Asian Economic and Financial Review
ISSN(e): 2222-6737
ISSN(p): 2305-2147
DOI: 10.55493/5002.v13i7.4802
Vol. 13, No. 7, 492-514.

URL: www.aessweb.com

Medium and high-tech manufacturing development and the connections to macroeconomic factors: Insights from a fast-growing market

Nguyen Tuan Anh[1]
Nguyen Duc Hien[2]
Dao Le Trang Anh[3+]

[1]*BIDV Training and Research Institute, Hanoi, Vietnam.*
Email: ntanh1711@gmail.com
[2]*The Central Economic Commission, Vietnam.*
Email: nguyenduchien.bsi@gmail.com
[3]*The Business School, RMIT University, Hanoi, Vietnam.*
Email: anh.dao28@rmit.edu.vn

(+ Corresponding author)

Article History
Received: 20 March 2023
Revised: 28 April 2023
Accepted: 12 May 2023
Published: 23 May 2023

Keywords
Digitalization
Financial development
Medium and high-tech manufacturing
Special events
Trade openness
Vietnam.

JEL Classification:
E23; L60; O14.

ABSTRACT

The medium- and high-tech manufacturing (MHM) sector has played a crucial role in Vietnam's economic development. The purpose of this research is to identify the primary factors that contribute to the growth of the medium- and high-tech manufacturing sector in Vietnam. By applying the autoregressive distributed lag (ARDL) method to analyze annual data from 1990 to 2020, we discovered that different macroeconomic factors affect the short- and long-term development of the MHM sector in varying ways. Specifically, digitalization and human capital have a positive influence on the growth of the MHM sector over both the short and long terms. Trade openness and foreign direct investment, however, have a significant, negative long-term impact on the growth of the MHM sector. The effect of financial development on the MHM sector in Vietnam is significant and positive in the short term. Our study discloses that both the 2008–2009 global financial crisis and the Covid-19 pandemic positively impacted Vietnam's MHM sector, as global manufacturers diversified their supply chains and moved their production facilities to Vietnam during and after these events. From the empirical findings, our study offers valuable suggestions to the Vietnamese government, which will enable the country to unlock its full potential for MHM growth.

Contribution/Originality: To the best of our knowledge, this is the first comprehensive study that explores the driving forces underlying the growth of the MHM sector in Vietnam, providing a deeper understanding of the significant impetus for the development and innovation in this sector.

1. INTRODUCTION

Vietnam has emerged as a thriving and appealing economy in Southeast Asia after joining the Association of Southeast Asian Nations in 1995 and the World Trade Organization in 2007 (Gan & Anh, 2019). Over the past few decades, Vietnam has undergone impressive growth, particularly in the industrial sector, as demonstrated by its shift from an import substitution strategy to an export-oriented strategy, as seen in the "Doi Moi" reform (Anh, Duc, & Chieu, 2014). A recent World Bank (2022) report showed that Vietnam's economy has made significant progress in 2022, largely due to its robust service sector and resilient manufacturing industry. The country has established itself as a hub for global manufacturing, attracting a large number of multinational companies that are looking to take advantage of its skilled workforce, favorable business environment, and low-cost production capabilities. As a result, Vietnam has been recognized for its affordable manufacturing sector and its improvement in market efficiency over time (Andrikopoulos, Anh, & Newaz, 2016; Anh & Gan, 2022).

Even though the majority of Vietnam's industry was focused on low-tech manufacturing (91.45%), based on the World Bank Enterprise Survey dataset of 2015 (Na & Kang, 2019), the medium- and high-tech manufacturing (MHM) sector has played a crucial role in Vietnam's economic development. In recent years, high-tech companies in Vietnam have been able to achieve greater efficiency in profitability and marketability compared to traditional manufacturing companies that require significant resources and labor (Anh & Gan, 2019). The contribution of MHM value added to total manufacturing value added in Vietnam has increased from 21% in 1999 to around 39% during the 2015–2020 period (World Bank, 2023). The sector is characterized by the production of sophisticated and technologically advanced products, including electronics, machinery, and medical equipment. The presence of multinational companies has helped to spur growth in this sector, as they bring in new technologies and expertise, while also creating job opportunities for the local population. Additionally, the government has been working to develop the country's technology and innovation ecosystem, providing support for research and development activities, and creating a favorable business environment for high-tech companies. The result is a growing number of successful Vietnamese businesses that are producing high-quality products for both the local and global markets. The MHM sector is, therefore, a key driver of economic growth, as well as a source of innovation, competitiveness, and job creation for the country (Dat, 2023; VNA, 2021).

Given the significant impact of the MHM sector on Vietnam's economic growth, it is essential to understand the factors that influence its development. By identifying the key drivers that affect the success of this sector, policymakers and businesses can make informed decisions on where to invest their resources and develop strategies to support the growth of the sector. This is particularly important in today's global economy, where innovation and technological advancements are essential for sustainable development (Wang, Chen, & Teng, 2023). Furthermore, the MHM sector tends to have high-paying jobs and provides significant value add to the economy (Lee & Clarke, 2019). Therefore, it is crucial to identify the determinants of this sector to ensure its sustainable growth and contribution to the economy.

Despite the significant contributions of the MHM sector to Vietnam's economic growth, there is a notable lack of research on the determinants of this critical industry. While several studies have explored the factors that influence the broader manufacturing sector in Vietnam, there is a need for more focused research on the determinants of the development of the MHM sector. Addressing this research gap should be a priority for scholars and policymakers alike, as it is essential for ensuring that Vietnam's economy remains competitive and innovative in an increasingly technology-driven global market.

Our study, therefore, aims to discover the key drivers of the development of the MHM sector in Vietnam. The study will contribute to the literature and practice in the following aspects. First, to the best of our knowledge, this is the first comprehensive study that explores the driving forces behind the growth of Vietnam's MHM sector and provides a better understanding of the significant impetus for development and innovation in this sector. Second, using the ARDL approach, we recognize the short- and long-term impacts of individual factors. Further, our research not only examines the impact of macroeconomic factors on MHM development in Vietnam from 1990 to 2020, but also accounts for the impact of significant events that could potentially influence industrialization. Our results are robust across various regression models. Last, our research provides insightful recommendations to the Vietnamese government, paving the way for the realization of the country's MHM growth potential.

The paper is structured as follows: Section 2 provides a review of relevant literature on the factors that determine the growth of the MHM sector; Section 3 describes the data and empirical methodology; Section 4 presents the empirical results along with the robustness test and a discussion of the findings; finally, Section 5 concludes the paper with policy implications derived from the study.

2. LITERATURE REVIEW

The MHM sector is a crucial driver of economic growth and industrial upgrading (Zhao & Bu, 2017). However, there are a limited number of studies that investigate the factors that affect this sector. Therefore, we also reviewed literature that has explored the determinants of the manufacturing sector in general from a macroeconomic perspective.

2.1. Financial Development and Medium and High-Tech Manufacturing Sector

Prior studies indicate that enhanced financial development facilitates better capital allocation effects across industrial sectors, encourages the adoption of novel industrial technologies, and promotes the selection of leading industries. Therefore, financial development is integral to the growth and sustainability of the high-tech industry (Zhang, Li, Ding, & Zhang, 2019; Zhao & Bu, 2017). According to a study by Li, Sheng, and Ding (2020), the level of financial development is a positive indicator of the likelihood of high-tech industries obtaining loans from financial institutions. In other words, as the level of financial development increases, it becomes more probable that financial institutions will provide loans to support the development of high-tech industries.

Similarly, Sun, Wang, and Yu (2021) found that financial efficiency plays a significant role in the optimization and advancement of industrial structures. Their study suggests that the rationalization and upgrading of industrial structure can be facilitated through financial efficiency. Moreira (2016) suggests that European governments need to increase their consideration toward fulfilling the credit requirements of internet and high-tech SMEs to achieve a quicker and more stable economic expansion. This study's major policy recommendation is that more effort should be made in meeting the credit needs of these businesses. The research by Fang, Gu, and Li (2015) suggests that the advancement of export technical complexity significantly depends on the financial development of a region. The study concludes that regional financial scale and credit structure are more influential than the efficiency of finance. Different regions and industries experience varying effects on the upgrade of exported technical complexity from financial development. Notably, the high-tech industry's export of technical complexity depends heavily on the level of financial development compared to medium-tech and low-tech industries. This is because the high-tech industry is highly uncertain, with notable adverse selection problems in research and development (R&D) and production processes. Better efficiency of regional finance and a stronger ability to tackle adverse selection problems promote the development of the industry.

However, Luo, Feng, and Formaneck (2021) found that financial development has both positive and negative effects on the high-tech industry. On the one hand, financial development can lead to increased production scale and output, which provides continuous financial support for expanding production and can stimulate technological innovation. On the other hand, excessive financial development can harm the high-tech industry by making it vulnerable to regulatory deficiencies, overdependence on financial support, and the creation of economic bubbles. Therefore, the relationship between financial development and the high-tech industry is more complex than a simple positive correlation. Nonetheless, the financial industry can still play a crucial role in promoting industrial upgrades by easing the financing constraints of enterprises and providing more funds for R&D and investment, particularly for tech startups (Manova & Yu, 2016). Hsu, Tian, and Xu (2014) found that industries that rely heavily on external financing and have a high level of technological intensity tend to have higher levels of innovation in countries with well-developed equity markets. In contrast, better developed credit markets seem to discourage innovation in such industries. In general, external financing and technological intensity have a disproportionate effect on innovation in countries with well-developed equity markets, while better developed credit markets may not have the same impact on innovation.

2.2. Internet, Digitalization, and the Medium and High-Tech Manufacturing Sector

Since the beginning of the 21st century, there has been a new phase of the information technology revolution. This transformation has been driven by the internet and digitalization, which have brought about significant changes in industrial processes and technological advancements. Countries and regions worldwide have been using internet technology to attain industrial upgrades. For example, China introduced the "Made in China 2025" strategic plan in 2015, which emphasizes the importance of accelerating the use of internet technology as a critical means of achieving innovative industry and high-quality growth (Yu, 2022).

The internet offers an unprecedented platform for the transmission of information. The Internet of Things (IoT) has attracted the attention of researchers worldwide (Cetrulo & Nuvolari, 2019). Caputo, Marzi, and Pellegrini (2016) explain the transformative effects of IoT on the manufacturing industry. The practical benefit of the model is its capability to interpret and predict how the manufacturing industry will evolve as a result of the IoT, enabling managers to capitalize on the value created by technological advancements. Prior literature has linked firms' ability to sustain continuous innovation processes to their survival (Adner & Levinthal, 2001), which is even more relevant to the digital revolution brought about by the internet (Devaraj, Krajewski, & Wei, 2007). To achieve increased productivity, better quality, and reduced production costs, high-tech manufacturing companies depend on a range of information and communication technologies. The main focus is on the automation processes and information systems of manufacturing, according to Anaya, Dulaimi, and Abdallah (2015). Bi, Lang, Shen, and Wang (2008) show that the emergence of internet-based technologies has led to new manufacturing philosophies and organizational structures, including virtual organizations, remote manufacturing, computer-integrated manufacturing systems, and internet-based manufacturing. Bo-Hu et al. (2010) and Davenport and Short (2003) suggest that manufacturing firms will become more information-focused and knowledge-driven in the future, leading to an operational system that is more flexible and automated. For manufacturing technology to function effectively in distributed environments and with interconnected systems, it must be integrated into a network that can perform integrated tasks regardless of physical location and deal with different databases or external information, as noted by DaCosta (2013). Internet-based solutions have the advantage of scalability and flexibility when it comes to deploying and customizing solutions in manufacturing environments (Dewan, Jing, & Seidmann, 2000).

According to Muren, Koman, and Redek (2022), the high-tech manufacturing sector's productivity can be significantly improved by digital transformation. The adoption of digital transformation is critical for high-tech and medium-high-tech manufacturing companies, not only to sustain their competitive edge but also to create new or enhance existing business models. As digitalization is primarily dependent on the internet and communication technologies, the percentage of internet users in the population could be considered an effective proxy for measuring digitalization (Atasoy, 2021).

2.3. Human Capital and the Medium and High-Tech Manufacturing Sector

Human capital is proving to be a crucial factor in driving the growth of the manufacturing sector in general, and the high-tech industry in particular (Anwar, 2008; Chen & Chien, 2011; Doong, Fung, & Wu, 2011). According to Zaborovskaia, Nadezhina, and Avduevskaya (2020), in today's era of high-tech industries and the formation of a digital economy, human capital is increasingly becoming the most valuable and distinguishing resource.

An empirical analysis by Anwar (2008) revealed that there is a cointegration between human capital and the value added in manufacturing in Singapore. Mignamissi and Nguekeng (2022) assert that education is a crucial factor in the industrialization process of Africa. Their study found that industrialization is strongly influenced by the availability of educated human capital across all levels of education, including primary, secondary, and higher education. The authors proposed that this outcome can be attributed not only to the increase in capital accumulation resulting from various national and international education programs but also to the fact that trained individuals face fewer obstacles when entering the low-end industrial production chain due to the growing professionalism of educational programs.

Mubarik, Chandran, and Devadason (2018) suggest a model that quantifies and integrates both the measurable and intangible aspects of human capital (HC) to determine the overall level of the human capital index (HCI) in small and medium-sized manufacturing enterprises (SMEs). Data were collected from 100 SME experts through a questionnaire in two stages. The data collected was used for selection purposes and for prioritizing relevant dimensions and sub-dimensions of HC. The analytical hierarchy process was used to assign weights to the dimensions and sub-dimensions of HC to derive the HCI. The findings suggest that certain dimensions and sub-dimensions of HC are more important for the HCI, including experience, skills, education, abilities, and training. Experience was found to be more important than skills and education.

2.4. Foreign Direct Investment and the Medium and High-Tech Manufacturing Sector

Previous research has demonstrated that the connection between high-tech exports and foreign direct investment (FDI) can vary across developed and less developed countries (Bayar, Remeikienė, & Gasparėnienė, 2020). Bakirci, Heupel, Kocagoz, and Ozen (2017), for instance, discovered that FDI inflows positively affect high-tech exports in highly developed economies, but have a negative effect in the least developed economies. FDI inflows can contribute positively to technological progress by enhancing physical capital stock and providing new organizational forms and production methods. Nevertheless, the link between technological progress and FDI inflows can be unfavorable and depend on FDI types, human capital quality, and the country's level of economic development. Countries that possess a high development level and highly skilled human capital are typically more successful in attracting technology-based FDI. This can enhance a country's innovation and technological capabilities. Conversely, other types of FDI inflows can restrict a country's progress by continuing to use conventional production methods, resulting in a negative impact on technological development. Therefore, the adverse impact of FDI inflows on high-tech exports in Romania, Latvia, Bulgaria, Hungary, the Slovak Republic, and the Czech Republic may be due to the distinct attributes of these countries.

Chenery (1967) suggested that FDI can enhance the productivity and economic growth of developing countries by transferring technology and improving marketing and managerial expertise of domestic industries. FDI has become a crucial contributor to external resource inflows in developing countries and plays a pivotal role in the process of globalization. Additionally, FDI can stimulate innovation, improve productivity, create better-paying jobs in the manufacturing sector and support the industries of the host countries (Arnold, Javorcik, & Mattoo, 2011; Bijsterbosch & Kolasa, 2010; Echandi, Krajcovicova, & Qiang, 2015; World Economic Forum (WEF), 2013).

Findlay (1978) believes that FDI has the potential to enhance the pace of technological advancement in the recipient country. FDI in the manufacturing sector played a significant role in the transformation of developing countries, such as South Korea, Hong Kong, Singapore, and Taiwan, into developed nations. Research conducted in both developed and developing countries worldwide has revealed a diverse correlation between FDI and growth in the manufacturing sector (Azolibe, 2021). For example, Patience (2011) discovered that FDI contributed to the expansion of West Africa's manufacturing output, while Azolibe (2021) found no significant nexus between manufacturing sector growth and FDI.

2.5. Trade Openness and the Medium and High-Tech Manufacturing Sector

Trade openness has an inconsistent association with manufacturing sector growth in the literature. Khobai and Moyo (2021) analyzed the impact of trade openness on industry performance in several countries of the Southern African Development Community (SADC) and observed that, although economic growth has increased in these countries since the 1990s, industry output and employment levels have declined. They used data from 1990 to 2017 to test the hypothesis that trade openness has had a detrimental effect on industry in the long term, and found that, overall, trade openness has a positive effect on industrial performance. However, the manufacturing sector has experienced lower output levels and job losses due to lack of competitiveness and a rise in imports. The authors recommended that SADC countries maintain high levels of trade openness but should also invest in infrastructure, human capital, and the re-skilling of workers to enhance the competitiveness of their manufacturing sector.

Chikabwi, Chidoko, and Mudzingiri (2017) and Siyakiya (2017) also examined the drivers of manufacturing productivity and the relationship between trade openness and productivity, respectively, in selected African countries. Chikabwi et al. (2017) found that trade openness, capital investment, and technology transfer have a positive effect on manufacturing sector productivity growth, while Siyakiya's study shows that trade openness has a positive impact on manufacturing and service value added.

Adamu and Dogan (2017); Ogu, Aniebo, and Elekwa (2016) and Onakoya, Fasanya, and Babalola (2012) discovered that, in Nigeria, there is a favorable relationship between trade openness and industrial output in the long run. Ogu et al. (2016) additionally found that trade openness harms manufacturing output in the short run. In Pakistan and Malaysia, Chandran (2009) and Dutta and Ahmed (2004) respectively concluded that trade openness has a long-run impact on manufacturing/industrial output. Tahir, Estrada, Khan, and Afridi (2016) found that trade openness positively affects industrial output in the economies of the South Asian Association for Regional Cooperation (SAARC). Ebenyi, Nwanosike, Uzoechina, and Ishiwu (2017) found that the export potential did not have a positive impact on the Nigerian manufacturing sector, and Mukherjee and Chanda (2017) discovered that the openness of trade had a positive impact on the effectiveness and profitability of big manufacturing companies in India. Okoye, Nwakoby, and Okorie (2016) found that Nigeria's industrial output is negatively affected by trade openness, primarily due to the high production costs that place the manufacturing firms at a disadvantage in global competition. Ilyas, Ahmad, Afzal, and Mahmood (2010) used annual time series data covering the period from 1965 to 2007 to investigate the factors affecting Pakistan's manufacturing value added. The authors utilized a bounds test-based cointegration technique but found that trade openness did not have a statistically significant influence.

Trade openness can have negative impacts on high-tech manufacturing in developing countries for several reasons. One of the main reasons is that foreign competition can reduce the market share of domestic companies, limiting their capacity to invest in R&D and innovation (UNCTAD, 2021). Foreign companies generally have more resources and economies of scale, making it difficult for domestic companies to compete. In addition, trade openness can lead to the transfer of production to countries with lower labor costs, such as China, which can lead to a loss of high-tech jobs in developing countries (OECD, 2018). This is especially true for industries that depend heavily on skilled labor and advanced technologies, such as electronics and information and communication technology (ICT). Consequently, developing countries may encounter challenges when it comes to improving their industrial capabilities and competing in the global high-tech market.

In summary, the literature on the significant drivers of the MHM sector's development differs across nations and time periods. Each country has a unique formula for sector achievement, emphasizing the importance of conducting country-specific investigations. However, there are very few empirical studies on the determinants of MHM growth in Vietnam. This study aims to fill this research gap by exploring the critical factors that influence MHM development and suggesting policies to promote the expansion of Vietnam's MHM sector.

3. DATA AND METHODOLOGY

After reviewing previous literature, we propose an empirical model that demonstrates how different macroeconomic elements could influence Vietnam's progress in the MHM sector, measured by the medium- and high-tech manufacturing value added share of the total manufacturing value added (World Bank, 2022). The macroeconomic components we have identified include digitalization (Atasoy, 2021), trade liberalization (Khobai & Moyo, 2021; Ogu et al., 2016), financial development (Li et al., 2020; Luo et al., 2021), foreign direct investment

(Azolibe, 2021; Bakirci et al., 2017; Bayar et al., 2020), and human capital (Anwar, 2008; Chen & Chien, 2011; Mignamissi & Nguekeng, 2022).

The baseline model that explores the impact of macroeconomics factors (digitalization, trade openness, FDI, human capital and financial development) on Vietnam's MHM sector development is constructed as below:

Model I: Baseline model:

$$LNMHVASH = F(INTERNET, FDI\_S, LNHUMAN, TRADE, CREDIT) \quad (1)$$

Where:

LNMHVASH is the dependent variable and represents MHM sector development. LNMHVASH is measured by the natural logarithm (LN) of MHM value added share of the total manufacturing value added. The explanations and data sources of the variables in Model I are summarized in Table 1.

Table 1. Model I's explanation and data sources of variables.

Variable	Explanation	Data source
LNMHVASH	Medium and high-tech manufacturing sector development proxy, measured by the natural logarithm of the MHM value added share of the total manufacturing value added	UNIDO (2023) The UNIDO national accounts database
INTERNET	Internet penetration – digitalization proxy, measured by the percentage of individuals using the internet (% of population)	World Bank (2023) World development indicators
FDI_S	Foreign direct investment, measured by FDI, net inflow, % gross domestic product (GDP)	World Bank (2023) World development indicators
LNHUMAN	Human capital proxy, measured by the natural logarithm of the mean years of schooling	World Bank (2023) World development indicators
TRADE	Trade openness, measured by the ratio of the sum of imports and exports relative to GDP	World Bank (2023) World development indicators
CREDIT	Financial development proxy, measured by domestic credit to the private sector (% of GDP)	World Bank (2023) World development indicators

In order to examine Model I, we collected yearly data on Vietnam from 1990 to 2020, utilizing official sources (the World Bank and UNIDO) as mentioned in Table 1. The ARDL method was used for the time series data to analyze the impact of macroeconomic factors on Vietnam's MHM development in both the short and long terms. The ARDL method was chosen for several reasons, including its suitability for small sample sizes (Anh, Anh, & Chandio, 2023; Makuyana & Odhiambo, 2019), such as the 31 observations in our study, its ability to handle variables with integrating orders of zero (I(0)) or one (I(1)) (Badeeb & Lean, 2017; Tuan, Gan, & Anh, 2020), and its capacity to investigate both short- and long-term effects of the independent variables on the dependent variable (Olaniyi, 2017). Also, the ARDL model's use of lagged fit and concurrent estimations of short- and long-term components helps to avoid endogeneity, multicollinearity and serial correlation issues (Anh et al., 2023; Pesaran & Shin, 1999; Qamruzzaman, 2022; Shabbir et al., 2019).

Overall, following Anh et al. (2023), Model I's analysis process of investigating the relationships between macroeconomic factors and MHM development in Vietnam involves three key steps:

Step 1: Adoption of unit root tests (ADF, PP, KPSS tests) to determine the integrating order of the variables.

Step 2: Application of the ARDL approach to explore the short- and long-term relationships between industrial development and other variables. This major step includes four sub-stages:

- Selecting the optimal lag length of the model by the Akaike information criterion.
- Detecting cointegration existence by the bounds test for cointegration (F-test).
- Examining the short- and long-term effects of the ARDL models.
- Checking the robustness of the model by using diagnostic and stability tests – Breusch–Godfrey serial correlation Lagrange multiplier (LM) test, Breusch–Pagan–Godfrey heteroskedasticity test, Jarque–Bera normality test, Ramsey RESET test, cumulative sum (CUSUM), and cumulative sum of squares (CUSUMSQ).

We use the ARDL unrestricted error correction model to examine the long-term effects of macroeconomic factors on the development of the MHM sector in Vietnam.

$$\Delta LNMHVASH_t = \alpha + \alpha_1 LNMHVASH_{t-1} + \alpha_2 FDI\_S_{t-1} + \alpha_3 CREDIT_{t-1} + \alpha_4 TRADE_{t-1} + \alpha_5 LNHUMAN_{t-1} + \alpha_6 INTERNET_{t-1} + \sum_{i=1}^{r} \alpha_{7i} \Delta LNMHVASH_{t-i} + \sum_{i=0}^{s} \alpha_{8i} \Delta FDI\_S_{t-i} + \sum_{i=0}^{u} \alpha_{9i} \Delta CREDIT_{t-i} + \sum_{i=0}^{v} \alpha_{10i} \Delta TRADE_{t-i} + \sum_{i=0}^{x} \alpha_{11i} \Delta LNHUMAN_{t-i} + \sum_{i=0}^{y} \alpha_{12i} \Delta INTERNET_{t-i} + \omega_t \quad (2)$$

In the equation, LN refers to the natural logarithm value, Δ denotes the first difference, ω_t represents white noise, and r, s, u, v, x and y signify the optimal number of lags.

To assess the existence of cointegration in Equation 2, we apply the ARDL bounds test with a joint F-statistic. The null hypothesis (H0: $\alpha_k = 0$ ($\forall$ k = 1, 2, …, 6)) is tested, and if the F-statistic exceeds the upper bound critical value provided by Narayan (2005) for small sample sizes, the null hypothesis is rejected, indicating the presence of cointegration or a long-term relationship between the independent and dependent variables.

Regarding the short-term association between the related factors and MHM development, the ARDL model's short-term function is constructed as follows:

$$\Delta MHVASH_t = \alpha_{14} + \sum_{i=1}^{r} \alpha_{15i} \Delta MHVASH_{t-i} + \sum_{i=0}^{s} \alpha_{16i} \Delta FDI\_S_{t-i} + \sum_{i=0}^{u} \alpha_{17i} \Delta CREDIT_{t-i} + \sum_{i=0}^{v} \alpha_{18i} \Delta TRADE_{t-i} + \sum_{i=0}^{x} \alpha_{19i} \Delta LNHUMAN_{t-i} + \sum_{i=0}^{y} \alpha_{20i} \Delta INTERNET_{t-i} + \varphi ECM_{t-1} + \omega_t \quad (3)$$

In Equation 3, the error correction term and its coefficient are denoted as ECM (error correction model) and φ, respectively. The coefficient φ specifies the adjusted speed required to revert from a short-term disturbance to long-term equilibrium, and it is significantly negative if cointegration exists.

Step 3: Using the Toda and Yamamoto (1995) causality approach to identify the causality directions among the variables of the ARDL regression model, thus verifying the reliability of the ARDL bounds test. The Toda and Yamamoto (1995) test is advantageous for our study for two reasons: (i) it is suitable for variables with mixed integrating orders, and (ii) it is applicable regardless of the presence of cointegration in the model (Tuan et al., 2020).

Table 2. ARDL model's descriptive statistics and correlation matrix.

Descriptive statistics	LNMHVASH	Internet	FDI_S	LNHUMAN	TRADE	CREDIT
Mean	3.200	21.391	5.525	1.848	119.671	58.977
Standard deviation	0.259	24.150	2.245	0.235	30.584	34.820
Skewness	0.970	0.767	1.252	-0.433	-0.238	0.025
Kurtosis	2.292	2.271	3.666	1.767	1.965	1.516
Jarque–Bera	5.508	3.728	8.668	2.933	1.675	2.848
Probability	0.064	0.155	0.013	0.231	0.433	0.241
Correlation matrix						
LNMHVASH	1.000					
INTERNET	0.895***	1.000				
FDI_S	-0.265	-0.204	1.000			
LNHUMAN	0.757***	0.856***	-0.239	1.000		
TRADE	0.761***	0.810***	-0.214	0.926***	1.000	
CREDIT	0.790***	0.909***	-0.190	0.960***	0.920***	1.000

Note: *** $p < 0.01$.

Table 3. Unit root test results.

Variable	Test	KPSS test statistic		PP test statistic		ADF test statistic	
		Intercept	Intercept	Intercept	Intercept and trend	Intercept	Intercept and trend
LNMHVASH	Level	0.590** (4)	0.590** (4)	-0.309 (4)	-1.987 (3)	-0.285 (0)	-1.898 (0)
	1st dif.	0.157 (5)	0.157 (5)	-4.233*** (7)	-4.711*** (10)	-4.326*** (0)	-4.323*** (0)
INTERNET	Level	0.673 (4)	0.673 (4)	2.894 (0)	-1.375 (4)	2.894 (0)	-1.375 (0)
	1st dif.	0.565 (3)	0.565 (3)	-3.318** (1)	-4.461*** (6)	-3.423** (0)	-3.687** (2)
FDI_S	Level	0.141 (3)	0.141 (3)	-2.572 (1)	-2.822 (1)	-2.749* (1)	-3.121 (0)
	1st dif.	0.096 (1)	0.096 (1)	-4.728*** (3)	-4.676*** (3)	-4.752*** (0)	-4.700*** (0)
TRADE	Level	0.653** (4)	0.653** (4)	-0.618 (5)	-2.264 (1)	-0.683 (0)	-2.133 (1)
	1st dif.	0.090 (6)	0.090 (6)	-5.783*** (7)	-5.870*** (8)	-5.534*** (0)	-5.411*** (0)
LNHUMAN	Level	0.710** (4)	0.710** (4)	-3.706*** (4)	1.381 (4)	-1.934 (1)	0.370 (1)
	1st dif.	0.159 (4)	0.159 (4)	-2.643** (3)	-6.750*** (2)	-2.934** (0)	-3.707** (0)
CREDIT	Level	0.701** (4)	0.701** (4)	-0.079 (0)	-2.264 (0)	-0.079 (0)	-2.206 (0)
	1st dif.	0.092 (0)	0.092 (0)	-5.327*** (0)	-5.257*** (0)	-5.328*** (0)	-5.258*** (0)

Note: KPSS = Kwiatkowski–Phillips–Schmidt–Shin; PP = Phillips–Perron; ADF = Augmented Dickey–Fuller.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Optimal lag lengths are in parentheses.

4. RESULTS AND DISCUSSIONS

4.1. Descriptive Statistics

The ARDL model variables' descriptive statistics (see Table 2) indicate that all variables, except for FDI_S, are normally distributed at the 5% level of significance based on the Jarque–Bera statistics. The correlation matrix (see Table 2) reveals that INTERNET, LNHUMAN, TRADE, and CREDIT are positively, significantly correlated with LNMHVASH, whereas FDI_S is negatively, insignificantly correlated with LNMHVASH. There are some pairwise correlation coefficients (e.g., that of INTERNET and CREDIT or that of TRADE and LNHUMAN) higher than 0.8, indicating a strong correlation among some explanatory variables. However, following common practice in econometric analyses, we ignore the potential multicollinearity issue when performing the ARDL model since the ARDL technique utilizes the suitable lag length of the variables to effectively eliminate multicollinearity among the explanatory variables (Islam, Alharthi, & Murad, 2021; Qamruzzaman, 2022; Shabbir et al., 2019).

4.2. Unit Root Test Results

Table 3 shows the results of three standard unit root tests (the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test, the Phillips–Perron (PP) test, and the Augmented Dickey–Fuller (ADF) test. The results confirm that LNMHVASH and TRADE are integrated of order 1, while the order of integration of the remaining variables remains indecisive between I(0) and I(1). However, all variables are confirmed to have the integrated order of no more than I(1) that satisfies the necessary condition for employing the ARDL model.

4.3. ARDL Model Results

The ARDL model's maximum lag length is two, since this study uses annual time series data based on the recommendation of Pesaran and Shin (1999). The Akaike information criterion (AIC) was selected to choose the optimal lag length for our ARDL model because this criterion suggests lag lengths that are long enough to avoid the issues of error term autocorrelation (Tuan et al., 2020). According to the result of the AIC (see Figure 1), we select the ARDL specification (2,2,0,2,2,2) for analyzing cointegration. In particular, the optimal lag lengths for LNMHVASH, INTERNET, FDI_S, LNHUMAN, TRADE, and CREDIT are 2, 2, 0, 2, 2, and 2, respectively.

4.3.1. Cointegration Test Results

The ARDL bounds test was conducted to assess the potential cointegration relationship between the development of the MHM sector and other explanatory variables. As depicted in Table 4, the F-statistic value of the ARDL bounds test is 9.386, which significantly exceeds the upper and lower bounds at the 1% level. This outcome indicates that the null hypothesis of no cointegration among the variables in the ARDL model is rejected, and a long-term relationship among the development of the MHM sector, digitalization, FDI, human capital, and financial development is confirmed to exist in Vietnam.

4.3.2. Short- and Long-Term Relationship Analysis

This study employs the ARDL error correction model to investigate the short- and long-run dynamics between the variables in light of the presence of cointegration. The estimated outcomes for the short- and long-term effects are presented in Table 5.

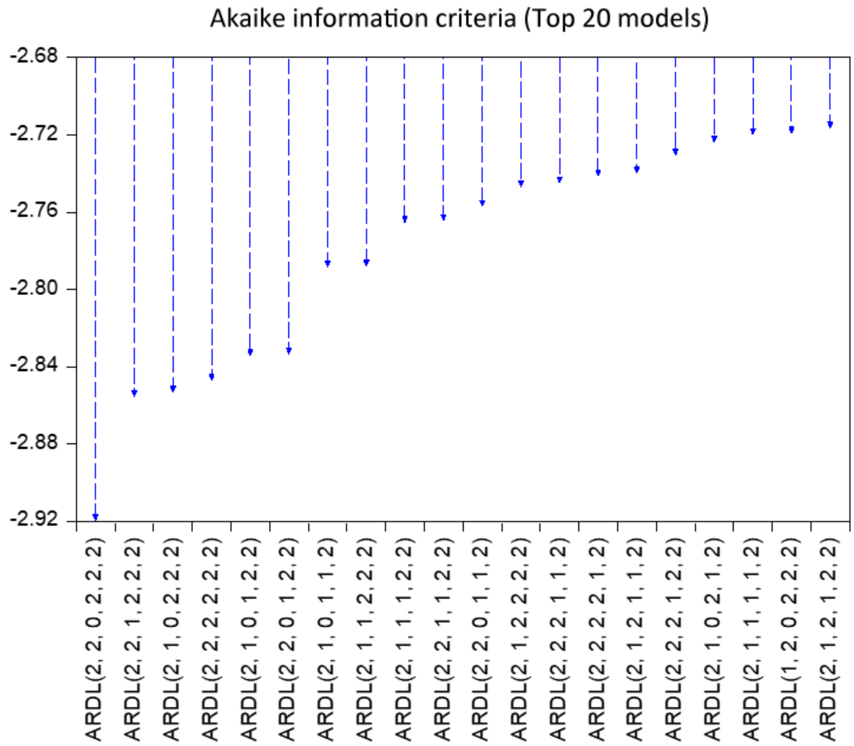

Figure 1. ARDL model's optimal lag lengths based on the AIC.

Table 4. ARDL bounds test results.

Estimated model	Maximum lag length	F-stat	Significance level	Critical values	
				Lower bound	Upper bound
Model I: LNMHVASH = f (INTERNET, FDI_S, LNHUMAN, TRADE, CREDIT)	2	9.386	10%	2.578	3.858
			5%	3.125	4.608
			1%	4.537	6.370

In the long run, digitalization measured by internet penetration was found to have a significant and favorable effect on the MHM sector, with a significance level of 1%. More specifically, an increase of one percentage point in internet penetration is linked to a corresponding increase of 0.029% in the value added by the MHM sector, ceteris paribus. This finding supports the conclusion of Hung (2023), that increasing digitalization plays an important role in boosting Vietnam's economic development. Similarly, the long-term growth of the MHM sector is positively influenced by human capital at the 5% significance level. This means that a 1% increase in Vietnam's mean years of schooling results in a 1.991% expansion in the MHM value added, ceteris paribus. This reinforces the assertion of Doong et al. (2011) and Chen and Chien (2011), who stated that high-tech industries require human capital as an essential component.

Interestingly, this study reveals that FDI has a significant and adverse impact on the development of the MHM sector over the long term. Specifically, a 1% increase in the FDI inflow to GDP ratio results in a 0.024% reduction in the MHM value added, ceteris paribus. This result is in line with the findings of Bayar et al. (2020), which suggests that FDI inflows have harmful effects on the high-tech export sector of transition economies. This result also supports the conclusion of Bakirci et al. (2017) regarding the negative correlation between FDI inflows and high-tech industries in developing countries. Bayar et al. (2020) further noted that the effects of inward FDI inflows on high-tech exports can vary depending on the quality of human capital, the type of FDI, and the level of technological and economic development in the nations. In the case of Vietnam (a developing country), the negative effect of FDI inflows on the high-tech sector may be because FDI inflows in developing countries typically involve production processes that require low-quality and/or low-paid labor, rather than high-tech production (Bakirci et al., 2017).

Likewise, trade openness has a significant, adverse effect on the long-term development of the MHM sector at a 5% level. The reveals that an increase of one percentage point in trade openness causes a 0.018% decrease in the MHM value added, ceteris paribus. This finding corroborates the assertion by Khobai and Moyo (2021) that the manufacturing industries in the SADC have encountered diminished output levels and workforce reduction as a result of inadequate competitiveness and amplified imports triggered by increased trade openness.

Table 5. Results for the relationships in the short and long runs.

Variable	Coefficient	T-stat
Long-term results		
INTERNET	0.029*** 0.006	4.959
FDI_S	-0.024** 0.008	-2.862
LNHUMAN	1.991** 0.696	2.859
TRADE	-0.018** 0.006	-2.905
CREDIT	-0.003 0.004	-0.710
Short-term results		
C	0.436*** 0.049	8.914
D(LNMHVASH(-1))	0.302*** 0.100	3.025
D(INTERNET)	0.008* 0.004	1.999
D(INTERNET(-1))	-0.009** 0.004	-2.521
D(LNHUMAN)	19.826*** 3.646	5.438
D(LNHUMAN(-1))	8.486** 3.644	2.329
D(TRADE)	-0.003*** 0.001	-3.092
D(TRADE(-1))	0.005*** 0.001	4.535
D(CREDIT)	0.008*** 0.001	5.799
D(CREDIT(-1))	0.013*** 0.002	6.069
ECM(-1)	-0.871*** 0.099	-8.830
Diagnostic tests		
Breusch–Godfrey serial correlation LM test	F-stat p-value	1.861 0.201
Breusch–Pagan–Godfrey heteroskedasticity test	F-stat p-value	0.712 0.738
Jarque–Bera normality test	Test-stat p-value	1.379 0.502
Ramsey reset test	F-stat p-value	1.702 0.217

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

In the short run, although the current coefficient of INTERNET is significantly negative, that of the first lag of INTERNET is significantly positive and the cumulative effect of digitalization is positive. This provides further support for the pivotal role of digitalization in fostering the development of the MHM sector. Regarding human capital, both the current and first lags of LNHUMAN are significant and positive at the 1% and 5% levels, respectively, revealing that human capital is an essential component for enhancing the MHM value added in both the short and long runs.

The current short-term coefficient of TRADE is significantly negative, while that of the first lag of TRADE is significantly positive. However, the overall effect of trade openness on the MHM sector in the short run is beneficial and statistically significant at the 1% level. This result is in line with the conclusion of Güneş, Gürel, Karadam, and Akın (2020), who found that trade openness has a short-term, favorable influence on the high-technology exports of 48 selected countries. It is noteworthy that the favorable short-term effect of increased trade openness is juxtaposed against the unfavorable long-term effect that it has on the progress of the MHM sector. The explanation for this may be that increased trade openness can bring short-term benefits by enabling technology transfer and expanding market access, which can boost productivity and enhance technological capabilities. Nonetheless, in the long term, trade openness can engender the displacement of local high-tech manufacturing industries as foreign firms dominate the market, resulting in a diminution of technological capabilities and limited opportunities for technology transfer.

The impact of financial development on the MHM sector is significant and positive in the short run; however, the long-run impact is unclear. This finding aligns with the viewpoints presented by Darrat (1999) and Baharumshah and Almasaied (2009), who suggested that, while greater financial development can yield advantages in the short term, these benefits may diminish over time as the economy matures.

The results in Table 5 show that the coefficient of ECM(-1) is -0.871, which is statistically significant at the 1% level. This coefficient suggests that approximately 87.1% of deviations from the long-term equilibrium are rectified annually after a short-term shock. This finding provides further support for the notion of stable long-term connections between digitalization, FDI, human capital, financial development, trade openness, and MHM development in Vietnam.

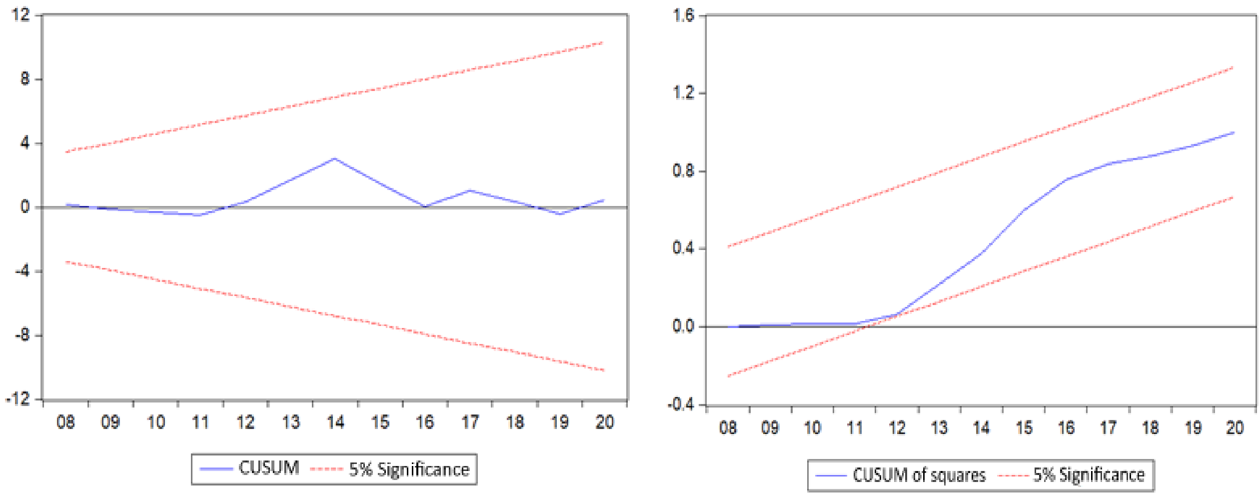

Figure 2. CUSUM and CUSUMSQ plots.

4.3.3. Diagnostics and Stability Test Results

In order to verify the reliability of the ARDL model utilized in this study, various diagnostic tests were performed, including the Ramsey RESET test (to identify any issues with functional form misspecification or omitted variables), the Jarque–Bera normality test (to examine normality), the Breusch–Pagan–Godfrey heteroskedasticity test (to evaluate heteroskedasticity), and the Breusch–Godfrey serial correlation LM test (to assess autocorrelation). According to the results displayed in Table 5, these tests indicate that the ARDL model adopted in this study is free from any concerns related to functional form misspecification, normality, heteroscedasticity, or autocorrelation. Furthermore, the stability of the ARDL model's parameters is assessed using the CUSUM and CUSUMSQ tests, which demonstrate that the plots of both statistics are situated within the critical bounds (see Figure 2), confirming the stability of the ARDL model's parameters.

Table 6. Toda and Yamamoto (1995) Granger causality test results.

Dependent variable	Explanatory variable					
	LNMHVASH	**INTERNET**	**FDI_S**	**LNHUMAN**	**TRADE**	**CREDIT**
LNMHVASH	-	1.195	4.118	4.078	2.853	1.704
INTERNET	5.063*	-	0.438	0.624	1.717	1.221
FDI_S	1.272	2.809	-	0.381	1.098	2.341
LNHUMAN	7.532**	4.316	10.858***	-	15.722***	14.028***
TRADE	2.211	10.350***	2.812	6.793**	-	0.866
CREDIT	0.091	0.047	2.671	0.470	0.480	-

Note: * p < 0.1; ** p < 0.05; *** p < 0.01.

4.4. Toda and Yamamoto (1995) Test Results

Table 6 displays the results of the Toda and Yamamoto (1995) Granger causality test, which indicate the presence of unidirectional causal links from LNMHVASH to LNHUMAN and from LNMHVASH to INTERNET. The results also reveal three other unidirectional causal relationships: (1) INTERNET Granger-causes TRADE; (2) FDI_S Granger-causes LNHUMAN; and (3) CREDIT Granger-causes LNHUMAN. Furthermore, the existence of a bidirectional causality relationship between TRADE and LNHUMAN is detected. Overall, the results of the Toda and Yamamoto (1995) test lend support to the conclusion drawn from the ARDL bounds test that the variables are cointegrated.

4.5. Robustness Check

In order to verify the robustness of the ARDL model's outcomes, we add some dummy variables into the regression model to account for particular social and economic events that could potentially influence the growth of the MHM sector. Three separate dummies are utilized to represent distinct events: the COVID-19 pandemic in 2020, the global financial crisis in 2008–2009, and the Asian financial crisis in 1997–1998. In addition, we substitute the MHM value added share of the total manufacturing value added with the MHM value added to serve as another proxy for the development of the MHM sector. The two new models appear as follows:

Model II: Baseline model with dummy (DUM) variables for special economic and social events:

$$LNMHVASH = F(INTERNET, FDI\_PERCENT, LNHUMAN, TRADE, CREDIT, 97DUM, 08DUM, 20DUM) \quad (4)$$

Model III: Model with an alternative dependent variable and dummy variables:

$$LNMHMVA\_U = F(INTERNET, FDI\_PERCENT, LNHUMAN, TRADE, CREDIT, 97DUM, 08DUM, 20DUM) \quad (5)$$

Where 20DUM is a dummy indicator that signifies the Covid-19 pandemic (it takes a value of 1 in 2020, and 0 otherwise); 08DUM is a binary indicator that indicates the global financial crisis period in 2008–2009 (it takes a value of 1 in those years, and 0 otherwise); 97DUM is a binary variable that denotes the Asian financial crisis in 1997–1998 (it takes a value of 1 in those years, and 0 otherwise). LNMHMVA_U is the natural logarithm of the value added in the MHM measured in US dollars at the constant 2015 price.

Accordingly, Equation 4 presents the impacts of macroeconomic factors as well as special economic and social events on MHM development (LNMHVASH). Equation 5 further explores the impacts of macroeconomic and dummy event variables on an alternative measurement of MHM development (LNMHMVA_U).

Similar to the baseline model without dummies, the new two models are estimated using the ARDL method with the maximum number of lags being two. The AIC is employed to determine the optimal lag length for these models. The main estimation outcomes of Models II and III are presented in Appendix Tables A1 to A4. Both the F-statistic values resulting from the ARDL bounds test for Models II and III (see Appendix Tables A1 and A3) significantly exceed the upper and lower bounds at the 1% level. Furthermore, the coefficients of the ECM(-1) for Models II and III, which are -0.893 and -0.758, respectively, are statistically significant at the 1% level. These findings provide further evidence of a stable long-term relationship between Vietnam's MHM sector development and other explanatory variables. The long-term relationship results of Models II and III (see Appendix Tables A2 and A4) demonstrate significant and positive effects of digitalization and human capital, while indicating significant and negative influences of FDI and trade openness on the advancement of the MHM sector over the long run. These findings are similar to the conclusions obtained from Model I, thereby validating the robustness of the outcomes estimated by our baseline ARDL model.

It is worth noting that the coefficients for 08DUM and 20DUM are both significant and positive in Models II and III, indicated by the short-term estimation results presented in Appendix Tables A2 and A4. This confirms that both the 2008–2009 global financial crisis and the Covid-19 pandemic have had a favorable impact on the development of Vietnam's MHM sector. According to Sharma (2021) and Jong (2022), the Covid-19 pandemic and the US–China trade war have led to global manufacturers relocating their manufacturing plants from China to other countries to diversify supply chains and decrease over-reliance on a single country. Vietnam's manufacturing sector, particularly in the high-tech product category, has experienced benefits from the shifting trend (Barai, 2021; Dollar, 2022; Jong, 2022). Regarding the global financial crisis of 2008–2009, many developing nations, such as Vietnam, experienced the depreciation of domestic currencies against the US dollar. Mefford (2009) reported that in order to reduce costs, some global manufacturers relocated to countries that experienced the most significant currency depreciation (e.g., to Vietnam from China). As a result, Vietnam's manufacturing industry enjoyed a favorable impact. Despite being positive, the coefficient for 97DUM lacks statistical significance. One plausible explanation for this finding is that the Vietnamese economy's relative isolation from the global market at that time (Nguyen, Nguyen, Nguyen, & Nguyen, 2010) might have limited the impact of the Asian financial crisis on the MHM sector.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Our study aims to identify the main factors that contribute to the growth of the MHM sector in Vietnam. Using the ARDL approach to examine Vietnam's annual data from 1990 to 2020, we found that different macroeconomic factors have various impacts on the short- and long-term development of the MHM sector. Our findings are robust when altering the dependent variable, as well as including dummy variables for special economic and social events.

Digitalization, measured by internet penetration, has been shown to have a significant and positive impact on the MHM sector in both the short and long terms. This lends further credence to digitalization's critical role in promoting the growth of the MHM sector.

Similarly, human capital has a positive impact on the MHM sector's short- and long-term growth. Our findings confirm that MHM sector development is associated with human capital with a high level of education.

Trade openness has a significant negative impact on the MHM sector's long-term development. In the short run, on the other hand, trade openness benefits the MHM sector. The contradictory impacts of trade openness on the short- and long-term growth of Vietnam's MHM sector can be explained by the fact that increased trade openness can provide short-term benefits by facilitating technology transfer and expanding market access, which can boost productivity and technological capabilities. However, in the long run, trade openness can result in the displacement of local high-tech manufacturing industries as foreign firms dominate the market, resulting in a reduction in technological capabilities and limited opportunities for technology transfer.

FDI has a significant and negative impact on the long-term development of the MHM sector in Vietnam. In the case of a developing country such as Vietnam, the negative impact of FDI inflows on the high-tech sector may be because FDI inflows in developing countries typically involve low-quality and/or low-paid labor rather than high-tech production (Bakirci et al., 2017).

The effect of financial development on Vietnam's MHM sector is significant and positive in the short run but unclear in the long run. This finding supports the idea that while greater financial development can yield advantages in the short term, these benefits may diminish over time as the economy matures (Baharumshah & Almasaied, 2009; Darrat, 1999).

Lastly, our study discloses that Vietnam's MHM sector has been positively affected by the 2008–2009 global financial crisis and the COVID-19 pandemic. A possible explanation is that the pandemic and the trade conflict between the US and China have encouraged global manufacturers to move their production plants from China to other nations to decrease their dependence on one country and diversify their supply chains. Vietnam's high-tech manufacturing sector, in particular, has benefited from this trend, as evidenced by various studies (Barai, 2021; Dollar, 2022; Jong, 2022).

5.2. Recommendations

Based on the study's findings, we make several policy recommendations that could help boost Vietnam's MHM sector development.

First, the findings highlight the importance of digitalization in Vietnam's high-tech manufacturing. It's worth mentioning that the Vietnamese government has shown a strong commitment to advancing the Fourth Industrial Revolution and promoting national digital transformation. However, there has been insufficient action taken by the government and the industry in terms of necessary reforms despite the presence of new technology and digital disruption. The country's digital infrastructure remains basic, with restricted data and slow transmission speeds (Cameron et al., 2019). To overcome these challenges, the government should establish a regulatory reform advisory panel to identify regulations that obstruct the growth of Vietnam's MHM sector. This panel must propose solutions and recommendations to enhance regulations. Furthermore, investing substantially in digital infrastructure is crucial to further advance digitalization. Vietnam can also foster collaboration among government agencies, private companies, and academic institutions to create a supportive environment for digitalization and innovation that effectively serves the needs of the MHM sector.

Second, due to the significant impact of human capital on the MHM sector's development in both the short and long runs, one of the key tasks to promote the development of the MHM sector specifically, and the Vietnamese economy in general, is the development of high-quality human resources. Vietnam faces a shortage of skilled personnel to fully realize the potential of digitalization in various industries (Cameron et al., 2019). To address this issue, the country must prioritize the development of its national education policies, particularly in areas related to the Fourth Industrial Revolution technologies, such as AI, the IoT, and blockchain. The government should actively promote training programs to meet this need. However, as noted by Zhou (2018), the efficacy of human capital in driving industrial upgrading also depends on institutional quality. Therefore, in addition to developing human resources, it is essential to implement measures to enhance Vietnam's institutional quality.

Third, our findings demonstrate the adverse influence of trade openness on Vietnam's MHM sector in the long run. However, it cannot be denied that trade openness also presents potential opportunities for firms to enhance their international competitiveness and deepen their technological and global marketing capabilities. Thus, rather than restricting international trade, the Vietnamese government could adopt a proactive approach to mitigating the negative impacts of trade openness on the MHM sector. Feasible solutions that the government could implement include promoting international partnerships between MHM firms in Vietnam and other countries, which could facilitate the transfer of technology and knowledge to Vietnam. In addition, the government could support research and development efforts to enable domestic medium- and high-tech manufacturers to remain ahead of the curve and distinguish themselves from foreign competitors. By pursuing these measures, Vietnam could foster the development of its MHM sector and enhance its competitiveness in the global marketplace.

Fourth, the adverse effects of FDI on the advancement of the MHM sector is a matter of particular concern that requires attention from the government of Vietnam. From the perspective of developing nations, such as Vietnam, FDI constitutes a crucial external catalyst for industrial and economic development. Thus, the Vietnamese government ought to reassess the sectors currently receiving FDI inflows, eradicate FDI inflows employing outdated technology that exploits labor and induces environmental pollution, and modify policy frameworks to draw FDI inflows in technologically advanced and eco-friendly industries. Concurring with the recommendation of Bayar et al. (2020), channeling resources toward enhancing the caliber of the workforce and upgrading physical capital presents a viable approach for Vietnam to attract FDI inflows in its MHM sector.

Finally, despite the positive impact of the Covid-19 pandemic in 2020 and the global financial crisis of 2008–2009 on the development of the MHM sector, the increasing openness of the Vietnamese economy implies that similar events in the future will have a stronger and more volatile impact on the MHM sector and the overall economy. To mitigate the risk of volatility, the government could incentivize medium- and high-tech firms to broaden their supply chains by incorporating various suppliers in diverse regions, prioritize the local market, and strengthen firms' risk management strategies by recognizing potential hazards and establishing backup plans to tackle them.

Funding: This research is supported by Ministry of Science and Technology, Vietnam (Grant code: ĐTĐL.XH-10/21).
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study.
Acknowledgement: The article is conducted within the framework of the independent national project "Scientific theory on models and policies of industrialization and modernization in new conditions", Code ĐTĐL.XH-10/21, chaired by The Central Economic Commission and sponsored by the Ministry of Science and Technology, Vietnam.

REFERENCES

Adamu, F. M., & Dogan, E. (2017). Trade openness and industrial growth: Evidence from Nigeria. *Panoeconomicus, 64*(3), 297-314. https://doi.org/10.2298/pan150130029a

Adner, R., & Levinthal, D. (2001). Demand heterogeneity and technology evolution: Implications for product and process innovation. *Management Science, 47*(5), 611-628. https://doi.org/10.1287/mnsc.47.5.611.10482

Anaya, L., Dulaimi, M., & Abdallah, S. (2015). An investigation into the role of enterprise information systems in enabling business innovation. *Business Process Management Journal, 21*(4), 771-790. https://doi.org/10.1108/BPMJ-11-2014-0108

Andrikopoulos, P., Anh, D., & Newaz, M. (2016). Structural breaks, efficiency, and volatility: An empirical investigation of Southeast Asian frontier markets, In Handbook of Frontier Markets. In (pp. 251-272). United Kingdom: Academic Press.

Anh, D. L. T., Anh, N. T., & Chandio, A. A. (2023). Climate change and its impacts on Vietnam agriculture: A macroeconomic perspective. *Ecological Informatics, 74*, 101960. https://doi.org/10.1016/j.ecoinf.2022.101960

Anh, D. L. T., & Gan, C. (2019). Profitability and marketability efficiencies of Vietnam manufacturing firms: An application of a multi-stage process. *International Journal of Social Economics, 47*(1), 54-71. https://doi.org/10.1108/IJSE-05-2019-0321

Anh, D. L. T., & Gan, C. (2022). Manufacturers efficiency disparity: A comparative analysis in the Southeast Asian region. *Asia-Pacific Journal of Business Administration, 15*(1), 25–45. https://doi.org/10.1108/APJBA-09-2021-0446

Anh, N. T. T., Duc, L. M., & Chieu, T. D. (2014). *The evolution of Vietnamese industry*. Retrieved from World Institute for Development Economic Research (UNU-WIDER). No. wp-2014-076.

Anwar, S. (2008). Foreign investment, human capital and manufacturing sector growth in Singapore. *Journal of Policy Modeling, 30*(3), 447-453. https://doi.org/10.1016/j.jpolmod.2007.12.008

Arnold, J. M., Javorcik, B. S., & Mattoo, A. (2011). Does services liberalization benefit manufacturing firms?: Evidence from the Czech Republic. *Journal of International Economics, 85*(1), 136-146. https://doi.org/10.1016/j.jinteco.2011.05.002

Atasoy, B. S. (2021). The determinants of export sophistication: Does digitalization matter? *International Journal of Finance & Economics, 26*(4), 5135-5159. https://doi.org/10.1002/ijfe.2058

Azolibe, C. B. (2021). Does foreign direct investment influence manufacturing sector growth in Middle East and North African region? *International Trade, Politics and Development, 5*(1), 71-85. https://doi.org/10.1108/ITPD-04-2020-0010

Badeeb, R. A., & Lean, H. H. (2017). Natural resources, financial development and sectoral value added in a resource based economy. In: Kreinovich, V., Sriboonchitta, S., Huynh, VN. (Eds.), Robustness in Econometrics. Studies in Computational Intelligence. In (pp. 692). Cham: Springer.

Baharumshah, A. Z., & Almasaied, S. W. (2009). Foreign direct investment and economic growth in Malaysia: Interactions with human capital and financial deepening. *Emerging Markets Finance and Trade, 45*(1), 90-102. https://doi.org/10.2753/REE1540-496X450106

Bakirci, F., Heupel, T., Kocagoz, O., & Ozen, U. (2017). *German-Turkish perspectives on IT and innovation management: Challenges and approaches*. Wiesbaden: Springer.

Barai, M. K. (2021). COVID 19 in South Asia and the way forward: An introduction. *South Asian Survey, 28*(1), 7-19. https://doi.org/10.1177/09715231211002303

Bayar, Y., Remeikienė, R., & Gasparėnienė, L. (2020). Intellectual property rights, R&D expenditures, and high-tech exports in the EU transition economies. *Journal of International Studies, 13*(1), 143-154.

Bi, Z. M., Lang, S. Y., Shen, W., & Wang, L. (2008). Reconfigurable manufacturing systems: The state of the art. *International Journal of Production Research, 46*(4), 967-992. https://doi.org/10.1080/00207540600905646

Bijsterbosch, M., & Kolasa, M. (2010). FDI and productivity convergence in Central and Eastern Europe: An industry-level investigation. *Review of World Economics, 145*, 689-712. https://doi.org/10.1007/s10290-009-0036-z

Bo-Hu, L., Lin, Z., Shi-Long, W., Fei, T., Jun-Wei, C., Xiao-Dan, J., . . . Xu-Dong, C. (2010). Cloud manufacturing: A new service-oriented networked manufacturing model. *Computer Integrated Manufacturing System, 16*(01), 1-7.

Cameron, A., Pham, T. H., Atherton, J., Nguyen, D. H., Nguyen, T. P., Tran, S. T., & Hajkowicz, S. (2019). *Vietnam's future digital economy–towards 2030 and 2045*. Brisbane: Commonwealth Scientific and Industrial Research Organisation.

Caputo, A., Marzi, G., & Pellegrini, M. M. (2016). The internet of things in manufacturing innovation processes: Development and application of a conceptual framework. *Business Process Management Journal, 22*(2), 383-402. https://doi.org/10.1108/BPMJ-05-2015-0072

Cetrulo, A., & Nuvolari, A. (2019). Industry 4.0: Revolution or hype? Reassessing recent technological trends and their impact on labour. *Journal of Industrial and Business Economics, 46*, 391-402. https://doi.org/10.1007/s40812-019-00132-y

Chandran, V. (2009). Trade openness and manufacturing growth in Malaysia. *Journal of Policy Modeling, 31*(5), 637-647. https://doi.org/10.1016/j.jpolmod.2009.06.002

Chen, L.-F., & Chien, C.-F. (2011). Manufacturing intelligence for class prediction and rule generation to support human capital decisions for high-tech industries. *Flexible Services and Manufacturing Journal, 23*, 263-289. https://doi.org/10.1007/s10696-010-9068-x

Chenery, H. B. (1967). Foreign assistance and economic development. In (pp. 268-292). UK: Palgrave Macmillan.

Chikabwi, D., Chidoko, C., & Mudzingiri, C. (2017). Manufacturing sector productivity growth drivers: Evidence from SADC member states. *African Journal of Science, Technology, Innovation and Development, 9*(2), 163-171.

DaCosta, F. (2013). *Rethinking the internet of things: A scalable approach to connecting everything*. New York: Apress Open.

Darrat, A. F. (1999). Are financial deepening and economic growth causally related? Another look at the evidence. *International Economic Journal, 13*(3), 19-35. https://doi.org/10.1080/10168739900000002

Dat. (2023). *Vietnam emerges as high-tech manufacturing hub*. Retrieved from https://e.vnexpress.net/news/economy/vietnam-emerges-as-high-tech-manufacturing-hub-4554830.html

Davenport, T. H., & Short, J. (2003). Information technology and business process redesign. In Lewis, M.A. and Slack, N. (Eds.), Operations Management: Critical Perspectives on Business and Management. In (Vol. 1, pp. 97-209). London: Routledge.

Devaraj, S., Krajewski, L., & Wei, J. C. (2007). Impact of ebusiness technologies on operational performance: The role of production information integration in the supply chain. *Journal of Operations Management*, *25*(6), 1199-1216. https://doi.org/10.1016/j.jom.2007.01.002

Dewan, R., Jing, B., & Seidmann, A. (2000). Adoption of internet-based product customization and pricing strategies. *Journal of Management Information Systems*, *17*(2), 9-28. https://doi.org/10.1080/07421222.2000.11045644

Dollar, D. (2022). US-China trade relations in an era of great power competition. *China Economic Journal*, *15*(3), 277-289. https://doi.org/10.1080/17538963.2022.2117185

Doong, S.-C., Fung, H.-G., & Wu, J.-Y. (2011). Are social, financial, and human capital value enhancing? Evidence from Taiwanese firms. *International Review of Economics & Finance*, *20*(3), 395-405. https://doi.org/10.1016/j.iref.2010.11.018

Dutta, D., & Ahmed, N. (2004). Trade liberalization and industrial growth in Pakistan: A cointegration analysis. *Applied Economics*, *36*(13), 1421-1429. https://doi.org/10.1080/0003684042000206951

Ebenyi, G. O., Nwanosike, D., Uzoechina, B., & Ishiwu, V. (2017). The impact of trade liberalization on manufacturing value-added in Nigeria. *Saudi Journal of Business and Management Studies*, *2*(5), 475-481.

Echandi, R., Krajcovicova, J., & Qiang, C. Z. W. (2015). *The impact of investment policy in a changing global economy: A review of the literature*. Retrieved from World Bank Policy Research Working Paper No. (7437).

Fang, Y., Gu, G., & Li, H. (2015). The impact of financial development on the upgrading of China's export technical sophistication. *International Economics and Economic Policy*, *12*, 257-280. https://doi.org/10.1007/s10368-014-0277-8

Findlay, R. (1978). Relative backwardness, direct foreign investment, and the transfer of technology: A simple dynamic model. *The Quarterly Journal of Economics*, *92*(1), 1-16.

Gan, C., & Anh, D. L. T. (2019). Should firms keep a balance between state and foreign ownership? A perspective on financial constraints and investments in Vietnam. *Asian Economic and Financial Review*, *9*(4), 517–530. https://doi.org/10.18488/journal.aefr.2019.94.517.530

Güneş, S., Gürel, S. P., Karadam, D. Y., & Akın, T. (2020). The analysis of main determinants of high-technology exports: A panel data analysis. *Journal of the Faculty of Economics and Administrative Sciences of Kafkas University*, *11*(21), 242–267. https://doi.org/10.36543/kauiibfd.2020.012

Hsu, P.-H., Tian, X., & Xu, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of Financial Economics*, *112*(1), 116-135. https://doi.org/10.1016/j.jfineco.2013.12.002

Hung, N. T. (2023). Green investment, financial development, digitalization and economic sustainability in Vietnam: Evidence from a quantile-on-quantile regression and wavelet coherence. *Technological Forecasting and Social Change*, *186*(Part B), 122185. https://doi.org/10.1016/j.techfore.2022.122185

Ilyas, M., Ahmad, H. K., Afzal, M., & Mahmood, T. (2010). Determinants of manufacturing value added in Pakistan: An application of bounds testing approach to cointegration. *Pakistan Economic and Social Review*, *48*(2), 209-223.

Islam, M. M., Alharthi, M., & Murad, M. W. (2021). The effects of carbon emissions, rainfall, temperature, inflation, population, and unemployment on economic growth in Saudi Arabia: An ARDL investigation. *Plos One*, *16*(4), e0248743. https://doi.org/10.1371/journal.pone.0248743

Jong, H. Y. (2022). The art of trade war: Spurring investments in Indonesia amidst the US–China trade war. *Global Journal of Emerging Market Economies*, *14*(2), 204-221. https://doi.org/10.1177/09749101211034110

Khobai, H., & Moyo, C. (2021). Trade openness and industry performance in SADC countries: Is the manufacturing sector different? *International Economics and Economic Policy*, *18*, 105-126. https://doi.org/10.1007/s10368-020-00476-0

Lee, N., & Clarke, S. (2019). Do low-skilled workers gain from high-tech employment growth? High-technology multipliers, employment and wages in Britain. *Research Policy, 48*(9), 103803. https://doi.org/10.1016/j.respol.2019.05.012

Li, H., Sheng, Y., & Ding, Y. (2020). Research on the institutional influence on the development of the high-tech industry. *IEEE Access, 8*, 90895-90906. https://doi.org/10.1109/access.2020.2994164

Luo, X., Feng, J., & Formaneck, S. (2021). The influence of linear feedback control suppression under the calculation of fractional financial system on the upgrading of high-tech industries. *Mathematical Biosciences and Engineering, 18*(5), 5114-5124. https://doi.org/10.3934/mbe.2021260

Makuyana, G., & Odhiambo, M. N. (2019). Public and private investment and economic growth in Malawi: An ARDL-bounds testing approach. *Economic Research, 32*(1), 673-689. https://doi.org/10.1080/1331677X.2019.1578677

Manova, K., & Yu, Z. (2016). How firms export: Processing vs. ordinary trade with financial frictions. *Journal of International Economics, 100*, 120-137. https://doi.org/10.1016/j.jinteco.2016.02.005

Mefford, R. N. (2009). The financial crisis and global supply chains. *AIB Insights, 9*(3), 8-11.

Mignamissi, D., & Nguekeng, B. (2022). Trade openness-industrialization nexus revisited in Africa. *Economic Change and Restructuring, 55*(4), 2547-2575. https://doi.org/10.1007/s10644-022-09401-8

Moreira, D. F. (2016). The microeconomic impact on growth of SMEs when the access to finance widens: Evidence from internet & high-tech industry. *Procedia-Social and Behavioral Sciences, 220*, 278-287. https://doi.org/10.1016/j.sbspro.2016.05.500

Mubarik, M. S., Chandran, V., & Devadason, E. S. (2018). Measuring human capital in small and medium manufacturing enterprises: What matters? *Social Indicators Research, 137*, 605-623. https://doi.org/10.1007/s11205-017-1601-9

Mukherjee, S., & Chanda, R. (2017). Differential effects of trade openness on Indian manufacturing firms. *Economic Modelling, 61*, 273-292. https://doi.org/10.1016/j.econmod.2016.10.001

Muren, P. D., Koman, M., & Redek, T. (2022). *Metaversing the corporate strategy: The opportunities and challenges of digital transformation. Editors Polona Domadenik Muren, Matjaž Koman, Tjaša Redek* (1st ed.). Ljubljana: Casnik Finance.

Na, K., & Kang, Y.-H. (2019). Relations between innovation and firm performance of manufacturing firms in Southeast Asian emerging markets: Empirical evidence from Indonesia, Malaysia, and Vietnam. *Journal of Open Innovation: Technology, Market, and Complexity, 5*(4), 98. https://doi.org/10.3390/joitmc5040098

Narayan, P. K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics, 37*(17), 1979-1990. https://doi.org/10.1080/00036840500278103

Nguyen, A. N., Nguyen, N. D., Nguyen, C. D., & Nguyen, T. (2010). *The global crisis and medium term growth prospects for developing countries: The case of Vietnam*. Retrieved from Development and Policies Research Center Working Paper Series No. 2010/08.

OECD. (2018). *OECD science, technology and innovation outlook 2018: Adapting to technological and societal disruption*. Paris: OECD Publishing.

Ogu, C., Aniebo, C., & Elekwa, P. (2016). Does Trade liberalisation hurt Nigeria's manufacturing sector. *International Journal of Economics and Finance, 8*(6), 175-180. http://dx.doi.org/10.5539/ijef.v8n6p175

Okoye, L. U., Nwakoby, C. I., & Okorie, U. E. (2016). Economic openness and industrial development in Nigeria. *Journal of Policy and Development Studies, 10*(1), 1-15.

Olaniyi, E. (2017). Back to the land: The impact of financial inclusion on agriculture in Nigeria. *Iranian Economic Review, 21*(4), 885-903. http://dx.doi.org/10.22059/IER.2017.64086

Onakoya, A. B., Fasanya, I. O., & Babalola, M. T. (2012). Trade openness and manufacturing sector growth: An empirical analysis for Nigeria. *Mediterranean Journal of Social Sciences, 3*(11), 637-646.

Patience, G. (2011). Impact of foreign direct investment on manufacturing output growth of West Africa. *Africa Journal of Management and Business, 6*(21), 67-77.

Pesaran, M. H., & Shin, Y. (1999). An autoregressive distributed-lag modelling approach to cointegration analysis. In S. Strom (Ed.), Econometrics and Economic Theory in the 20th Century. In (pp. 371–413). Cambridge: Cambridge University Press.

Qamruzzaman, M. (2022). Nexus between renewable energy, environmental innovation, trade and environmental sustainability in Russia and India. *Energy Research & Social Science, 88*, 1-28. https://doi.org/10.5281/zenodo.7619299

Shabbir, A. H., Zhang, J., Liu, X., Lutz, J. A., Valencia, C., & Johnston, J. D. (2019). Determining the sensitivity of grassland area burned to climate variation in Xilingol, China, with an autoregressive distributed lag approach. *International Journal of Wildland Fire, 28*(8), 628-639. https://doi.org/10.1071/WF18171

Sharma, B. (2021). Covid-19 and recalibration of FDI regimes: Convergence or divergence? *Transnational Corporations Review, 13*(1), 62-73. https://doi.org/10.1080/19186444.2021.1890433

Siyakiya, P. (2017). Can trade openness stimulate output performance? A case of selected African countries. *Journal of International and Global Economic Studies, 10*(2), 55-67.

Sun, S. H., Wang, A., & Yu, H. (2021). *Analysis of financial development and industrial structure transformation*. Paper presented at the E3S Web of Conferences. EDP Sciences.

Tahir, M., Estrada, M. R., Khan, I., & Afridi, M. A. (2016). The role of trade openness for industrial sector development: Panel data evidence from SAARC region. *Journal of Asia Business Studies, 10*(1), 93-103. https://doi.org/10.1108/JABS-01-2015-0007

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics, 66*(1–2), 225–250. https://doi.org/10.1016/0304-4076(94)01616-8

Tuan, A. N., Gan, C., & Anh, D. L. T. (2020). Does credit boost agricultural performance? Evidence from Vietnam. *International Journal of Social Economics, 47*(9), 1203-1221. https://doi.org/10.1108/IJSE-04-2020-0238

UNCTAD. (2021). *Technology and innovation report 2021: Catching technological waves: Innovation with equity*. Paper presented at the United Nations Conference on Trade and Development.

UNIDO. (2023). *UNIDO statistics data portal*. Retrieved from https://stat.unido.org/

VNA. (2021). *Vietnam boosts high-tech industry*. Retrieved from https://en.vietnamplus.vn/vietnam-boosts-hightech-industry/208056.vnp

Wang, Z., Chen, H., & Teng, Y. P. (2023). Role of greener energies, high tech-industries and financial expansion for ecological footprints: Implications from sustainable development perspective. *Renewable Energy, 202*, 1424-1435. https://doi.org/10.1016/j.renene.2022.12.039

World Bank. (2022). *Taking stock, August 2022: Educate to grow*. Retrieved from http://hdl.handle.net/10986/37834

World Bank. (2023). *World development indicators*. Retrieved from https://databank.worldbank.org/source/world-development-indicators

World Economic Forum (WEF). (2013). *Manufacturing for growth: Strategies for driving growth and employment, WEF, Geneva*. Retrieved from http://www3.weforum.org/docs/WEF_ManufacturingForGrowth_ReportVol1_2013

Yu, B. (2022). The impact of the internet on industrial green productivity: Evidence from China. *Technological Forecasting and Social Change, 177*, 121527. https://doi.org/10.1016/j.techfore.2022.121527

Zaborovskaia, O., Nadezhina, O., & Avduevskaya, E. (2020). The impact of digitalization on the formation of human capital at the regional level. *Journal of Open Innovation: Technology, Market, and Complexity, 6*(4), 184. https://doi.org/10.3390/joitmc6040184

Zhang, X., Li, X., Ding, L., & Zhang, X. (2019). The impact of financial development on manufacturing structural upgrading: Quantity or quality. *American Journal of Industrial and Business Management, 9*(12), 2112-2128. https://doi.org/10.4236/ajibm.2019.912140

Zhao, B., & Bu, W. (2017). *A study on the impact of financial environment on the upgrading of high tech industries in Beijing*. Paper presented at the 2017 4th International Conference on Industrial Economics System and Industrial Security Engineering (IEIS). IEEE.

Zhou, Y. (2018). Human capital, institutional quality and industrial upgrading: Global insights from industrial data. *Economic Change and Restructuring*, *51*(1), 1–27. https://doi.org/10.1007/s10644-016-9194-x

Appendix Tables

Table A1. ARDL bounds test results for Model II.

Estimated model	Maximum lag length	F-stat	Significance level	Critical values	
				Lower bounds	Upper bounds
Model II: LNMHVASH = f (INTERNET, FDI_S, LNHUMAN, TRADE, CREDIT) with 97DUM, 08DUM, 20DUM	2	9.344	10%	2.578	3.858
			5%	3.125	4.608
			1%	4.537	6.370

Table A2. Model II's results for short- and long-run relationships.

Variable	Coefficient	t-stat
Long-term results		
INTERNET	0.032*** 0.007	4.795
FDI_S	-0.03** 0.011	-2.797
LNHUMAN	2.582** 0.900	2.870
TRADE	-0.023** 0.008	-3.094
CREDIT	-0.004 0.005	-0.820
Short-term results		
C	-0.127*** 0.040	-3.152
D(LNMHVASH(-1))	0.322*** 0.092	3.499
D(INTERNET)	0.013** 0.005	2.911
D(LNHUMAN)	23.303*** 4.602	5.064
D(LNHUMAN(-1))	11.674** 3.861	3.023
D(TRADE)	-0.004*** 0.001	-3.250
D(TRADE(-1))	0.006*** 0.001	5.135
D(CREDIT)	0.009*** 0.002	5.958
D(CREDIT(-1))	0.015*** 0.002	6.420
97DUM	0.018 0.035	0.523
08DUM	0.091** 0.039	2.323
20DUM	0.167** 0.061	2.724
ECM(-1)	-0.893*** 0.099	-9.031
Diagnostic tests		
Breusch–Godfrey serial correlation LM test	F-stat p-value	1.953 0.197
Breusch–Pagan–Godfrey heteroskedasticity test	F-stat p-value	0.503 0.902
Jarque–Bera normality test	Test-stat p-value	2.067 0.356
Ramsey reset test	F-stat p-value	2.155 0.057

Note: ** $p < 0.05$; *** $p < 0.01$.

Table A3. ARDL bounds test results for Model III.

Estimated model	Maximum lag length	F-stat	Significance level	Critical values	
				Lower bounds	Upper bounds
Model III: LNMHMVA_U = f (INTERNET, FDI_S, LNHUMAN, TRADE, CREDIT) with 97DUM, 08DUM, 20DUM	2	7.200	10%	2.578	3.858
			5%	3.125	4.608
			1%	4.537	6.370

Table A4. Model III's results for short- and long-run relationships.

Variable	Coefficient	t-stat
Long-term results		
INTERNET	0.034*** 0.006	6.099
FDI_S	-0.026* 0.014	-1.925
LNHUMAN	4.831*** 0.885	5.462
TRADE	-0.014* 0.007	-2.001
CREDIT	-0.008 0.006	-1.261
Short-term results		
C	-4.931*** 0.619	-7.963
D(LNMHMVA_U(-1))	0.301*** 0.089	3.390
D(INTERNET)	0.015*** 0.004	3.348
D(INTERNET(-1))	0.010** 0.004	2.501
D(FDI_S)	-0.027*** 0.006	-4.563
D(FDI_S(-1))	0.010* 0.005	1.936
D(LNHUMAN)	27.529*** 3.705	7.431
D(TRADE)	-0.001 0.001	-0.446
D(TRADE(-1))	0.003*** 0.001	2.958
D(CREDIT)	0.007*** 0.002	4.589
D(CREDIT(-1))	0.012*** 0.003	4.636
97DUM	0.022 0.034	0.638
08DUM	0.031* 0.037	0.837
20DUM	0.368*** 0.078	4.738
ECM(-1)	-0.758*** 0.092	-8.198
Diagnostic tests		
Breusch–Godfrey serial correlation LM test	F-stat p-value	2.336 0.167
Breusch–Pagan–Godfrey heteroskedasticity test	F-stat p-value	0.555 0.866
Jarque–Bera normality test	Test-stat p-value	2.456 0.267
Ramsey reset test	F-stat p-value	1.327 0.145

Note: * p < 0.1; ** p < 0.05; *** p < 0.01.