# MODERATING ROLES OF INFORMATION TECHNOLOGY LINK AND INFORMATION SHARING IN DRIVING SUPPLY CHAIN PERFORMANCE THROUGH SUPPLIER DEVELOPMENT AND KNOWLEDGE ABSORPTION: EMPIRICAL EVIDENCE FROM MANUFACTURING FIRMS ACROSS COUNTRIES

***Anh Chi Phan[1], Ha Thu Nguyen[2], Hao Anh Nguyen[3], Yoshiki Matsui[4]***

[1] *Vietnam National University – University of Economics and Business, School of Business Administration, Vietnam, ORCID: 0000-0002-0153-1845, anhpc@vnu.edu.vn;*

[2] *Vietnam National University – University of Economics and Business, School of Business Administration, Vietnam, ORCID: 0000-0001-6739-6378, hant@vnu.edu.vn (corresponding author);*

[3] *Yokohama National University, Department of Business Administration, Japan, ORCID: 0000-0002-2669-1538, nguyen-hao-nd@ynu.jp;*

[4] *The Open University of Japan, Faculty of Liberal Arts, Japan, ORCID: 0000-0002-5475-5199, y.matsui@ouj.ac.jp.*

***Abstract:*** *Along with information technology adoption, supply chain coordination through information sharing activities has become essential to achieve supply chain effectiveness and resilience. This paper presents the results of an empirical study investigating the moderating roles of information technology link and information sharing on the relationship between supplier development, knowledge absorption from customers, and supply chain performance. Statistical techniques such as measurement test, correlation analysis, and regression analysis are applied to analyze the data collected during the Round 4 of the High Performance Manufacturing (HPM) Project. The data sample includes 304 manufacturing plants operating in 13 countries including Brazil, China, Finland, German, Italy, Israel, Japan, Korea, Spain, Sweden, Taiwan, United Kingdom, and Vietnam. Analytical results indicate that a supply chain would perform better when focal firms invest their effort in supplier development and knowledge absorption activities and develop a strong link with suppliers and customers through information technology systems. Information technology links with suppliers and customers have significant moderating roles in strengthening the relationship between supplier development, knowledge absorption from customers, and supply chain performance. Moreover, information sharing exchange with suppliers were found to make the association between supplier development and supply chain performance becomes more pronounced. The empirical results contribute to the existing literature of information sharing and supply chain coordination in supply chain management. In addition, this study provides several practical implications, such that information technology linkage and information sharing activities should be considered as the platforms for organizations to interact with different supply chain partners for achieving high supply chain performance.*

***Keywords:*** *Information technology link, information sharing, supplier development, knowledge absorption, supply chain performance.*

***JEL Classification:*** *M10, M11, M15.*

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## Introduction

The COVID-19 pandemic has caused turbulence that significantly shocks supply chain management. Regardless of the industry, we have seen the supply chain disruption due to factories shutdown, social distancing, restrictions in transportation, raw materials shipping, and border closure (Sarkis, 2020; van Hoek, 2020). Consequently, a research trend emerged to improve supply chain sustainability, resilience, and performance (e.g., Ivanov & Das, 2020; Shen & Sun, 2021), which raised the importance of close communication and collaboration among supply chain partners. For example, manufacturing firms can improve supply chain learning through supplier development activities and customer knowledge absorption (Huo et al., 2020). Supplier development refers to upstream supply chain coordination, which is the effort of focal firms to improve suppliers' performance and capabilities to ensure long- and short-term supply needs (Krause et al., 2007). Moreover, knowledge absorption from customers is a necessary downstream activity, which describes a process that firms communicate with retailers to achieve information to help realize demand and customer preferences (Braojos et al., 2020). Both supplier development and knowledge absorption are critical determinants of supply chain performance (e.g., Luo et al., 2010; Roberts & Grover, 2014). However, we have seen a significant challenge towards supply chain coordination under environments of high workplace turbulence, uncertainty, and fragility. Without a sufficient communication between firms and their partners, the benefits of supply chain coordination might not be ensured. For example, literature related to the dark side of business-to-business relationships shows that supplier development initiatives can cause opportunistic behaviour, or it can harm operational effectiveness due to unrealistic goals and mismatch between challenges and suppliers' current capacity (Sucky & Durst, 2013; Tran et al., 2021). In addition, relying on knowledge from a specific group of customers and lacking of close information sharing back and forth can cause risks of market myopia and loss of know-how (Gassmann et al., 2010). Therefore, there is a need to establish an effective information technology (IT) link system and a high level of information sharing for greater information availability in the supply chain (Sarkis, 2020; van Hoek, 2020). IT link is the integration in using of electronic tools to communicate with key suppliers and customers, thus facilitating information sharing intensity and speed, leading to better buyer-supplier relationship and operational performance (Baihaqi & Sohal, 2013).

This study has two main objectives. First, the authors would like to verify the impact of supplier development and knowledge absorption from customers activities on supply chain performance. Rather than testing the effect of those practices separately (Carr & Kaynak, 2007; Krause et al., 2007; Storey & Larbig, 2017), we integrate them into a single model to provide a holistic view of how focal firms improve supply chain performance by interacting with both upstream and downstream partners. Second, we propose that IT link and level of information sharing should be significant foundations to strengthening the relationship between supply chain coordination and supply chain performance. Although previous studies have indicated the critical role of IT capacity on supply chain performance (e.g., Prajogo & Olhager, 2012), the underlying mechanism is more complicated since it might depend on how compatible information systems are among chain members and how a firm develops capabilities to process shared information effectively. Thus, attempts to fill the research gaps by answering the research question: could IT link and information sharing with/by suppliers and customers facilitate the effect of supplier development and knowledge absorption on supply chain performance?

The remainder of this study is as follows. The following section provides a literature review on supply chain performance, supplier development, knowledge absorption, IT link,

and information sharing. Subsequently, the hypothesis development and conceptual model are presented, followed by the methodology section includes data collection, measures, and analysis procedure. Then, we provide the analysis result to validate hypotheses. Based on the findings, discussion and implications are drawn. Finally, we discuss several limitations and future research directions.

# 1. Literature Review

## 1.1 Supply Chain Performance

Supply chain performance refers to the effectiveness and efficiency of a supply chain, which is strongly influenced by supplier performance in quality, delivery, responsiveness, cost, and technical support (Wu et al., 2014). Suppliers have become essential partners of manufacturers in technical innovation, product development, quality improvement, rather than merely material deliverers (Krause et al., 2007). A low-performance or dissatisfied supplier would influence the performance of all supply chain members by creating a bullwhip effect. Specifically, suppliers who provide low-quality materials cause a higher defect rate in buyers' production, leading to lower sales and customer satisfaction. Moreover, unsatisfied partners tend to exit the existing relationship, hence incurring a higher cost for focal firms to find other suitable suppliers. Thus, well-performing supplier is a key to maintaining supply chain sustainability and satisfaction.

Determinants of supply chain performance have been studied intensively in the literature. There is a consensus that supply chain integration should be a key to enabling a centralized management approach across the value network, thus improving information sharing and supply chain performance (Koçoğlu et al., 2011; Shee et al., 2018). Chau et al. (2021) indicated that supply chain collaboration, process integration, customer focus together with an effective information technology system are critical success factors of supply chain quality. Under an uncertain and dynamic business environment that requires collaboration and innovation, supplier development is a core practice helping focal firms communicate and continually enhance their suppliers' capabilities (Saghiri & Wilding, 2021). Moreover, knowledge from customers (e.g., demand, market information, etc.) is also essential for firms in strategic decision-making, thereby coordinating with upstream partners to adjust strategic goals, thus leading to better supply chain performance (Huo et al., 2020; Storey & Larbig, 2017).

## 1.2 Supplier Development: Concepts and Outcomes

The concept of supplier development has been discussed in supply chain management literature to indicate manufacturers' effort to establish a viable network of suppliers and enhance suppliers' performance. It emerged in response to a need to develop a cooperative buyer-supplier relationship to benefit supply chain activities and create organizational competitive advantage (Lee et al., 2018). Specifically, the reciprocal interdependence among components providers and final assemblers in industries that produce complex products became crucial. Some examples of the industry, to name but a few, include automobiles, electronics, and machinery industry (Krause et al., 2007), which are the target industries in this study.

The practice of supplier development has been started in Japanese companies such as Toyota and Honda, then spread out to other countries as a strategic weapon of buying firms (Glavee-Geo, 2019). In more detail, when the firms invest in developing supplier capabilities, involved in knowledge exchange, implementing governance mechanisms, both buyer and supplier can gain supernormal profit (Krause et al., 2007). Literature suggests that supplier development is a way to achieve long-term suppliers' relationships; therefore, a supply chain can be beneficial of lower cost, better quality and flexibility, and reliable delivery (Krause et al., 2007; Lee et al., 2018). Moreover, efficient supplier development initiatives can lead to higher supplier satisfaction and supplier performance and facilitate new product development processes (Glavee-Geo, 2019; Modi & Mabert, 2007). However, several studies even found negative impact of supplier development such as opportunism (Tran et al., 2021) and operational deficiency (Sucky & Durst, 2013) due to lacking of appropriate mechanism and platform for close communication (Krause et al., 2007).

## 1.3 Knowledge Absorption from Customers: Concepts and Outcomes

Knowledge absorption from customers is how a manufacturing firm learns from its customers

during the new product development process, in terms of product knowledge, technology, demands, purchasing history, and others (Salojärvi et al., 2010). To fulfil customers' needs and be more responsive to the market, exploiting customers' knowledge to facilitate internal learning has become a potential source of competitive advantage. A focal firm can absorb customers' knowledge by involving customers in its operations (e.g., designing process) rather than just gathering feedback by traditional market research (Storey & Larbig, 2017). Nguyen and Harrison (2018) used the term "customer leverage" to describe a firm's capability to obtain and utilize knowledge from customers in developing new products and services. Other terms are used to describe the customer knowledge management process, such as customer relationship management, customer intimacy, and customer references.

Surprisingly, to some extent, there is an inconsistency among previous studies regarding the outcomes of customer involvement, collaboration, and integration. Many works have confirmed the positive effect of the acquisition of customers' knowledge (e.g., Huo et al., 2020; Nguyen & Harrison, 2018; Phan et al., 2020). However, several studies even pointed out the opposing sides of customer integration in the process of developing and commercializing new products (e.g., Gassmann et al., 2010). Specifically, relying on knowledge and information from a particular group of customers can make firms too dependent on specific customers' interests, leading to serving a niche market only. Gassmann et al. (2010) noted that customer integration causes a risk of loss of know-how, as some knowledgeable customers might use the organization's intellectual properties for their personal purposes. Therefore, the inconsistent findings emphasize the importance of moderating factors in the relationship between customers' knowledge absorption and performance, such as developing an integrated IT infrastructure and frequently sharing information (Braojos et al., 2020).

## 1.4 IT Link and Information Sharing as Platforms for Supply Chain Coordination

The highly competitive and uncertain business environment leads to the necessity of collaboration with external partners to ensure supply chain performance. However, communication across the supply chain, also managing knowledge absorbed from supply chain partners, requires organizational capabilities of linking IT systems and sharing information with its partners (Braojos et al., 2020; van Hoek, 2020).

IT is defined as the application of similar automated systems or computer-to-computer links within or between firms and supply chain partners (Prajogo & Olhager, 2012). It has become a crucial part of supply chain management (SCM) to participate in knowledge and capabilities sharing. Internally, IT integration provides several benefits such as agility, transaction management efficiency, and fast decision-making, leading to higher efficiency in R&D and new product development. Externally, IT creates a unique value chain, helping focal firms to collaborate with suppliers for on-time delivery or communicate information from customers to become more responsive. If the IT is linked across the supply chain regarding similarity, connectivity, and compatibility, it will enhance supply chain efficiency because of collaboration through information sharing, coordination, monitoring, and joint decision making (Ye & Wang, 2013).

While IT link is a platform for communication, the type of information shared across the supply chain also plays an essential role. Supply chain information sharing refers to the actions that make information available to other chain members (Li et al., 2019). This is an inevitable practice to mitigate supply chain uncertainty, including delivery delays, machine breakdowns, and order fluctuations (Jeong & Hong, 2017). Information sharing between manufacturer, supplier, and customer can be tactical (e.g., purchasing and logistics) or strategic (e.g., long-term relationship objectives and customer information). Information sharing has been proved to be significant in driving several types of performance. It enables focal firms to access various information such as sales, production, and logistics, hence improving visibility, as well as reducing cost and improving financial performance (Şahin & Topal, 2018). Moreover, information sharing allows firms to collaborate closely with their suppliers and customers, thereby developing trust and a better long-term relationship. This long-term relationship leads to a shorter lead time and order fulfilment cycle, a faster and high-quality new product development process (Braojos et al., 2020).

Tab. 1: Recent literature of IT link and information sharing in supply chain

| Author | IT link conceptualization | Information sharing conceptualization | Data collection and sample | Data analysis | Main findings |
|---|---|---|---|---|---|
| Phung et al. (2021) | IT link with suppliers | Information sharing with suppliers | 304 manufacturing firms from 13 countries | Serial-multiple mediation analysis | IT link with suppliers and information sharing with suppliers mediate the relationship between supply chain process integration and upward supply chain performance |
| Sundram et al. (2020) | IT applications (e.g., online transaction, website system, CRM, etc.) adoption | Information sharing with and by trading partners | 112 manufacturing firms in Malaysia | Structural equation modeling | IT improves information sharing, leading to a higher level of supply chain integration and supply chain performance |
| Maskey et al. (2019) | Electronic linkages between trading partners | Operational information sharing and strategic information sharing | 131 supply chain participants in Nepal | Exploratory factor analysis and path analysis | Several factors are confirmed as determinants of supply chain information sharing, for example, supply network configuration, organizational capability, commitment |
| Pham et al. (2019) | In-house and logistics systems, a system for customers to book online, track shipment, and make payment | Information sharing, including operational, capability-related, strategic plan, and competitive information | 14 participants from 11 small-to-medium local service providers and Vietnam Logistics Association | Data analysis of in-depth interviews | Most firms share operational information through traditional communication channels and lack an integrated system |
| Vanpoucke et al. (2017) | Using of electronic tools to connect with suppliers and customers | Information exchange in terms of inventory, production planning, demand forecast with key suppliers and customers | 563 companies in 20 countries | Constrained non-linear regression analysis | IT use moderates the impact of information exchange on operational integration; the use of IT is stronger for upstream integration |
| Baihaqi and Sohal (2013) | Integrated IT system including database, production planning, and internet | Information sharing with/by suppliers and customers | 150 Australian manufacturing companies | Regression analysis by using structural equation modeling (SEM) | Integrated IT positively impacts information sharing intensity, leading to better buyer-supplier relationships and operational performance |
| Ye and Wang (2013) | How IT infrastructure is aligned with supply chain partners regarding similarity, connectivity, and compatibility | Information sharing with suppliers, including order processing, inventory, production capacity planning, and order forecasting | 141 Chinese manufacturers | *t*-test, psychometric test, regression analysis using SEM | Information sharing mediates the relationship between IT alignment and operational performance |
| Prajogo and Olhager (2012) | Electronic links with suppliers, which include IT-enabled transaction processing, tracking shipments, electronic transfer of orders, funds, and invoices | Information sharing with suppliers and information sharing by suppliers | 232 Australian firms | Regression analysis using SEM | Information technology and information sharing significantly improve logistic integration, improving operational performance |
| Koçoğlu et al. (2011) | A common IT infrastructure to facilitate transactions, communication within organizations and among supply chain partners | Information sharing with customers and suppliers, and information sharing between functions of the organization | 158 manufacturing firms in Turkey | Exploratory factor analysis, regression analysis using Partial Least-Squares (PLS) – based SEM | Supply chain integration facilitates information sharing by providing connectedness and collaboration among members; better information sharing improves supply chain performance |

Source: own

The empirical evidence related to the effect of information technology and information sharing in supply chain management is summarized in Tab. 1.

The above literature review shows that it is essential to consider IT link and information sharing as technological bases to ensure supply chain cooperation and integration. However, direct effect of IT and information sharing might fail to explain why there is a difference in performance improvement among firms when there is a similar adoption of IT and information sharing. We propose that supply chain coordination, which includes supplier development and knowledge absorption from customers, would play direct influence roles, while IT and information sharing are necessary moderators to strengthen those influences.

## 2. Hypotheses Development and Conceptual Model

### 2.1 Role of Supplier Development and Knowledge Absorption in Supply Chain Performance

Since supplier development activities enhance the coordination between buyers and suppliers, a positive impact on both sides can be expected. Specifically, collaborative activities, including giving feedback, training from buyers, can assist suppliers in improving their performance (Krause et al., 2007). When supplier performance is improved, focal firms will be beneficial from high-quality materials, on-time delivery, and better inventory management. Previous studies showed that supplier development helps the firm reduce the supply base, then improves financial performance such as cost and revenue, and non-financial performance such as product quality, collaborative product development, and customer service (Luo et al., 2010). Therefore, supplier capabilities improvement regarding technical, quality, delivery, and cost performance is one of the requirements to build a competitive advantage in the supply chain, i.e., to meet the unstable market demand (Carr & Kaynak, 2007). More importantly, close interaction with suppliers ensures good supplier relationships and develops supply chain agility in case upstream activities have to be adapted to any change from downstream (Tripathy et al., 2016). Therefore, we propose the first hypothesis as follow:

*H1: Supplier development is positively related to supply chain performance.*

Customer relationship was argued as a key for strategic decision-making, providing new opportunities for value creation and improving supply chain competitive advantage (Salojärvi et al., 2010; Tripathy et al., 2016). As such, firms should collect timely and reliable customer information (Chau et al., 2021). Grover and Kohli (2012) indicated that knowledge absorption from retailers (e.g., analytical planning, forecasting, replenishment) would help firms realize cyclical fluctuation in customers' demand and preferences so that they can adjust and provide better customer services. Knowledge absorption from customers also helps upstream firms to develop customer agility for better sensing market opportunities (Roberts & Grover, 2014). Thus, building an IT interaction platform for customers such as web-based customer infrastructure together with the firm's analytical ability will facilitate knowledge-creating, therefore enhancing the firm's competitive advantage. Lead users who are product-savvy may even involve in the idea generation stage of the new product development process to provide customer knowledge, contributing to the flexibility and success of new product launches (Storey & Larbig, 2017). In general, customer knowledge improves sensing and improvising capabilities, reduces uncertainty, and enhances supply chain performance. Therefore, the second hypothesis is stated as:

*H2: Knowledge absorption from customers is positively related to supply chain performance.*

### 2.2 Moderating Role of IT Link and Information Sharing

Supply chain coordination requires an integrated IT system to obtain better real-time information intensity and quality (Baihaqi & Sohal, 2013; Prajogo & Olhager, 2012). Specifically, IT alignment allows coordinating activities with supply chain partners, such as forecasting and scheduling operations, regardless of time and spatial distance. For suppliers, firms can seamlessly share order information, operational information, strategies, and competition information. In turn, they can ask suppliers for cost information, delivery information, or any change in engineering information (Prajogo & Olhager, 2012). If there is supplier integration, firms are more willing to implement supplier

development activities (Jin et al., 2019). For customers, the IT link helps firms continuously understand customer demand (Fawcett et al., 2007). Moreover, customers with technical knowledge can monitor the production of their orders (Ye & Wang, 2013). In general, IT link with suppliers and customers leads to better connectivity, facilitating coordinating activities among supply members so that managers across organizational boundaries can decide in a faster and more collaborative way. It leads us to the following two hypotheses:

*H3a: IT link with suppliers strengthens the relationship between supplier development and supply chain performance.*

*H4a: IT link with customers strengthens the relationship between knowledge absorption from customers and supply chain performance.*

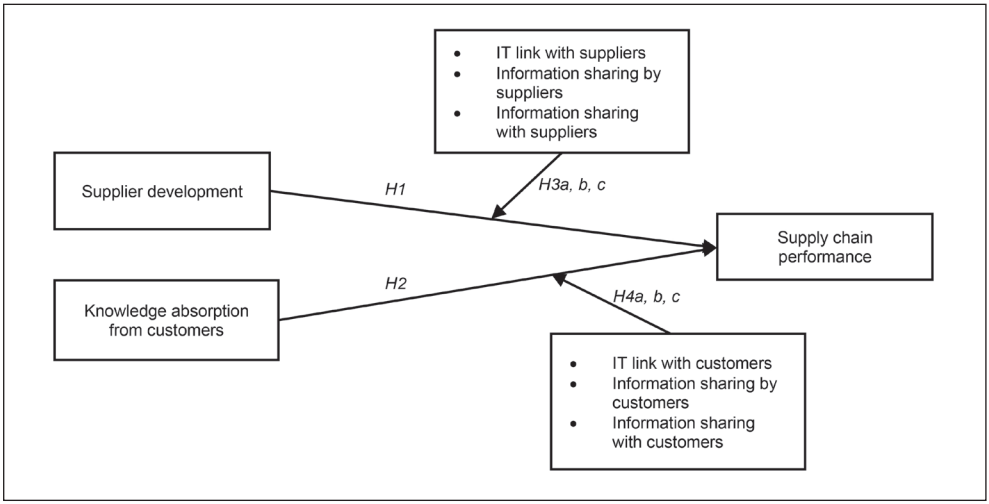
Willingness and ability to develop suppliers depend significantly on the trust and commitment of focal firms in the relationship with specific suppliers. Therefore, manufacturers are more likely to select and develop suppliers with a higher willingness to share information because it increases understanding of suppliers' situations (Carr & Kaynak, 2007). As long-term orientation is developed, it facilitates direct interaction (e.g., on-site visit, joint problem solving) that creates value for both buyers and suppliers whenever problems occur. Information sharing can be considered a platform for knowledge transfer, which disseminates implicit knowledge to help both parties tackle problems in the production process (Lee et al., 2018; Modi & Mabert, 2007). Chen et al. (2018) argued that supplier development and knowledge management activities are interdependent and need to be implemented simultaneously to achieve desired outcomes. Thus, higher information sharing with and by suppliers supports the supplier development activities, improving supplier capabilities and performance in terms of high-quality materials, lower-cost offering, on-time delivery. We propose the following hypotheses:

*H3b: Information sharing by suppliers strengthens the relationship between supplier development and supply chain performance.*

*H3c: Information sharing with suppliers strengthens the relationship between supplier development and supply chain performance.*

The knowledge-based view suggests that knowledge is a critical asset of an organization to create value, raising the importance of how focal firms acquire external knowledge and generate new values for customers (Nguyen & Harrison, 2018). Information sharing by customers provides insights of customer behaviour; therefore, they

**Fig. 1: Analytical framework**




Source: own

can improve the product development process and enhance customer satisfaction. Acquiring information sharing from the customer is an initial stage to creating a learning organization, in which the acquired information is assimilated for commercial exploitations (Huo et al., 2020). Moreover, frequent sharing with customers and receiving information from them encourage discussion among agents and experts, making it easier for firms to compare then integrate new knowledge into an existing knowledge base, as well as ensuring information transparency (Braojos et al., 2020). As a result, flexibility performance is improved as the decision-making process can be adjusted quickly across the supply chain. Final hypotheses are argued as follow:

*H4b: Information sharing by customers strengthens the relationship between knowledge absorption and supply chain performance.*

*H4c: Information sharing with customers strengthens the relationship between knowledge absorption and supply chain performance.*

All hypotheses are illustrated in the analytical framework presented in Fig. 1.

# 3. Methodology

## 3.1 Data Collection

Data in this study are utilized from a questionnaire survey of High Performance Manufacturing (HPM) project. This project was initiated as joint research in the 1980s by group of academicians in the United States, focusing on manufacturing firms in 3 industries: electrical & electronics, machinery, and automobile. HPM project aims to determine best practices in the manufacturing industry to achieve high performance in a global competition (Schroeder & Flynn, 2001). During 1990s–2010s, there was a great involvement of international experts and researchers to develop a theoretical background and questionnaire survey. The HPM Project collected information in various aspects such as manufacturing strategy, supply chain management, quality management, human resource management, knowledge management, and so on. Based on business and trade journals and financial information, the researchers identified and selected manufacturers to be surveyed in each country. While the first survey conducted in 1980s focused on 46 manufacturing plants in the US, the second survey was extended to 146 manufacturing plants in German, Italy, Japan, the UK, and the US in 1990s. The third survey in 2000s involved other countries such as Austria, Finland, Korea, Spain, and Sweden to join the project with total 266 plants. Based on this HPM database, a large number of international publications was made to highlight the impacts of manufacturing performance on performance of manufacturing plants from different aspects (Flynn et al., 2016; Phan et al., 2020). This study analyses data in Round 4 of the HPM project, which were collected during 2013–2015. The sample includes 304 plants in 13 countries: Brazil (24), China (30), Finland (17), German (28), Italy (29), Israel (26), Japan (22), Korea (26), Spain (25), Sweden (9), Taiwan (30), United Kingdom (13), and Vietnam (25). The HPM survey asked participants from 12 positions in each plant, including plant superintendents, managers, supervisors, engineers, etc. Data use in this study collected from 2 positions: question items related with customers were evaluated by downstream supply chain managers and question items related with suppliers were evaluated by upstream supply chain managers. By collecting data from multiple sources, we could reduce the perceptual bias, ensure the independence among variables the reliability of causal relationships by linear regression analysis at both downstream and upstream level. Moreover, this study uses scales related to supply chain coordination, information technology link and information sharing, in which we primarily test the moderating roles of both downstream and upstream IT link and information sharing on the relationship between supplier development and knowledge absorption from customers on supply chain performance.

## 3.2 Measurement

The measurement scales were developed based on theoretical review and adapted from previous research in supply chain management (e.g., Li et al., 2019; Paulraj & Chen, 2007; Vanpoucke et al., 2017), which ensure the content validity of the measurement. Reviewing and adapting measurement scales from previous literature helps to consolidate the linearity of relationships between variables used in the conceptual model, which strengthens the reliability of using linear regression analysis. A five-point Likert scale was used to measure the respondent's judgment by scoring each item from 1 to 5. The respondents are manufacturing plant representatives working in the fields

of Upstream Supply Chain Management (to answer questions related to suppliers), Downstream Supply Chain Management (to answer questions related to customers). The measurement items are provided in the Appendix (Tab. A1).

### 3.3 Data Analysis Procedure

Data are analysed by using the SPSS 22.0 software. First, measurement test is executed to check the scale reliability and validity. Also, the data were checked to make certain that it meets all conditions to perform linear regression analysis. Second, we implement correlation analysis to observe the bivariate association between variables. Subsequently, direct relationships are tested by performing linear regression, and moderating effect is tested by using the PROCESS macro developed by Hayes (2017). Finally, we use *t*-test to assess the difference between countries regarding adopting IT link, information sharing, supplier development, and knowledge absorption.

## 4. Result

### 4.1 Measurement Test

Initially, each variable in the data sample was checked to ensure that linear regression analysis can be conducted. For example, using techniques such as Durbin-Watson test, normality test and scatter plot, the outlier condition, errors independence, homoscedasticity among variables, as well as normal distributed condition are checked to be satisfactory for further analysis. Then, measurement test was implemented to ensure reliability and validity of collected data as follows:

- **Reliability test:** Cronbach's alpha indices of all scales have to be greater than 0.6 to satisfy the internal consistency between items within constructs.
- **Content validity:** Extensive literature review has been done to ensure that all concepts have a solid scientific foundation.
- **Construct validity:** Factor analysis is performed to test the validity within a construct. In other words, it is to ensure within-construct items are one-dimensional. Several criteria should be satisfied, including percentage of variance is greater than 0.5, Eigenvalues are larger 1, and factor loadings are greater than 0.5. The factor loadings of all items are provided in the Appendix (Tab. A1).

The result of the measurement test is provided in Tab. 2 indicating that all tests are satisfied, and the data are reliable and validated.

**Tab. 2: Measurement test results**

| Factor | Min | Max | Mean | Standard deviation | Cronbach's alpha | Eigenvalues | Percentage of variance |
|---|---|---|---|---|---|---|---|
| Supplier development | 2.33 | 5.00 | 3.89 | 0.61 | 0.801 | 3.031 | 50.522 |
| Knowledge absorption from customers | 1.00 | 5.00 | 3.63 | 0.74 | 0.869 | 3.295 | 65.902 |
| IT link with suppliers | 1.00 | 5.00 | 3.37 | 1.01 | 0.839 | 2.716 | 67.902 |
| Information sharing by suppliers | 1.00 | 5.00 | 3.40 | 0.88 | 0.886 | 3.888 | 64.802 |
| Information sharing with suppliers | 1.00 | 5.00 | 3.21 | 0.99 | 0.920 | 5.138 | 64.229 |
| IT link with customers | 1.00 | 5.00 | 3.03 | 1.04 | 0.858 | 2.820 | 70.509 |
| Information sharing by customers | 1.00 | 5.00 | 2.94 | 0.94 | 0.858 | 3.189 | 63.784 |
| Information sharing with customers | 1.00 | 5.00 | 3.15 | 0.95 | 0.911 | 4.955 | 61.939 |
| Supply chain performance | 1.88 | 5.00 | 3.86 | 0.54 | 0.873 | 4.299 | 53.738 |

Source: own

**Tab. 3: Correlation matrix**

| | Supplier development | Knowledge absorption from customers | IT link with suppliers | Information sharing by suppliers | Information sharing with suppliers | IT link with customers | Information sharing by customers | Information sharing with customers | Supply chain performance |
|---|---|---|---|---|---|---|---|---|---|
| **Supplier development** | 1 | | | | | | | | |
| **Knowledge absorption from customers** | 0.265** | 1 | | | | | | | |
| **IT link with suppliers** | 0.482** | 0.281** | 1 | | | | | | |
| **Information sharing by suppliers** | 0.420** | 0.278** | 0.437** | 1 | | | | | |
| **Information sharing with suppliers** | 0.336** | 0.228** | 0.401** | 0.696** | 1 | | | | |
| **IT link with customers** | 0.143* | 0.327** | 0.440** | 0.274** | 0.291** | 1 | | | |
| **Information sharing by customers** | 0.167** | 0.457** | 0.303** | 0.369** | 0.411** | 0.577** | 1 | | |
| **Information sharing with customers** | 0.156* | 0.418** | 0.197** | 0.377** | 0.387** | 0.489** | 0.641** | 1 | |
| **Supply chain performance** | 0.540** | 0.262** | 0.298** | 0.501** | 0.376** | 0.159* | 0.181** | 0.196** | 1 |

Source: own

Note: *$p < 0.05$; **$p < 0.01$ (two-tailed).

## 4.2 Correlation Analysis

The next step in the analytical process is correlation analysis and the result is presented in Tab. 3.

Tab. 3 indicates that all scales are significantly and positively correlated with each other. As such, supply chain performance is associated significantly with supplier development, knowledge absorption from customers, IT link, and information sharing. Positive linkages between all factors imply that a firm that links IT and shares information with upstream partners has a tendency to also link IT and share information with downstream partners, and vice versa.

## 4.3 Hypotheses Testing

To test direct relationships between supplier development, knowledge absorption, and supply chain performance; linear regression is conducted, and the result is presented in Tab. 4.

The adjusted *R*-square is 0.328, which means that supplier development and knowledge absorption together can explain 32.8% the variation of supply chain performance. Moreover, *F*-test shows a favorable result ($F = 64.723$; $p = 0.000 < 0.01$), indicating that the regression model is significant.

*H1* states that supplier development is positively related to supply chain performance. The result validates this hypothesis with the significance level of 1% ($\beta = 0.533$; $p = 0.000 < 0.01$). *H2* is also supported as the result shows a positive and significant influence of knowledge absorption from customers on supply chain performance ($\beta = 0.121$; $p = 0.023 < 0.05$).

To test the moderation effect, we adopt a tool called PROCESS macro developed by Hayes (2017). The significance of the interaction term (e.g., supplier development × IT link with suppliers) is evaluated to determine whether there is moderating effect. The result is shown in Tab. 5.

*H3a, H3b,* and *H3c* argue the positive moderating effect of IT link with suppliers, information sharing with and by suppliers on the relationship between supplier development and supply chain performance. The result

**Tab. 4: Linear regression analysis**

| | Direct effects | Adjusted *R*-square | *F*-statistic | *P*-value (*F*-test) | Coefficients | *T*-statistic | *P*-value (*t*-test) | Evaluation |
|---|---|---|---|---|---|---|---|---|
| *H1* | Supplier development → supply chain performance | 0.328 | 64.723 | 0.000 | 0.533*** | 10.135 | 0.000 | Supported |
| *H2* | Knowledge absorption from customers → supply chain performance | | | | 0.121* | 2.294 | 0.023 | Supported |

Source: own

Note: *$p$ < 0.05; **$p$ < 0.01; ***$p$ < 0.001 (two-tailed).

**Tab. 5: Moderation analysis result**

| Hypothesis | Interaction effect | Coefficient | *T*-statistic | *P*-value | Evaluation |
|---|---|---|---|---|---|
| *H3a* | Supplier development × IT link with suppliers → supply chain performance | 0.0981* | 2.5270 | 0.0121 | Supported |
| *H3b* | Supplier development × information sharing by suppliers → supply chain performance | 0.1012* | 2.3582 | 0.0191 | Supported |
| *H3c* | Supplier development × information sharing with suppliers → supply chain performance | 0.1349** | 3.2667 | 0.0012 | Supported |
| *H4a* | Knowledge absorption of customers × IT link with customers → supply chain performance | 0.0809* | 2.5121 | 0.0126 | Supported |
| *H4b* | Knowledge absorption of customers × information sharing by customers → supply chain performance | 0.0608 | 1.4490 | 0.1486 | Not supported |
| *H4c* | Knowledge absorption of customers × information sharing with customers → supply chain performance | 0.0062 | 0.1502 | 0.8807 | Not supported |

Source: own

Note: *$p$ < 0.05; **$p$ < 0.01; ***$p$ < 0.001 (two-tailed).

shows that all those three hypotheses are accepted because the interaction coefficients are positive and significant (β = 0.0981, 0.1012, 0.1349 respectively; $p$ = 0.0121, 0.0191, 0.0012 respectively).

*H4a* proposes that IT link with customers moderates the relationship between knowledge absorption and supply chain performance. It is validated by the result as the coefficient β = 0.0809 that is significant at 5% level ($p$ = 0.0126). We expected that information sharing by and with customers also significantly moderates the linkage of knowledge absorption and supply chain performance. However, there is not enough statistical evidence to confirm those moderating effects $p$ = 0.1486 and 0.8807, respectively). Therefore, *H4b* and *H4c* are not supported.

## 5. Discussion and Implications

### 5.1 Main Findings

This study provides several findings that contribute to the literature related to IT adoption and information sharing in supply chain management. First, the analytical results show that a higher level of supplier development would lead to better supply chain performance. This substantiates the previous findings in many studies such as Carr and Kaynak (2007), Krause et al. (2007), Modi and Mabert (2007), and Lee et al. (2018). As such, supplier development can improve suppliers' technical

skills through face-to-face interactions such as plant visits and knowledge transfer. It requires direct involvement from the manufacturing firm through a dedicated team to support suppliers in problem-solving (Krause et al., 2007). Hence, supplier development activities help reduce supply base and improve quality of suppliers, which enhance the non-financial performance of suppliers such as quality improvement, delivery, and flexibility, which later benefit financial performance (Saghiri & Wilding, 2021). Critically, supplier development activities would strengthen the buyer-supplier relationship, bring up trust and commitment of suppliers toward buyers, reduce the risk of supplier uncertainty or opportunistic behaviour (Modi & Mabert, 2007).

Second, this study confirms the positive impact of knowledge absorption from customers on supply chain performance. This is in line with previous research related to organizational absorptive capacity, organizational learning, and supply chain integration (e.g., Huo et al., 2020; Nguyen & Harrison, 2018; Storey & Larbig, 2017). Since customers enrich the company's understanding of customers' latent needs through information sharing, knowledge from customers should be used for several purposes such as building customer profiles, designing selling processes, detecting new opportunities as well as facilitating change in products and services. Therefore, more knowledge absorption from customers leads to a higher level of flexibility and market responsiveness, making the supply chain activities become more efficient (Roberts & Grover, 2014). In addition, customers' knowledge is a crucial driver of product improvement and new product development (Lau et al., 2010).

Third, we found that IT link with suppliers and IT link with customers have significant moderating roles in strengthening the relationship between supplier development, knowledge absorption, and supply chain performance. It indicates that IT is a platform for organizations to interact with supply chain partners, receive real-time and useful information. The finding supports previous studies that the implementation of an integrated IT system would improve a firm's communication competencies, hence making the information exchange process uncomplicated (Paulraj & Chen, 2007; Ye & Wang, 2013). It is also connected with the study of Jin et al. (2019), which argued that firms would invest more in supplier development activities if there is already supplier integration. Furthermore, a higher level of information exchange with suppliers (i.e., information sharing by and with suppliers) also reinforces the association of supplier development and supply chain development. It is consistent with the idea of Modi and Mabert (2007) and Chen et al. (2018), which showed a significant link between supplier communication and operational knowledge transfer activities. As such, a high level of information sharing by suppliers would improve the inter-organizational relationship, leading to the involvement of firms in supplier's operation. Under a relational perspective, higher information sharing by suppliers helps the firm to determine current issues of suppliers, as well as what knowledge and resources are needed to invest in supplier development, hence improving supplier performance (Krause et al., 2007). Additionally, we could not confirm the significant moderation effects of information sharing by and with customers. It can be explained that most of manufacturing plants all made effort in connection with their customers so that information sharing by and with customers could be able to explain the difference existed in supply chain performance.

## 5.2 Managerial Implications

The analytical results of this study provide some managerial implications for practitioners in supply chain management in the global context. First, manufacturing managers should seriously consider shifting from a traditional communication method to an IT link system as a strong foundation for better managing information flow in supply chain (Pham et al., 2019). The IT system should be linked both internally and externally to lessen supply chain complexity and support coordinating activities such as information sharing (Ye & Wang, 2013). A firm that invests in IT capability may face the trade-off of giving up the capability to identify the opportunities from the share information if there is no fit with its partners.

As IT link and information sharing are considered a backbone of supply chain integration (Baihaqi & Sohal, 2013), manufacturing plants should utilize the IT system as a fundamental platform to involve customers and suppliers, implementing practices that help to develop supplier's capabilities and

being more knowledgeable about customers. Competitiveness has forced manufacturers to outsource parts and services to their suppliers and focus on their competencies. Because an increasing number of suppliers would increase uncertainty and complexity, firms should focus on and maintain a long-term relationship with core and competent suppliers through coordinating activities such as supplier development. Once again, IT links with suppliers is required to acquire information sharing and good inter-organizational relationship based on trust, commitment, and shared vision. Focal firms can take several actions to develop suppliers such as investing capitals and facilities, allocating personnel to supplier's site for knowledge transfer, providing suppliers with training and incentives to recognize supplier effort (Modi & Mabert, 2007).

Another implication is that manufacturing companies should improve the interactivity with diverse customers through IT links (e.g., web-based, social networks) and develop analytical capabilities. When a big amount of customer information is acquired, it is necessary to deeply analyse and sense realistic market opportunities (Roberts & Grover, 2014). It is also known that a firm is better at acquiring customer knowledge than utilizing it (Salojärvi et al., 2010). Therefore, organizations can utilize IT link to facilitate coordination internally among functions in dealing with massive information from customers (e.g., forming a key account team), improve organizational ability to analyse and quickly respond to customers' demand.

## Conclusions

The booming of technology has raised the significance of effective information management in supply chain management. Moreover, supply chain coordination becomes more important since the environmental uncertainty has increased the risk of supply chain disruption and disconnection. This study contributes to the literature by proposing and testing a framework of how information technology and information sharing improve supply chain performance. Since using data collected from companies across 13 countries, the reliability and generalizability of the findings can be more guaranteed. It is suggested that information technology should be linked closely with supply chain partners for a greater level of information sharing from suppliers and customers. Furthermore, manufacturing firms should develop supplier development capabilities to support suppliers for better performance and stronger buyer-supplier relationships, then leading to higher supply chain performance. Besides, IT should be applied as a foundation to communicate and absorb information sharing by customers. When there is a higher level of knowledge absorption from customers, supply chain activities become more efficient with flexibility and market responsiveness. Based on empirical evidence in this study, managers can consider supply chain IT links and information sharing as fundamental platforms to strengthen the positive effect of supply chain coordinating activities.

This study is not without limitations that can be solved in future research. First, the data were collected based on the perception of survey respondents, which causes bias in the data analysis, especially for performance measurement. Future research can overcome this issue by investigating diverse types of performance using both subjective and objective measurements. Supply chain performance can be broken down into several types, such as financial (e.g., revenue, profit, return on asset) or non-financial (e.g., quality, cost, delivery, flexibility) to analyse and provide more implications. Second, because there are differences in some contextual factors, each manufacturing firm may implement IT in different ways. Future studies may re-examine the current framework and consider the effect of moderators or control variables such as national culture, policy, and competitiveness to bring out more intresting findings.

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# APPENDIX

Tab. A1 presents scale measurement and factor analysis result in validity test. The factor loading of each item is also provided.

**Tab. A1: Scale measurement and factor loading – Part 1**

| Scale | Sources | Items | Factor loading |
|---|---|---|---|
| **Supplier development** | Carr and Kaynak (2007); Krause et al. (2007) | 1. We provide our suppliers with sufficient technical assistance | 0.66 |
| | | 2. We hold regular meetings to exchange improvement ideas with our suppliers | 0.62 |
| | | 3. We encourage our suppliers to continuously improve their production processes | 0.72 |
| | | 4. If necessary, we ask our suppliers to invest in significant process improvement | 0.64 |
| | | 5. We offer the necessary training to our suppliers | 0.75 |
| | | 6. We share our vision and supply chain policy with our key suppliers | 0.72 |
| | | 7. As our suppliers strive to improve their processes, we provide assistance | 0.72 |
| **Information technology links with suppliers** | Vanpoucke et al. (2017); Paulraj and Chen (2007) | 1. Our information system is electronically connected with those of our key suppliers | 0.84 |
| | | 2. We use information technology enabled transaction processing with our key suppliers | 0.90 |
| | | 3. We use electronic transfer of purchase orders, invoices and/or funds to our key suppliers | 0.80 |
| | | 4. We use information technology (for example, RFID or PIDT) to track and/or expedite shipments to our key suppliers | 0.75 |
| **Information sharing by suppliers** | Vanpoucke et al. (2017); Baihaqi and Sohal (2013) | ***Our plant has access to the following information about our key suppliers:*** | |
| | | 1. Cost information | This item was excluded |
| | | 2. Delivery information | 0.80 |
| | | 3. Demand change information | 0.91 |
| | | 4. Demand forecast information | 0.90 |
| | | 5. Inventory information | This item was excluded |
| | | 6. Production capacity information | 0.79 |
| | | 7. Productivity information | This item was excluded |
| | | 8. Quality information | This item was excluded |
| | | 9. Schedule information | 0.80 |
| | | 10. Sensitive information (e.g., financial information, proprietary process information, etc.) | 0.61 |

**Tab. A1: Scale measurement and factor loading – Part 2**

| Scale | Sources | Items | Factor loading |
|---|---|---|---|
| Information sharing with suppliers | Prajogo and Olhager (2012); Ye and Wang (2013); Baihaqi and Sohal (2013) | ***Our key suppliers have access to the following information about our plant:*** | |
| | | 1. Cost information | This item was excluded |
| | | 2. Delivery information | 0.80 |
| | | 3. Demand change information | 0.73 |
| | | 4. Demand forecast information | This item was excluded |
| | | 5. Information about plant manufacturing capabilities | 0.81 |
| | | 6. Inventory information | 0.82 |
| | | 7. Production capacity information | 0.87 |
| | | 8. Productivity information | 0.80 |
| | | 9. Quality information | 0.82 |
| | | 10. Schedule information | 0.75 |
| | | 11. Sensitive information (e.g., financial information, proprietary process information, etc.) | This item was excluded |
| Knowledge absorption from customers | Storey and Larbig (2017); Salojärvi et al. (2010) | 1. We obtain a great amount of our product knowledge from our customers | 0.81 |
| | | 2. Our customers provide us with valuable information on product innovation | 0.81 |
| | | 3. We have learned a lot from our customers as part of our product development process | 0.86 |
| | | 4. We quickly adopt new technologies by applying what we learn from our customers | 0.80 |
| | | 5. We systematically check whether we have applied the knowledge we acquire from our customers regarding our products | 0.76 |
| Information technology links with customers | Vanpoucke et al. (2017); Paulraj and Chen (2007) | 1. Our information system is electronically connected with those of our customers | 0.86 |
| | | 2. Our customers use information technology enabled transaction processing with our plant | 0.90 |
| | | 3. Our customers use electronic transfer of purchase orders, invoices and/or funds to us | 0.83 |
| | | 4. Our customers use information technology (e.g., RFID or PIDT) to track and/or expedite shipments to our plant | 0.76 |
| Information sharing by customers | Li et al. (2019); Vanpoucke et al. (2017); Paulraj and Chen (2007) | ***Our plant has access to the following information about our key customers:*** | |
| | | 1. Demand change information | 0.71 |
| | | 2. Demand forecast information | This item was excluded |
| | | 3. Inventory information | 0.85 |
| | | 4. Production schedule information | 0.79 |
| | | 5. Productivity information | 0.86 |
| | | 6. Sensitive information (e.g., financial information, proprietary process information, etc.) | 0.77 |

**Tab. A1: Scale measurement and factor loading – Part 3**

| Scale | Sources | Items | Factor loading |
|---|---|---|---|
| **Information sharing with customers** | Koçoğlu et al. (2011); Baihaqi and Sohal (2013) | ***Our key customers have access to the following information about our plant:*** | |
| | | 1. Cost information | 0.75 |
| | | 2. Delivery information | This item was excluded |
| | | 3. Demand change information | 0.84 |
| | | 4. Demand forecast information | 0.82 |
| | | 5. Information about plant manufacturing capabilities | 0.78 |
| | | 6. Inventory information | 0.75 |
| | | 7. Production capacity information | 0.84 |
| | | 8. Productivity information | 0.78 |
| | | 9. Quality information | This item was excluded |
| | | 10. Schedule information | 0.72 |
| | | 11. Sensitive information (e.g., financial information, proprietary process information, etc.) | This item was excluded |
| **Supply chain performance** | Wu et al. (2014); Krause et al. (2007) | ***We are satisfied with the performance of our key suppliers on the following criteria:*** | |
| | | 1. Conformance with specifications | 0.69 |
| | | 2. Design capability | 0.67 |
| | | 3. On-time delivery | 0.78 |
| | | 4. Price | 0.69 |
| | | 5. Product liability | 0.79 |
| | | 6. Quick response on short notice | 0.69 |
| | | 7. Service level | 0.79 |
| | | 8. Technical skill | 0.77 |

Source: own