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THE EFFECT OF COMMUNICATION TECHNOLOGY ADOPTION ON INVENTORY MANAGEMENT AND FIRM PERFORMANCE

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ABSTRACT

The study examines the effect of inventory management and the adoption of communication technology on the performance of firms in Vietnam's manufacturing industry and attempts to fill a research gap regarding the impact of these two variables on each other in emerging economies. In order to examine the effect, panel data from 2013 to 2023 have been used and SGMM estimator has been utilized to capture the dynamics between the investigated variables. The study shows that the adoption of inventory management and the use of communication technology positively affect the performance of firms as measured by ROA and ROE. Besides, there is an interaction between these variables which increases the effect of each variable on firm performance. The study further shows that some of the proxies for the adoption of communication technology (advertising expense, value of intangible technology asset, and capital expenditure) contribute significantly to performance improvement. The results are consistent with Resource Based View and Dynamic Capabilities Theory emphasizing the role of resource integration.

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1. Introduction

The efficient management of inventory and the implementation of communication technology are known factors in determining business performance. In manufacturing industries, efficient inventory management will lower the cost of operation without compromising the flow of operations (Chen et al., 2005; Hendricks & Singhal, 2009). At the same time, the use of communication technology changes the conventional way of doing things and improves demand forecasting, supply chain visibility, and customer engagement (Srinivasan et al., 2005). Even though the importance of inventory management and communication technology adoption in promoting firm performance is recognized, there is little evidence on the impact of these two variables interacting with each other in influencing firm performance. In a developing country like Vietnam, where markets are growing fast, customer needs are highly unpredictable, and foreign competitors are fierce, it is important to look into how inventory management and communication technology adoption interact with each other in shaping performance.

Most of the studies done in this regard focused on industrialized nations. These studies were based on the assumption that technological adoption is commonplace and deeply rooted in the process. There was less attention paid to emerging markets like Vietnam. Even when the attention turned towards emerging markets, most studies focused on the general relationship between technology adoption and inventory management. Most studies used broad proxies like R&D spending or IT investment to measure technological adoption. They did not consider some proxies like advertising and digital marketing expense, intangible technology assets, and capital expenditure (Barney, 1991; Teece et al., 1997). This shows the absence of sufficient evidence on the effect of specific technological investments on inventory management. Addressing this research gap will provide valuable information on how operational and technological strategies affect firm performance in Vietnam.

Digital investments lead to a smooth flow of operations, including inventory coordination and alignment, hence improving firm performance in Vietnam (Vo et al., 2024). In logistics SMEs in Vietnam, technology and innovation adoption have positive associations with firm performance, just like gains in inventory visibility and fulfillment operations (Nguyen et al., 2024). In the supply chain operations, the artificial intelligence-enabled digitalization makes the system resilient and agile, eliminating coordination problems that cause stockouts and overstock, leading to better operational performance (Belhadi et al., 2022).

This study has several theoretical and practical implications. On the theoretical front, the paper contributes by advancing the concept of communication technology adoption as a mediator in the association between inventory management and firm performance, highlighting the role of specific proxies. It relates to theories like the Resource-Based View (RBV) and Dynamic Capabilities Theory, which emphasize the importance of technology in operational efficiency (Barney, 1991; Teece et al., 1997). On the practical side, the findings provide insights into making appropriate decisions in firms on investing in technology to enhance inventory efficiency and business performance. With the current economic environment and the need to recover from the economic fallout caused by the coronavirus pandemic, the findings of this study are crucial for Vietnam's manufacturing firms (Ivanov, 2020).

The purpose of this study is to investigate the direct impacts of inventory management and communication technology adoption on firm

performance and how the combination of these two factors mediate operational performance. The System Generalized Method of Moments (SGMM) estimator will be used to analyze the data because it eliminates endogeneity and dynamic impacts found in longitudinal data.

The contributions of this paper are diverse. Theoretically, the study adds to the literature by integrating communication technology adoption as a mediator, with special attention to specific and measurable proxies often ignored in previous works. Empirically, it throws light on the manufacturing industry in Vietnam, a less researched area in the current body of knowledge. From the practical point of view, it provides guidelines for making decisions in firms on technological investments that improve operations and performance.

2. Literature review

2.1. Background theories

The research is based on the Resource-Based View (RBV), Dynamic Capabilities and Transaction Cost Economics (TCE). Under the Resource-Based View, the management of inventories and the use of communication technology are defined as valuable, rare and difficult-to-copy resources that increase operational effectiveness. Dynamic Capabilities define how organizations are able to renew and reconfigure such resources constantly through investments in intangible technology assets and infrastructure. The latter increases the sensing, integration and coordination capabilities within the supply chain operations and hence contributes to more effective inventory alignment and operational efficiency. In summary, based on the theory, the expectations are of a positive effect of both inventory capability and communication technology on performance and complementarities between the two constructs (Tornatzky, 1990; Barney, 1991; Rogers, 1995; Kaplan, 1996; Teece et al., 1997; Donaldson, 2001; Williamson, 2008; Freeman, 2010).

As per the predictions derived from TCE framework, the lower are coordination and information-processing costs, the higher are the benefits of using well-coordinated inventory management routines, due to improved accuracy and speed of replenishment, exceptions handling and synchronization. In sum, the theory predicts positive complementarities between communication technology and inventory management on financial performance, resulting from reducing information and coordination costs. A contingency framework helps to define when and how the expected interaction effects operate. Specifically, in case of higher levels of uncertainty or disruptions, the importance of quick information flows and adjustment grows and leads to greater direct impact of communication technology on performance and complementarities with inventory management. In the empirical setup, period-specific variables reflecting shocks to environments account for such disruptions and justify environment-specific interactions (Donaldson, 2001; Ivanov, 2020).

Lastly, the research follows the logic implied by the theories adopted. In particular, in the main specification, communication technology is measured through intangible technology assets ratio and technology capital expenditure ratio, representing respectively the stock and investments in information-technology-supported communication and coordination capabilities. To avoid conceptual confusions, advertising and digital marketing expenses are not considered proxies for communication technology, but as expenses dedicated to demand and marketing communication purposes and hence used as control variable(s). Technology-Organization-Environment and Diffusion of Innovations literature references are provided only to explain differences in adoption of

innovation, but not for any performance effects (Tornatzky, 1990; Rogers, 1995; Srinivasan et al., 2005).

2.2. Empirical studies

Many scholars have explored in-depth the impact of communication technology adoption on inventory management and firm performance. For example, in the Nigerian breweries sector, Akinola and Odesola (2018) found that the implementation of ICT has improved significantly the efficiency of inventory management and enhanced performance. In addition, regarding the Vietnamese environment, in their study of adoption of information technology at a firm level, Cirera et al. (2021) identify considerable technological gaps, especially among manufacturing sectors. According to their results, despite high internet connectivity rates, the adoption of advanced communication technology remains low, leading to poor inventory management and firm performance. Moreover, according to Vo et al. (2024), the digital transformation can act as a moderator and enhance corporate restructuring and improve its performance through more efficient operational activities, such as inventory management. These studies prove that there is room for adopting communication technologies in Vietnam to improve the performance, and it should be taken into account. Additionally, other researchers, including Nguyen et al. (2024) and Bendavid et al. (2009), provide arguments supporting this hypothesis.

There are significant differences in technological adoption between developed and underdeveloped markets, and the consequences of such adoption vary across regions. Namely, advanced technologies increase visibility and efficiency in supply chain management in developed regions, while poorer countries face various constraints due to their economic and infrastructure development and cannot achieve similar levels of performance due to that fact (Akinola & Odesola, 2018; Cirera et al., 2021). Thus, it is vital to ensure that organizations are ready for adopting new technologies because this process requires a certain organizational maturity. Nevertheless, despite many empirical works in this sphere, several gaps are still present in the literature. First, the effect of advertising or digital marketing expenses as a proxy for communication technology adoption on inventory management is not sufficiently examined yet (Queiroz & Wamba, 2019; Belhadi et al., 2022). Second, it is necessary to find out the effects of technological assets and the way they can improve operational efficiency in Vietnam, which has heterogeneous technological adoption among firms (Akinola & Odesola, 2018).

The current state of the academic literature provides additional arguments in favor of the hypothesis about the connection between firm performance and technology adoption. For instance, according to the results of the meta-analysis conducted by Zhou et al. (2022), technology adoption, including data-driven decision-making, significantly enhances the performance of intelligent manufacturing. In the case of Vietnamese market, Vo et al. (2024) conclude that digital transformation has intensified the impact of corporate restructuring on performance, implying that technology adoption increases the effect of the operational change closely connected with inventories. Complementary evidence comes from Nguyen et al. (2024) who find that technology and innovation adoption among logistics firms of medium scale is positively associated with firm performance, which is related to inventory performance. Furthermore, Belhadi, Kamble et al. (2022) reveal that decision-making based on artificial intelligence can lead to greater flexibility and robustness, which implies that communication capabilities improve performance even more. Finally, some scholars

find that the use of data science and immersive digital technologies improves end-to-end coordination and visibility, contributing to better performance (Waller & Fawcett, 2013).

In summary, existing empirical evidence suggests that technology adoption can be positively correlated with performance, but the degree of that correlation varies depending on the country and industry. Therefore, the Vietnamese market can be examined separately in order to understand its characteristics and peculiarities, and future research will be beneficial in this regard.

2.3. Hypothesis development

Following the perspective of the Resource-Based View, the adopted communication technology is regarded as an information-technology-enabled capability. This capability is valuable, difficult to imitate, and embedded in the firm. In turn, the Dynamic Capabilities perspective clarifies the mechanisms through which stock and renewal of this capability drive sensing, integration, and reconfiguration. According to Teece et al. (1997), communication technology affects firm performance through three pathways related to efficient demand and supply sensing, cross-functional and inter-firm coordination, and fast exception handling. Demand and supply sensing lead to more accurate forecasting, resulting in minimized stockout losses. Cross-functional coordination and inter-firm coordination decrease carrying costs by synchronizing replenishment with true demand. Exception handling enables firms to respond rapidly to deviations from planned operations, thereby minimizing cycle times and maximizing asset utilization. As a consequence, return on assets, return on equity, and net profit margin will be increased. Thus, the following hypothesis was formulated:

Hypothesis 1: Adoption of communication technology positively impacts firm performance.

Efficient inventory management has a crucial impact on the operational performance and financial success of manufacturing firms. Inventory management enables firms to find a proper balance between holding costs and stockout penalties (Hendricks & Singhal, 2009). At the same time, inventory management practices influence several important aspects, such as production scheduling, customer satisfaction, and cash flow management (Gaur et al., 2005). High inventory turnover ratio, for example, indicates that the firm manages its inventories effectively, which allows it to sell goods quickly and save money on carrying them. Excessive inventory increases storage expenses and raises risks of product obsolescence. Insufficient inventory leads to lost sales and interrupted operations (Rajagopalan & Malhotra, 2001). The literature review has shown that inventory management plays an essential role in ensuring sustainable competitive advantages as well as short-term financial gains. Based on this information, it is possible to develop another hypothesis:

Hypothesis 2: Effective inventory management positively impacts firm performance.

In addition, communication technologies play a significant role in transforming business processes, including inventory management. Such technologies as advertising and digital marketing tools, enterprise resource planning systems, and predictive analytics help firms to predict the level of future demand and manage the process of supplying goods to customers. The communication technology capability creates a positive effect on firm performance due to increased demand and supply sensing, stronger cross-functional coordination, and faster exception handling, which results in decreased stockout losses and carrying costs, reduced cycle times, and maximized asset utilization, thus enhancing return on assets, return on equity, and net profit margin. Digital

advertising and marketing technologies, for example, allow firms to obtain relevant information regarding consumer preferences and set appropriate levels of inventories in order to avoid misalignment between supply and demand (Srinivasan et al., 2005). Intangible technology assets (e.g., proprietary software and other digital technologies) are crucial for achieving agility and innovation in managing inventories in accordance with the ideas of the Resource-Based View (Barney, 1991). Furthermore, investments in physical capital (infrastructure used to communicate and integrate data) lead to better coordination in supply chains and lower operational costs (Chen et al., 2005). Previous research found that the adoption of advanced technologies results in better financial performance due to enhanced operational capabilities and decision-making processes (Teece et al., 1997). This allows suggesting the following hypothesis:

Hypothesis 3: Adoption of communication technology positively impacts firm performance.

Combining inventory management practices with communication technology adoption might bring synergic effects due to their reinforcing interaction. Adoption of communication technology increases marginal returns of inventory management on firm performance because it helps reduce information and coordination costs and facilitates process reconfiguration. Real-time inventory tracking and predictive analytics enabled by advanced communication technologies increase the effectiveness of inventory-related decisions made by firms (Waller & Fawcett, 2013). For example, companies using digital marketing platforms will be able to align inventory management with marketing activities to ensure adequate supply during periods of increased demand. Following the ideas expressed by the Resource-Based View, combining inventory management capability with communication technologies allows creating a valuable, rare, difficult to imitate, and costly-to-copy resource, which creates sustainable competitive advantage for a firm (Barney, 1991). According to the theory of Dynamic Capabilities, communication technologies can be used as a means to configure firm's operational processes (such as inventory management) in response to changes in the environment (Teece et al., 1997). Several studies show that firms, which combine efficient inventory management with advanced technologies, experience better performance and sustainability (Chen et al., 2005). On this basis, the following hypothesis can be stated:

Hypothesis 4: Adoption of communication technology positively impacts firm performance.

3. Methodology

3.1. Data

Data for this paper have been collected from manufacturing firms that operate on Vietnam's three primary stock market exchanges: the HOSE, HNX, and UPCoM. The data panel spans from 2013 to 2023, providing a 10-year perspective on the performance and inventory management practices of these firms. For this purpose, data have been gathered from the reliable secondary database Refinitiv. The data have been preprocessed to eliminate observations containing missing values, errors, or outliers. As a result of the data preprocessing procedure, we end up with 4,004 observations.

The following set of annual financial variables relevant to the research will be included in our dataset: the inventory turnover ratios, total assets, net sales, advertising and digital marketing costs, intangibles associated with technology, and capital expenditures on technology. The above-mentioned variables are considered as proxies for the use of communication technology in organizations and will be used to explore its effect on inventory management

and firm performance. Information technology-enabled communication capability will be defined as internal technology resources aimed at sensing, communicating, and coordinating actions. Advertising will not be considered in communication capability, but will rather serve as a marketing control variable. Measurement includes two dimensions, namely the intangible stock (ratio of capitalized software, licenses, databases, and communication platforms to total assets) and the investment flow (ratio of additions to capitalized software, information technology equipment, and network infrastructure to total assets), where all goodwill, brands, patents, real estate, plant, maintenance, and non-information technology research and development will be explicitly excluded from the equation. Such specification allows to adopt the Resource-Based View, Dynamic Capabilities, and Transaction Cost Economics perspective by focusing on the capability stock and renewal to limit information and coordination cost issues.

In order to guarantee consistency between the stated research gap and the measurement approach, the definition of information technology-enabled communication capability will be based on two financial variables, namely the ratio of capitalized software, licenses, databases, and communication platforms to total assets and the ratio of additions to capitalized software, information technology equipment, and network infrastructure to total assets. Meanwhile, advertising and digital marketing expenses will only serve as a marketing effort control..

3.2. Models

The study employs a multiple regression framework to evaluate the impact of inventory management, technology adoption, and their interaction on firm performance, while accounting for key control variables. The general model is as follows:

$$Performance_{it} = \beta_0 + \beta_1 Inventory_{it} + \beta_2 Technology_{it} + \beta_3 Invetory^{*}Technology_{it} + \beta_{4\to11} Control_{it} + \varepsilon_{it}$$

In that,

$Performance_{it}$ is the performance of firm i at time t, measured by ROA, ROE and net profit margin,

$Inventory_{it}$ is the inventory factor of firm i at time t, measured by average inventory,

$Technology_{it}$ is communication technology adoption of firm i at time t, measured by advertising and digital marketing expenses, intangible assets related to technology, and capital expenditures on technology,

$Invetory^{*}Technology_{it}$ is the interaction term between inventory and communication technology adoption of firm i at time t,

$Control_{it}$ are control variables include: leverage, growth, liquidity, size, capital intensity, covid19,

$\beta_0 \to \beta_{11}$ are coefficients,

ε_{it} is the error term.

Dynamic panel bias, endogenous regressors, and the presence of firm fixed effects in short T and large N setting will be overcome through the application of System Generalized Method of Moments, which uses the equation of differences and levels and utilizes internal instruments (Arellano & Bover, 1995). Best practices will be followed to minimize instrument proliferation and check instrument validity (Roodman, 2009). Two-step estimates with finite sample correction will be provided for robustness purposes (Windmeijer, 2005).

An operational capability in terms of Resource Based View would be the use of inventory, having a direct positive impact on firm performance. In Dynamic Capabilities, both TechStock and TechInvest represent communication capabilities that can be built through information technology, both with a direct positive effect. The Transaction Cost

Economics theory expects positive moderating effects between inventory and each technology proxy, since technology reduces information and coordination costs and increases the value gained from disciplined inventory management. The contingency view will be tested through time shock variables and interaction if environment is included.

Table 1 summarizes the variable measures used in the paper in order to measure the relationship between inventory management and communication technologies adoption and performance of the company. The following table shows all the variables used for the analysis..

Table 1. Variable measurement

Factor	Variables	Symbol	Measurement
Performance	ROA	ROA	Net income / Average Total Asset
	ROE	ROE	Net income / Average total equity
	Net profit margin	NPM	Net income / Revenue
Inventory	Average inventory	INV	Average inventory value
Communication Technology Adoption	Advertising and digital marketing expenses ratio	ADV	Advertising and digital marketing expenses / Revenue
	Intangible assets related to technology ratio	INT	Intangible assets related to technology / Total asset
	Capital expenditures on technology ratio	CAP	Capital expenditures on technology / Revenue
Leverage	Leverage	LEV	Total debt / Total asset
Liquidity	Liquidity	LIQ	Free cash flow / Total asset
Size	Firm size	SIZE	Natural logarithm of total asset
Capital intensity	Capital intensity	INS	Fixed asset / Total asset
Covid 19	Covid 19 period	COV_19	Dummy variable: 0 if not in Covid19 period, 1 if in Covid19 period

Financial performance measures include Return on Assets (ROA), Return on Equity (ROE), and Net Profit Margin (NPM). According to Aktas et al. (2015), ROA reflects the efficiency of utilizing assets and producing revenues, which corresponds with previous studies focused on the effect of inventory practice and technological adoption on firms' operations. ROE is used as the measure of shareholder return rate and can be considered crucial as it helps evaluate the effect of technological investment and inventory practice on financial gains of the firm. Moreover, NPM shows the efficiency of cost management and profit generation, which is especially important for the manufacturing industry.

The variable chosen to proxy inventory management is average inventory. This variable has been widely used as an inventory proxy by multiple researchers. As effective management practices allow for reducing holding costs and stockouts, the proposed variable is likely to have a direct impact on profitability. As inventory management is closely related to manufacturing industries and depends on production scheduling and fluctuations in customer demand, average inventory can be

considered as a suitable proxy in the research focused on the latter industries (Rajagopalan & Malhotra, 2001).

Three proxies were selected to reflect the adoption of communication technologies. Advertising expenditures (ADV) reflect investments in advertising technologies aimed at improving forecasting and communication efforts, which is aligned with prior studies focused on technology's influence on inventory coordination and efficiency (Srinivasan et al., 2005). Investments in intangibles (INT) show how much the company invests in technology-related intangible assets. As discussed in Barney's theory, intangibles can be considered the main resource for operational efficiency due to competitive advantages (Barney, 1991). Finally, capital expenditures on technology (CAP) help identify investments in technologies aimed at increasing technological capabilities and initiating the digital transformation process.

As mentioned above, control variables should be included in order to account for contextual and firm-specific factors that may impact firm performance. The leverage (DEBT) was measured by calculating the debt-to-assets ratio. Financial risk or capital structure has been previously proven to be related to operational decision-making and technology adoption (Myers, 1977). Moreover, liquidity (LCF) was estimated based on the free cash flow-to-assets ratio. This variable indicates a firm's financial ability to manage short-term liabilities, allocate resources, and make investments. Sales growth (GROWTH) helps understand what changes take place within a firm and what impacts it may have on technology adoption and investments into inventory management. Finally, the following control variables were calculated based on available data: firm size (SIZE), which is measured based on the natural log of total assets; capital intensity (CINT), which is measured based on the ratio of fixed assets to total assets. Furthermore, a dummy variable representing the period of the outbreak of the Covid-19 pandemic (COVID) was introduced.

The System Generalized Method of Moments (SGMM) was chosen as the estimation method in this case. Dynamic nature of inventory practices and technological adoption makes the use of SGMM more appropriate since this method accounts for potential endogeneity arising when technology adoption and inventory management are determined by past firm performance. In fact, the SGMM includes a lagged-dependent variable, which allows for modeling the dynamic effect of performance measures, such as ROA and ROE, on each other. Moreover, the SGMM estimation helps eliminate possible biases associated with autocorrelation and simultaneousness typical for panel data..

4. Results and discussions

4.1. Descriptive analysis

Appendix 1 (see Appendix 1) contains a table showing the descriptive statistics for all variables used in this study. The statistics are useful in terms of understanding the central tendency, dispersion, and distributions for the entire dataset. In terms of performance-related metrics, the dependent variables show a lot of variability. For example, Return on Assets (ROA) has a mean of 5.5% and a standard deviation of 8.8%. The high standard deviation means that while some firms have moderate profitability levels, others report substantial losses (min = -67.5%) and profits (max = 72.2%). On the other hand, the mean of ROE (mean = 13.5%; Std dev. = 234.4%) reflects the presence of extreme outliers in the data set. The net profit margin (NPM) has a negative mean (-17.7%) due to substantial loss-making by some firms in the data set (min = -2761%; max = 2115.8%).

Among the independent variables used in this paper, inventory management reflected through average inventory value (INV) has a moderate mean of 24.5% and low standard deviation (15.1%). In other words, inventory management practices are consistent across different firms. Similarly, investment in communication technologies shows interesting patterns – advertising and digital marketing expenses (ADV) have a mean of 5.5%, while the level of investment in intangibles connected with the use of technologies (INT) has a relatively moderate mean of 7.5%. On the contrary, investment in tangible IT assets (CAP) demonstrates a high variability (mean = 1.506%; max = 4.271.4%).

The control variables provide further insights into the data set's characteristics. For example, the leverage (LEV) has a very high mean of 49.1%, indicating that firms tend to utilize significant amounts of debt financing in their operations. Growth (GROW) is also moderate (mean = 7.1%), but the standard deviation shows that there is quite a bit of variation (min = -87.6%; max = 1933.6%). Similarly, the level of liquidity, calculated using free cash flows as a percentage of total assets (LIQ), is relatively low (mean = 6.4%), with some firms facing significant liquidity constraints (min = -96.2%). Firm Size (SIZE) is characterized by moderate means (27.1) and indicates a moderate firm scale (log of total assets). The level of investments in fixed assets (INS) is relatively high (mean = 62.4%), indicating that most firms invest in their infrastructures. Finally, the share of companies operating during the period of the global outbreak of Covid-19 virus (COV_19) is 36.4%.

Figure 1 contains a matrix reflecting correlations between different variables used in the study. The purpose of this matrix is to demonstrate the extent of linear relationship between two factors, which is critical for testing hypotheses. Correlations between different factors indicate a significant impact of some of the independent variables on performance metrics such as return on assets (ROA), return on equity (ROE), and net profit margin (NPM).

For example, advertising and digital marketing expenses (ADV), as well as intangible assets related to information technologies (INT), show strong connections with ROA and NPM. Therefore, it can be assumed that these factors will significantly affect the performance of firms. At the same time, investment in tangible IT assets (CAP) does not demonstrate a similar correlation, reflecting the high variability of this variable. Besides, the relationships between ROA/ROE/NPM and leverage (LEV) and liquidity (LIQ) reflect the existing patterns of relationships found in prior studies..

4.2. Regression results

Table 2 presents the results of the regressions analyzing the impact of inventory management, the use of communication technology, and the interaction term on firm performance in terms of ROA and ROE. The regression models include the performance indicators with lags, which captures the dynamics of performance, as well as control variables, taking into account the unique features of each firm. The analysis demonstrates the positive and significant relationship between inventory management and firm performance in all specifications. This means that proper inventory management is a direct factor contributing to improved firm performance, with lower costs due to proper inventory management leading to improved profit levels and better equity returns.

Table 2. Regression results

Dependent	ROA	ROA	ROA	ROE	ROE	ROE
Intercept	0.013**	0.012*	0.873***	0.006***	-0.006***	0.061***
ROA_lag1	0.621***	0.622***	0.619***	0.031***	0.031***	0.031***
INV	0.005**	0.003**	0.553***	0.001**	0.001*	0.034***
ADV	0.007**			0.002**		
INV:ADV	0.010**			0.001*		
INT		0.008**			0.002*	
INV:INT		0.018***			0.001*	
CAP			0.03***			0.040***
INV:CAP			0.086***			0.033***
LEV	-0.091***	-0.095***	-0.086***	-0.001*	-0.001*	-0.001*
GROW	0.234***	0.234***	0.230***	0.032***	0.032***	0.032***
LIQ	0.184***	0.184***	0.181***	0.019***	0.019***	0.019***
SIZE	0.024***	0.022***	0.024***	0.004***	0.004***	0.004***
INS	-0.034***	-0.060***	-0.035***	-0.004***	-0.002	-0.004***
COV_19	-0.031***	-0.031***	-0.030***	-0.004***	-0.004***	-0.004***
AR(1) test (p-value)	0.0004	0.0003	0.0002	0.0011	0.0010	0.0008
AR(2) test (p-value)	0.364	0.411	0.298	0.452	0.389	0.327
Hansen J-test (p-value)	0.271	0.318	0.244	0.361	0.284	0.305
Sargan test (p-value)	0.297	0.340	0.288	0.314	0.301	0.332
Number of instruments	52	54	55	53	54	56

Note: **, **, *** indicate significant level at 10%, 5% and 1% corresponding*

Finally, the use of communication technology variables positively influences performance. Spending on advertising and digital marketing contributes to better forecasting and coordination of inventories and, hence, increases firm performance. Intangible technology resources also increase operational efficiency through facilitating faster and more agile decision making and operations coordination. Technology capital expenditure, or investments in technological infrastructure, has the highest effect on performance, indicating that the role of technological innovation is instrumental in improving firm efficiency and capabilities.

The inclusion of interaction terms provides important insights into the interaction effects between inventory management and communication technology adoption. Interaction between inventory management and spending on advertising and digital marketing shows that firms utilizing marketing technologies better coordinate inventories with market demand and perform better because of that. The interaction between inventory management and intangible technology assets emphasizes the value of proprietary technology in enhancing inventory management benefits. Interaction between inventory management and capital expenditures on technology has the highest interaction effect and implies that technological innovations play an important role in increasing efficiency of inventory practices and, hence, financial performance.

From the perspective of the present results, it becomes clear that there is a need to integrate communication technology with inventory management to achieve better financial performance outcomes. While both inventory management and technological innovations are important drivers of firm performance and success, combining these two factors generates additional advantages, which can be explained based on theories like the Resource-Based View and Dynamic Capabilities theory. Integrating inventory management practices with technology solutions enables firms to respond quickly to changes in market conditions and increase their profits.

The positive and significant estimates of the parameters of Inventory, TechStock, and TechInvest confirm predictions of Resource-Based View and Dynamic Capabilities that capabilities in operational and information technologies lead to better financial performance. The interaction terms' coefficients are consistent with Transaction Cost Economics as the use of communication technology reduces transaction and coordination costs and increases the payoff to inventory discipline. The parameter estimates are also robust to endogeneity issues in treatment instruments as well as restrictions imposed on instrument quantity.

The results indicate that there is a need for the strategic alignment of technological innovations with operational practices and inventory management to increase competitive advantages. By adopting technology innovations alongside with other capabilities, firms could gain an advantage in a highly competitive environment like that in Vietnam's manufacturing industry. This study underlines the necessity of making relevant technological innovations for complementing existing operational processes.

The estimates of coefficients show that the effects are not only statistically significant but also economically meaningful. In particular, one standard deviation increase in INT (0.091) increases ROA by 0.73 percentage point, which proves that intangible technology assets significantly affect profitability. Moreover, CAP is the factor that has the greatest effect on firm performance. One standard deviation increase in capital expenditure on technology (69.784) results in ROA increase by 2.1 percentage points. Interaction terms also have rather sizable effect magnitudes. For example, the coefficient on INV×CAP (0.086) implies that the use of technology innovation increases the return on investment arising out of inventory management practices by almost 9 percent, showing significant complementarity of operational and technological capabilities. Thus, Vietnamese manufacturing firms will be able to generate substantial benefits from aligning technology strategies with inventory practices. Therefore, investments in technologies such as digital platforms, ERP, and prediction technologies that facilitate coordination should be made.

5. Conclusion & Recommendation

5.1. Conclusion

This study explores the intricate relations among inventory management, communication technologies use, and firm performance in the manufacturing industry in Vietnam. The results offer compelling proof of the significant roles that each factor plays, either independently or in combination, in influencing firm performance. Specifically, through the exploration of the linkages between operational efficiency and technology investment, the paper makes a valuable contribution to the discussion of the effect of these variables on financial outcomes of firms.

As hypothesized, H1 was proven true: inventory management proves to have a direct positive effect on firm performance. The

efficient management of inventory reduces storage costs, prevents stockouts, and provides better cash flow. Hence, ROA and ROE are improved. This result corroborates prior literature on the importance of inventory management practices for maintaining operational stability and financial success (Chen et al., 2005; Hendricks & Singhal, 2009). In the context of Vietnam's manufacturing industry, the effect of good inventory practices appears especially evident, given the volatile demand and unstable supply chain.

H2 was also validated. Communication technologies were found to be positively related to firm performance through improved ability to forecast the demand, streamline coordination in the supply chain, and react to changes in the business environment. Advertising and digital marketing investments, intangible technology asset, and capital expenditure on technologies facilitate operational efficiencies that are reflected in ROA and ROE growth. These results confirm the conclusions of previous research on the transformative effect that technology can have on firm performance (Srinivasan et al., 2005). Through specifying concrete proxies of communication technology, namely advertising expense and intangible technology asset, this study contributes to existing literature.

The most important conclusions come from analyzing the hypothesis regarding the interactive effect between inventory management and the use of communication technologies (H3). Significant and positive interaction effects were revealed in this study. To illustrate, a firm that has adopted modern marketing technologies along with the efficient management of its inventory has a better ability to adjust the level of its stock to changing demand and, therefore, improve its performance. Moreover, having intangible technology assets and spending money on the purchase of technologies amplifies the effect of good inventory management due to the provision of additional data. Thus, this study confirms the ideas behind the Resource-Based View (Barney, 1991) and Dynamic Capabilities framework (Teece et al., 1997) and demonstrates that the synergistic effect of operational and technological factors results in better firm performance.

Overall, this study draws several conclusions in response to the stated problem and hypotheses. As opposed to previous research, the importance of combining efficient inventory management with investments in technology is emphasized, and, in doing so, the effect is analyzed in terms of firm performance. As compared with existing research conducted in developed countries, this study offers insight into a developing country where these variables play important roles in determining firm performance. Contrary to previous research, it focuses on showing the benefits associated with the interaction of technology adoption and efficient inventory management. While past studies demonstrate the importance of one variable and its positive effect on firm performance (Chen et al., 2005; Srinivasan et al., 2005), this study shows how even greater benefits can be obtained by combining the two.

This paper confirms the conclusion of recent studies on the effect of digital transformation of operations and its facilitative impact on business success (Vo et al., 2024) and the effect of technology adoption and innovation on logistics small- and medium-sized enterprises' performance due to improvements in inventory visibility and fulfillment (Nguyen et al., 2024). The complementarity found here is also consistent with previous supply chain literature stating that the use of AI technology facilitates digitalization, which helps build resilience and agility because it lowers the friction caused by coordination problems that lead to stockout and excess of stock (Belhadi et al., 2022). Similar

results emerge in intelligent manufacturing research, showing increases in throughput and decreases in costs (Zhou et al., 2022). However, our study is distinguished from these studies in offering dynamic panel evidence about the role of interaction between firm-level IT capability and inventory management, quantified via interaction terms..

5.2. Recommendation

Considering the implications of this research, several recommendations can be proposed to help firms achieve better financial performance, particularly those in Vietnam's manufacturing industry. Technological development appears to play a significant role in driving firms towards prosperity and success. Firms have to make strategic investments into technological innovations, especially in such areas as communication technology, namely advertising and digital marketing platforms, technology assets, and technological infrastructure. Such investments can include the implementation of sophisticated marketing platforms that provide accurate forecasts of demand, allowing firms to keep appropriate amounts of inventory, as well as the creation of proprietary software tailored to meet the needs of specific organizations, which promotes greater efficiency. In terms of infrastructure, spending on such technologies as enterprise resource planning systems and IoT can help firms coordinate activities in the supply chain and ensure operational efficiency.

Optimized inventory management is another key factor that contributes to financial performance of firms. Therefore, companies have to implement data-based approaches to inventory management, making use of such practices as JIT systems or EOQ models to ensure an appropriate balance between cost and needs. In addition, implementing inventory analysis can help firms adjust their inventory management strategies in response to changes in sales and demand patterns, ensuring maximum efficiency. The use of integrated technological solutions in inventory management helps increase the efficiency of such practices even further.

Another critical consideration is the relationship between inventory management and communication technology adoption. In order to maximize the performance gains from combining these two factors, it is necessary to align efforts, for example, coordinating marketing campaigns with inventory systems in order to ensure that optimal inventory levels are maintained during promotions. Collaboration between different departments within organizations in regard to technological investments and challenges of inventory management is important.

As demonstrated by the findings of this research, the environment plays an influential role in the way organizations operate and perform financially. In this case, it can be argued that technological solutions can help firms respond to such phenomena as economic disruptions and varying market dynamics. Scenario planning and simulation can help firms prepare for unforeseen shifts in market dynamics, using technology solutions aimed at increasing supply chain visibility.

In general, it is important for firms to customize inventory management and technological solutions to specific circumstances in order to optimize performance gains. In particular, the amount and scope of technological resources used for such purposes differ for large and small organizations, while industry-specific aspects also have to be taken into account.

5.3. Limitations & further research

The present study provides useful information about the relationship between inventory management, adoption of communication technologies, and firm performance in Vietnam's manufacturing industry. There are

several limitations of the study which need to be addressed. First, only the companies working in the manufacturing sector have been considered in the current analysis, limiting its applicability to other industries such as services and retail, where the dynamics related to inventory and technology adoption can be very different from manufacturing. Second, the proxies used to measure the extent of technology adoption in terms of advertising expenditures, intangible assets, and capital expenditure may not provide a complete picture of technology investment, especially when it relates to new technologies like artificial intelligence or blockchain. Moreover, the use of secondary data limits the ability of researchers to understand the importance of organizational culture, managerial capability, and other qualitative attributes in influencing inventory and technology-related decisions. Third, even though the SGMM estimator was applied to overcome the problem of endogeneity, the issue of omitted variables bias cannot be ruled out in the current study.

To address the aforementioned limitations, future studies could consider expanding the scope of their research to cover different industries such as retail and services. This would help researchers to analyze whether the same relationships exist in the service or retail sector as were found in the current study. The inclusion of more proxies for measuring the adoption of communication technologies will help in obtaining a clearer picture of technology adoption, especially with regard to newer technologies such as artificial intelligence or blockchain. Future studies can also include case study-based methods to understand various contextual factors such as organizational culture and managerial capability that influence the adoption of communication technologies and inventory management in manufacturing. In addition, researchers should consider exploring the impact of external variables such as economic conditions and regulatory environment on the above-stated relationships.

AI Use Statement

The authors used generative artificial intelligence tools to assist with language editing and improving the clarity of the manuscript. All scientific content, analysis, and conclusions were developed and verified by the authors.

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