them through strategic deployment of resources, and reconfigure internal processes in response to changing environments (Teece et al., 1997). Applied to this study, DCT explains how the technological capabilities identified through the TOE lens are converted into measurable competitive outcomes, cost competitiveness, market share, and customer satisfaction, by enabling firms to continuously

adapt their operations, marketing, and product offerings in line with digital transformation demands.

2.2 Networking integration and cost competitiveness

Networking integration involves connecting internal activities with external partners and systems. Such an approach makes it possible for firms to share information and processes while reducing delays and making better decisions. The outcome is lower production and operating costs; a clear improvement in cost competitiveness (Purohit, 2021; Zhou et al., 2021). Cost competitiveness reflects the ability of a firm and its offerings to meet market needs at a lower cost. Integration has consistently shown benefits regarding supply chain and production system coordination.
It helps in enabling knowledge sharing and collaboration between firms and their suppliers. All of this helps firms to improve innovation and problem solving in faster responses to market changes (Yang et al., 2018; Shen et al., 2021). Such benefits aid in managing supply chain problems and making quick recoveries from any crises, all helping cost control efforts (Paul & Chowdhury, 2021; Jiang et al., 2019; Çodur, & Erkayman, 2025). Studies (Knudsen et al., 2021; Yadegaridehkordi et al., 2018) have shown that firms that combine technology with strong integration systems find better performance and cost advantage. Thus, we hypothesized that:

H1: Networking integration has a significant effect on cost competitiveness.

2.3 Digital marketing and market share

Digital marketing offers firms simple means of promoting products and engaging with customers and gathering information regarding their decisions to buy products. Digital tools can improve the experience and satisfaction levels of customers and build brand loyalty (Purnomo, 2023; Özkan et al., 2020). The use of digital channels alone, however, can limit a firm's reach, especially to those customers not active within online platforms. Firms that understand data analytics elements well as well as social media features see benefits in understanding customer needs and offering better services and sales performance (Kaila, 2020; Seyyedamiri & Tajrobehkar, 2021). In the same way, digital marketing efforts build brand awareness, relationships and competitive advantage, all with speed and interaction with customers (Cao et al., 2018; Komulainen & Makkonen, 2018). The use of artificial intelligence and automation efforts also helps marketing activities improve speed, accuracy and targeting (Lee & Yoon, 2021). Digital marketing thus aids in both communication and customer engagement; elements that will result in market share growth if properly used in a planned and customer-focused way (Teece, 2018; Laaksonen & Peltoniemi, 2016). Thus, we formulate hypothesis that:

H2: Digital marketing has a significant effect on market share.

2.4 Product development and customer satisfaction

Previous studies show that product development has a strong effect upon customer satisfaction (Beltagui, 2018; Seyyedamiri, & Tajrobehkar, 2021). Companies that employ a clear and planned process to create their goods see better results in creating goods that solve problems, improve quality and features. Studies (Barrane et al., 2021; Beltagui, 2018; Song & Parry, 1997) indicate that including customers in development processes actually does lead to increased satisfaction. The inclusion of customer ideas in development processes supports innovation outcomes and more useful products, increasing interest and quality perceptions among customers (Browder et al., 2023; Zhou et al., 2021). The speed and efficiency in product development impacts customer satisfaction as well. Companies that continually update and improve their products do so quickly and with trust-based outcomes. Poor practices in contrast - ignoring feedback or cost-only focuses - naturally give rise to products failing to meet expectations. Thus, we hypothesized that:

H3: Product development has a significant effect on customer satisfaction.

2.5 Technology advancement and cost competitiveness

Firms investing in technology experience faster production whilst maintaining quality (Bosman et al., 2020; Dalmarco et al., 2019). Technology does not always bring about lower costs automatically. Elements like high initial costs, staff not ready for new systems and difficulties in linking to old systems can present problems. Should these issues remain unresolved, cost savings efforts will necessarily be small. Research shows that firms well-planned and properly managing their technology see best results for cost reduction and low prices without compromising quality offerings (Cocco et al., 2017; Mithas & Rust, 2016; Shrivastava, 2018). Technology within supply and production contexts allows firms to work better together whilst avoiding errors and faster decisions. Companies employing such digital and data-based systems find they can track cost at the appropriate time whilst also acting quickly to changes and avoiding waste (Ghoreishi, 2023). In such competitive markets firms that do not effectively utilise technology see both higher costs and weaker pricing capabilities than they observe from those that do (Fainshmidt et al., 2019; Jeng & Pak, 2016). Thus, we hypothesize that:

H4: Technology advancement has a significant effect on cost competitiveness.

3. METHODOLOGY

3.1 Research Design

This study utilized the survey research design. This involved gathering data through a survey-based questionnaire to recognize and establish connections among the variables (Aithal & Aithal, 2020). The design is an important procedure in quantitative research, and it helped to describe the attributes, and behavior characteristics of the population (Duckett, 2021).

3.2 Population and Sampling

The target population consisted of senior and junior staff from 50 selected manufacturing firms in Southeast, Nigeria. Purposive sample of was used. 342 respondents participated in the survey. The selection criterion is that the firms are more than five years in operation, and that employees have a reasonable knowledge about technology adoption in their workplace. The study also adopted snowball sampling method. This enabled respondents to make reference to other employees who have knowledge about technology adoption.

3.3 Instrument and Measurement

The research instrument used was questionnaire. The Network Integration Scale, developed by Burt (1992), was found and adapted as a valuable tool for assessing 'networking integration' within the manufacturing sector. A relevant scale for measuring "digital marketing" is the "Digital Marketing Maturity Model" developed by Kaplan and Haenlein in 2016. This model assesses the digital marketing capabilities and maturity levels of organizations. By applying the Digital Marketing Maturity Model to the manufacturing firms in Southeast Nigeria, the study effectively evaluated digital marketing. Product development was measured using the "New Product Development (NPD) Scale" developed by Song and Parry (1997). This scale helped measure the firms' proficiency in integrating technology-driven innovation into their product development processes. Other variables were measured subjectively using a 5 point Likert-type scale ranging from strongly agree (5), agree (4), undecided (3), disagree (2) and strongly disagree (1).

The variables were chosen as they reflect different, empirically derived aspects of the digital manufacturing capabilities under Industry 4.0, and the set covers the wide spectrum of technological change in firms, not a specific, limited aspect of this change. Networking integration is the cyber-physical connectivity that is key to Industry 4.0, whereas digital marketing represents the customer-oriented aspect of adoption; product development refers to a firm's capacity in digitally-enabled design and innovation practices closely related to customers satisfaction; and technological advancement and technological change are differentiated to distinguish a firm's current digital infrastructure from the speed and process of acquiring new tools in the course of time, a distinction in the adoption literature. They represent the aspects of sensing, seizing and reconfiguring, which are key to DCT, and are in line with the technological and organizational context described in the TOE framework, so that the constructs selected are theoretically grounded rather than arbitrary, and can be individually motivated as mechanisms that link digital manufacturing adoption to firm competitiveness.

3.4 Instrument Validity/Reliability

The study used construct validity. This was achieved through factor analysis. This ensured that all facets of the constructs are contained and well described in the instrument (Hair et al., 2024). The factor loadings derived from this analysis indicated the strength of these relationships, with values above 0.30 considered significant, those above 0.40 deemed more significant, and loadings over 0.70 classified as highly significant (Halimoon et al., 2021). Test-retest method was adopted to ascertain the reliability of the research instrument. The data collected were tested for internal consistency using Cronbach alpha coefficient. The validity and reliability results are shown in Table 1.

Table 1. Measurement Model: Factor Loadings, Average Variance Extracted (AVE), and Cronbach's Alpha

Indicator Variable	Loading	AVE	Square root of AVE	Chron (α)
Networking Integration	0.741	0.5752172	0.758430748	0.783
Digital Marketing	0.82	0.6249716	0.790551453	0.794
Product Development	0.78	0.6119238	0.782255585	0.768
Technological Advancement	0.813	0.6118312	0.782196395	0.765
Cost Competitiveness	0.765	0.6507964	0.80671953	0.791
Market Share	0.722	0.577235	0.75975983	0.810
Customer Satisfaction	0.772	0.6169534	0.785463812	0.781

Source: *AMOS SPSS, 2025*

The result presented in Table 1 demonstrates the reliability and validity of the research instrument. All indicator loadings hover above 0.7 indicating that each item does well in measuring its variable. The AVE value for all variables is above 0.5 indicating good convergent validity – the items include in each variable have a sufficient level of common meaning. The square root of the AVE for each variable proves to be higher than the AVE value itself, suggesting good discriminant validity among the variables. Furthermore, all variables feature Cronbach alpha (α) values above 0.7 indicating good internal consistency and reliability of the survey instrument.

Table 2. Discriminant Validity Assessment Using the Fornell–Larcker Criterion

	NKI	DMG	TLC	NPD	TCA	CCS	MSE	PDY	CSN
NKI	**0.895**								
DMG	-0.001	**0.984**							
TLC	0.050	-0.022	**0.977**						
NPD	-0.008	0.034	0.010	**0.981**					
TCA	0.012	0.050	-0.042	0.100	**0.894**				
CCS	0.004	0.109	-0.070	-0.021	0.544	**0.944**			
MSE	-0.012	0.044	0.582	-0.004	-0.060	-0.030	**0.993**		
PDY	-0.041	0.033	0.124	0.492	0.140	0.003	0.282	**0.918**	
CSN	0.017	0.036	0.023	0.860	0.138	-0.032	0.044	0.416	**0.784**

Discriminant validity is achieved (as shown in Table 2) for all constructs with values of AVE greater than the other constructs, except for NPD–CSN (0.86) and PDY–CSN (0.42), where the former construct is related to the latter construct by a real substantive relationship and not by measurement overlap.

Table 3. Multicollinearity (Variance Inflation Factor)

Predictor	VIF
Networking Integration (NKI)	1.003
Digital Marketing (DMG)	1.004
Technological Change (TLC)	1.005
New Product Development (NPD)	1.011
Technology Advancement (TCA)	1.014

Table 3 shows that no independent variable is problematic for multicollinearity as all of the VIF values are significantly lower than the conventional threshold of 10 and even lower than the more conservative threshold of 3–5.

Table 4. Common Method Bias (Harman's Single-Factor Test)

Component	Variance Explained (%)
Factor 1	21.22
Factor 2	17.57
Factor 3	14.37
Factor 4	10.48
Factor 5	9.16
Cumulative (Factors 1–5)	**72.80**

Table 4 shows the results for common method bias. An unrotated principal component analysis was conducted with all 36 items. If one factor accounts for less than 50% of the total variance, then common method bias is not a significant problem to invalidate the results. The result indicates that common method bias is not a serious concern since the first factor explains 21.22% of total variance.

3.5 Data Analyses Techniques

The data was presented in tables and the relevant values in percentages. Hypotheses 1,2 & 3 were tested via a Structural Equation Model (SEM) using Amos-IBM. All hypotheses were tested at 5% error. Such an approach to testing hypotheses 1, 2, 3, 4 and 5 is appropriate given the ordinal nature of the data. The structural model provides a measure of goodness-of-fit via a series of model fit indices – each providing robust validation of the model.

4. DATA ANALYSIS AND RESULTS

Table 5 indicates that 49.7% of the participants were of the male gender, while 50.3% were female. 38.6% of the participants were below the age of 25 years, while 40.1% were within the range of 26-31 years. 13.5% were within the range of 32-37 years, while the remaining 7.9% were of the age 38 years and above.

Table 5. Demographics of respondents

Demography	Frequency	Percent
Gender		
Female	172	50.3
Male	170	49.7
Age		
< 25 years	132	38.6
26-31 years	137	40.1
32- 37 years	46	13.5
> 38years	27	7.9
Marital Status		
Single	129	37.7
Married	201	58.8
Divorced	11	3.2
Separated	1	.3
Education level		
OND/Equivalence	100	29.2
HND/B.Sc	177	51.8
MBA/M.Sc	64	18.7
PhD	1	.3
Experience		
<5 years	127	37.1
6-11 years	111	32.5
12-17 years	75	21.9
18-23 years	16	4.7
24-29 years	7	2.0
30-35 years	4	1.2
> 35 years	2	.6

Source: *Field survey, 2025*

The analysis also indicates that 37.7% of the participants were considered single, while 58.8% were married with 3.2% being divorced and only 0.3% being separate. The analysis of the educational level of the participants indicates that 29.2% have an OND or similar level, while 51.8% have HND/B.Sc level. 18.7% were found with an MBA/M.Sc level, while only 0.3% have Ph.D. level. The

analysis also indicates that 37.1% of the participants have work experience of less than five years. However, 32.5% had six to eleven years of work experience, and 21.9% had twelve to seventeen years of experience.

In addition, 4.7% had experience between eighteen and twenty-three years old, and 2.0% had experience between twenty-four and twenty-nine years old. Furthermore, 1.2% had experience between thirty and thirty-five years, and 0.6% had experience above thirty-five years.

Table 6. Model Fit Summary on Technological Innovation

Fit Indices	Model	Default Model	Saturated Model	Independence Model
CMIN	NPAR	50	210	20
	CMIN	380.223	0	11163.671
	DF	160	0	190
	P	.000		.000
	CMIN/DF	2.376		58.756
RMR, GFI	RMR	.046	.000	.502
	GFI	.900	1.000	.302
	AGFI	.868		.228
	PGFI	.686		.273
Baseline Comparisons	NFI (Delta1)	.966	1.000	.000
	RFI (rho1)	.960		.000
	IFI (Delta2)	.980	1.000	.000
	TLI (rho2)	.976		.000
	CFI	.980	1.000	.000
Parsimony-Adjusted Measures	PRATIO	.842	.000	1.000
	PNFI	.813	.000	.000
	PCFI	.825	.000	.000
NCP	NCP	220.223	.000	10973.671
	LO 90	167.033	.000	10630.733
	HI 90	281.120	.000	11322.922
FMIN	FMIN	1.115	.000	32.738
	F0	.646	.000	32.181
	LO 90	.490	.000	31.175
	HI 90	.824	.000	33.205
RMSEA	RMSEA	.064		.412
	LO 90	.055		.405
	HI 90	.072		.418
	PCLOSE	.004		.000
AIC	AIC	480.223	420.000	11203.671
	BCC	486.786	447.563	11206.296
	BIC	671.964	1225.310	11280.367
	CAIC	721.964	1435.310	11300.367
ECVI	ECVI	1.408	1.232	32.855
	LO 90	1.252	1.232	31.850
	HI 90	1.587	1.232	33.880
	MECVI	1.428	1.313	32.863

Source: *Amos-IBM*

As presented in Table 6, the value of the chi-square test (CMIN = 380.223, p = .000) is significant – there is some difference between the model and the data. The test, however, is affected by the large sample size – hence the result is acceptable. The chi-square/df test value (2.376) remains less than 3 – indicating good model fit. The RMR value of 0.046 is low – another indication of good model fit and small error. Both the GFI (0.900) and AGFI (0.868) fall into the "good" range as well.

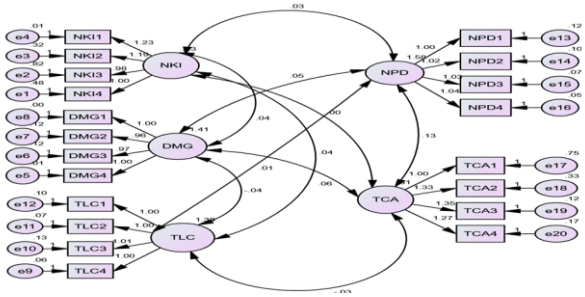

Figure 1. Structural Equation Model on Variables of Technology Innovation
Source: Amos-IBM

Figure 1 shows the relationship among the latent variables. The result is complemented by Table 4.

Table 7. Covariances Test for Technology Innovation

Variables			Estimate	S.E.	C.R.	P
NKI	<-->	DMG	.041	.062	.656	.512
NKI	<-->	TLC	.040	.062	.637	.524
TLC	<-->	TCA	-.025	.051	-.492	.622
NKI	<-->	NPD	.032	.066	.476	.634
NKI	<-->	TCA	.004	.042	.103	.918
TLC	<-->	NPD	.010	.081	.118	.906
DMG	<-->	NPD	.055	.082	.670	.503
NPD	<-->	TCA	.128	.056	2.294	.022
DMG	<-->	TLC	-.036	.076	-.469	.639
DMG	<-->	TCA	.056	.052	1.079	.280

Source: *Amos-IBM*

Note: NKI= Networking Integration; DMG= Digital Marketing; NPD= Product Development
TCA= Technological Advancement; CCS= Cost Competitiveness; MSE= Market Share; CSN= Customer Satisfaction

Other values indicate good model fit as well: the NFI (.966), IFI (.980), TLI (.976) and CFI (.980) all lie above the 0.90 mark. The parsimony values show good model fit too – PRATIO (0.842), PNFI (0.813) and PCFI (0.825) are all fairly high. The NCP value (220.223) is not zero – however it is considerably lower than that of the basic model. The values of FMIN (1.115) and F0 (0.646) are low – more evidence of good fit. The RMSEA value of 0.064 comes below the 0.08 threshold as well. The range (0.055-0.072) indicates good model fit.

Table 7 presents the covariance analysis of the various independent variables – networking integration, digital marketing, technological change, product development and technological advancement. The relationship between networking integration and digital marketing (Estimate = 0.041, C.R. = 0.656, p = 0.512) is non-significant – there is no strong covariance between these two variables. The linkage between networking

integration and technological change (Estimate = 0.040, C.R. = 0.637, p = 0.524) is positive yet non-significant – again indicating no meaningful connection. There does not appear to be a strong link between technological change and technological advancement – the two variables feature a negative covariance (Estimate = -0.025, C.R. = -0.492, p = 0.622). The covariance between networking integration and product development (Estimate = 0.032, C.R. = 0.476, p = 0.634) is likewise non-significant – these variables exhibit no strong association.

The same is true of the relationship between networking integration and technological advancement (Estimate = 0.004, C.R. = 0.103, p = 0.918) – no meaningful connection exists between these variables. The covariance between technological change and product development (Estimate = 0.010, C.R. = 0.118, p = 0.906) indicates no strong relationship between these variables. The same is true of digital marketing and product development (Estimate = 0.055, C.R. = 0.670, p = 0.503). Table 7 does, however, show that product development and technological advancement are significantly related (p = 0.022) – the two variables are positively related. The negative covariance between digital marketing and technological change (Estimate = -0.036, C.R. = -0.469, p = 0.639) is non-significant – suggesting no strong relationship between these variables. Lastly, the relationship between digital marketing and technological advancement (Estimate = 0.056, C.R. = 1.079, p = 0.280) is also non-significant – there is no strong association between these variables.

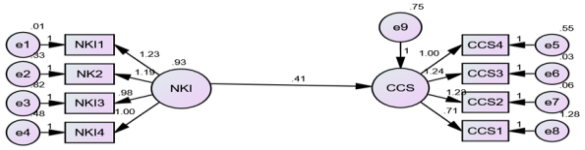

Figure 2. Structural Equation Model on Networking Integration and Cost Competitiveness
Source: Amos-IBM

Table 8. Regression Weights

Variables			Coef. (β)	S.E.	C.R.	P-value
CCS	<---	NKI	.414	.055	7.551	0.000

Source: *Amos-IBM*

Most of the relationships among these variables are non-significant – there are no issues with covariance. Thus, the data is credible and suitable for further analysis.The results of the regression analysis for the impact of networking integration on cost competitiveness are presented in Table 8. The regression coefficient (β = 0.414) implies that for every one unit change in networking integration, the level of cost competitiveness is expected to change by 0.414 units. This implies a positive relationship between networking integration and cost competitiveness. Figure 2 below shows the level of strength of the measuring parameters of networking integration, as well as its explanatory power for cost competitiveness. This is similar to the regression coefficient presented in Table 5. The p-value (p-value < 0.01) implies that networking integration has a positive impact on cost competitiveness.

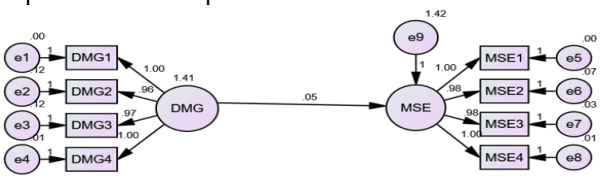

Figure 3. Structural Equation Model on Digital Marketing and Market Share
Source: Amos-IBM

Table 9. Regression Weights

Variables			Coef. (β)	S.E.	C.R.	P-value
MSE	<---	DMG	.049	.054	.894	.371

Source: *Amos-IBM*

Table 9 presents the result of the regression analysis for the effect of digital marketing on market share. The regression coefficient (β = 0.049) implies that for every one-unit increase in digital marketing, the market share will increase by 0.049 units. This suggests a weak positive relationship between digital marketing and market share. Figure 3 depicts the strength of the measuring parameters for digital marketing, which is low, thus explaining the limited power of the parameters.

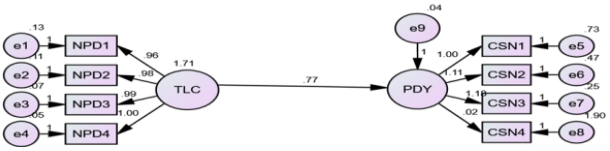

Figure 4. Structural Equation Model on Product Development and Customer Satisfaction
Source: Amos-IBM

Table 10. Regression Weights

Variables			Coef. (β)	S.E.	C.R.	P-value
CSN	<---	NPD	.774	.037	20.882	0.000

Source: *Amos-IBM*

The figure 3 also reflects the result of the regression analysis presented in Table 6, showing the insignificant effect of digital marketing on market share. The p-value (p-value = 0.371) is higher than 0.05, thus confirming the result showing an insignificant positive effect of digital marketing on market share. Table 10 presents the results of the regression analysis to determine the effect of product development on customer satisfaction. The regression coefficient of 0.774 indicates that if there is a one-unit increase in the product development stage, there will be an improvement of 0.774 units in customer satisfaction. This coefficient shows a strong positive relationship between product development and customer satisfaction. Figure 4 illustrates the measuring parameters of product development and their strengths, which are closely related to the regression coefficient in Table 7. Furthermore, the p-value, which is less than

0.01, validates the regression model that demonstrates the positive effect of product development on customer satisfaction.

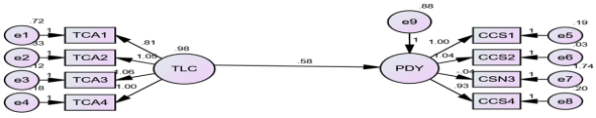

Figure 5. Structural Equation Model on Technology Advancement and Cost Competitiveness
Source: Amos-IBM

Table 11. Regression Weights

Variables			Coef. (β)	S.E.	C.R.	P-value
CCS	<---	TCA	.577	.057	10.182	0.000

Source: *Amos-IBM*

From the regression analysis result in Table 11, the effect of the factor "technological advancement" on the "cost competitiveness" was examined. The resulting regression coefficient (β) indicated that with a unit increase in the factor "technological advancement," there was an increase of 0.577 units in the factor "cost competitiveness." The strength of this linear relationship implies that the factor "technological advancement" plays an important role in the factor "cost competitiveness." Furthermore, the p-value for this relationship is less than 0.05 ($p < 0.05$; $p = 0.000$), which validates the statistical significance of the positive effect of "technological advancement" upon "cost competitiveness."

5. DISCUSSIONS

Finding revealed that networking integration has a significant positive effect on cost competitiveness of manufacturing firms (β=0.414, p= 0.000 < 0.05). The findings are in agreement with those of Gulati et al. (2017), who found that there is a significant positive relationship between networking between organizations and the advantages that can be gained from such an activity. Shin (2019) also found that incorporating networking into the organization can lead to cost efficiencies within that firm. Furthermore, Hernandez and Shaver (2019) and Galvão et al. (2019) found that incorporating networks into the manufacturing companies allows them to gain cost and innovative efficiencies that they are otherwise unable to create in their industries. Thus, these findings support the idea that networking can significantly impact cost competitiveness within the manufacturing sector.

Finding revealed that the use of digital marketing has no significant positive effect on the market share of the manufacturing firms studied (β = 0.049, p = 0.371 > 0.05). While Kannan (2017) and Herhausen et al. (2020) state that digital marketing is crucial for the modern business, the effectiveness of digital marketing in manufacturing is dependent upon the inclusion of digital marketing in their offline marketing and business strategies. Aish (2022) states that using digital marketing successfully increases the engagement and loyalty of their customers, which are aspects necessary to gain market share. However, Giantari et al. (2022) state that digital marketing for manufacturing is only one aspect of a complex strategy required to gain significant improvements in market share.

Finding revealed that the implementation of product development has a significant positive effect on the satisfaction of customers of the manufacturing firms (β = 0.774, p = 0.000 < 0.05). Iheanachor et al. (2021) state that implementing processes to develop products for their customers will lead to products that satisfy their customers and meet their needs. Furthermore, Cui and Wu (2017) state that understanding the needs and preferences of their customers is a crucial part of the product development process that will lead to the satisfaction of their customers. Additionally, Falahat et al. (2024) determined that manufacturing companies that focus upon developing their products according to the customers' specifications experience higher rates of customer satisfaction with the products that are provided to them.

Finding revealed that technological advancement has a significant positive effect on the cost competitiveness of the manufacturing companies (β = 0.577, p = 0.000 < 0.05). For example, manufacturers that implemented technological advancements in the form of IoT, AI, and robotics were found to have significantly impacted their costs and abilities to lower their costs of operation (Benotsmane et al., 2019). Additionally, companies that integrated technology into their supply chains were found to have significantly lower costs of operation and become cost-competitiveness in comparison to their competitors.

6. CONCLUSION

The study concludes that technology is a fundamental driver of competitiveness within today's business landscape. Technology is not just a tool but a strategic asset capable of redefining a firm's competitive landscape. Each of these elements (networking integration, digital marketing, technological advancements and product development) work to highlight the critical role of technology within a firm's strategic positioning and competitiveness. Firms that effectively leverage technology improve cost competitiveness yet gain increased agility in their business model. Such adaptability is vital in today's rapidly changing markets and business environments. The effective use of technology helps firms better optimize resources and provide value to customers more efficiently.

6.1 Recommendations

The study recommended that:

i. Firms should prioritize networking integration as a means of enhancing competitiveness –

forming strategic partnerships and collaborative networks. This approach will enable firms to achieve cost advantages.

ii. Firms should also consider reallocating resources towards enhancing other competitive strategies – ones that offer higher returns – instead of heavily investing in digital marketing strategies that exhibit only an insignificant positive effect upon market share. Exploring innovative technologies that enhance either products or customer experience may lead to a more substantial effect upon competitiveness.

iii. Firms should prioritize product development efforts focused upon innovative designs and features – especially those aligned with customer preferences or needs. Offering consistently high quality products enhances customer satisfaction and loyalty – and provides a competitive advantage within the market.

iv. Firms should actively pursue and adopt technological advancements to enhance cost competitiveness – such innovations lead to substantial expense reductions. Furthermore, continuous evaluation of emerging technologies will ensure that firms remain agile and able to take advantage of future cost savings opportunities.

6.2 Contribution to knowledge

This study contributes to theory by extending TOE and DCT to the context of digital manufacturing adoption in manufacturing firms. Rather than treating technology adoption as a monolithic construct, the study disaggregates it into dimensions (networking integration, digital marketing, product development, technology advancement, and technological change) each reflecting a distinct facet of Industry 4.0 practice, from cyber-physical interconnectivity to digitally enabled product innovation. By empirically linking these dimensions to specific competitiveness outcomes (cost competitiveness, market share, customer satisfaction), the study provides a more granular understanding of which digital manufacturing capabilities drive which forms of competitive advantage, addressing the tendency in prior literature to treat technology adoption and competitiveness as broad, undifferentiated constructs.

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Conflicts of Interest
The authors declare no conflicts of interest.

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