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Examining the Effects of FDI, R&D, and Human Capital on the High-Tech Exports in ASEAN 5 – A Panel Data Analysis

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Abstract: **This study investigates the effects of FDI, R&D, and human capital on high-tech exports and their subsequent impact on economic growth in the ASEAN 5 countries from 2000 to 2022. The study employs a two-stage regression analysis using secondary data from reliable sources such as the World Bank, Euromonitor, and UNESCO-UIS. The first stage examines the relationship between FDI, R&D, and human capital on high-tech exports and utilizes the Fixed Effects Model (FEM) with Cross-section weights and White Cross-section. At the same time, the second stage investigates the relationship between high-tech exports and economic growth and also uses FEM with Cross-section Weights and applies the White Diagonal Cross-section covariance method. The study's findings present that, in the first stage, there is a significant and positive relationship between human capital and high-tech exports; however, there is also a significant but negative relationship between FDI and R&D and high-tech exports. Moreover, the results from the second stage revealed an insignificant relationship between high-tech exports and economic growth.**

Keywords: **Economic growth, Foreign direct investment, Government expenditure, High-technology exports, Human capital, Innovation, R&D expenditure.**

1. Introduction

Innovation is widely acknowledged as a crucial catalyst for economic growth across numerous sectors. (Feng et al., 2020). Moreover, it is a vital competitive advantage for any company, given its pivotal role in promoting economic growth, generating wealth, facilitating business expansion, and advancing technological progress. (Domazet et al., 2022)

It is also an essential method for boosting a nation's power and improving the quality of life for its people. Recently, the fast-paced global adoption of advanced technology and the production capacity for such innovation have boosted its exports significantly. Developing nations' potential to match developed countries' standards hinges on the magnitude of their high-tech exports. Hence, it is crucial for these developing nations to swiftly concentrate on enhancing the quality of education and research and development initiatives as this will enable them to manufacture and export high-tech goods. (Kabaklarli et. al, 2018) Moreover, the economic well-being of a country relies on its capacity to leverage high technologies and intellectual property, as well as the ability to derive benefits from their use. (Buchinskaya & Dyatel, 2019)

Therefore, a country's economic growth is a highly complex process influenced by various variables, including capital accumulation (Medina-Smith, 2000), political and social issues, technological development, natural and human resource availability, and export. (Schrott, 2014) Among these, technological development is seen as the most significant today. According to the previous study by Bonsay et al. (2021), technological development is one of the causes that spur economic growth on a greater level, expanding a country's capacity to produce commodities of size, quantity, and quality well beyond what individuals are capable of. Equally, the emergence of new technologies affects a country's ability to export its high-tech industry. (Teknoloji et al., 2020) Furthermore, the increased prevalence of globalization has heightened the interconnectedness among economies. The emergence of the fourth industrial revolution and the growing importance of human capital, particularly its learning capacity, have also significantly influenced economic progress. (Schilirò, 2019)

Globalization and technological change also affect the structure of international trade among the countries. Developed nations with substantial capital, technological expertise, and skilled labor have excelled in high-tech industries. In contrast, developing economies leverage their comparative advantage of abundant and cost-effective labor, focusing on labor-intensive sectors. (Demir, 2018)

Thus, as economies grow, specific sectors undergo transformations driven by technological advancements through the development of human capital and the influx of foreign direct investment. High-tech industries demand substantial financial investments, which are closely linked to FDI. (Ekananda & Parlinggoman, 2017) Likewise, R&D expenditures are one of the most essential variables under consideration in order to achieve innovative development. (Sozen, 2019) Theoretical and empirical studies suggest that an increase in a country's R&D ability is associated with a corresponding increase in its exports. The discussions highlight that the only businesses that can survive overseas competition

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are those with the highest levels of competitiveness. Thus, companies that use the newest technology to create distinctive and differentiating products rank highest among domestic innovators. (Topcu, 2018)

This research aims to explore the correlation between high-tech industry and economic growth, including the factors that could affect this connection. Specifically, the study seeks to assess how Foreign Direct Investment (FDI), human capital, and Research and Development (R&D) influence High-tech exports (HTX) and subsequently impact economic growth.

The present study focuses on the ASEAN 5 countries, the largest and fastest-growing economies in the Southeast Asian region. The ASEAN 5 countries, Indonesia, Philippines, Thailand, Malaysia, and Singapore were selected due to their significant contributions to the region's economic growth and development. Collectively, these countries represent 90% of the Southeast Asian region's total Gross Domestic Product (GDP) and population, making them critical players in regional economic integration and development.

Through a comprehensive analysis of the literature, this research seeks to provide a clearer understanding of the potential benefits and challenges associated with promoting high-tech industries in different economic contexts. By investigating the extent to which FDI, human capital, and R&D impact the development and diffusion of technology, the study aims to provide valuable insights to policymakers and business leaders on how to harness emerging technologies for the betterment of society.

2. Literature Review

A. Human Capital on High-Tech Exports

Human beings, in the context of development, are considered to be the most significant assets of a nation. (Gökmen & Turen, 2013) The development of new technologies is significantly influenced by the quality of human capital, as the absence of highly skilled professionals can hinder economic advancement. Increased human capital fosters entrepreneurship in the nation, which is expected to improve activity in high-tech industries. (Drapkin et al., 2021)

The pioneering studies of Becker (1964, 2002) define human capital in the holistic approach as it comprises individuals' knowledge, information, skills, and health. It also describes the role of human capital in the sense that it is the most significant fuel for sustaining economic growth, concluding that it stimulates technological innovations and the high-tech sector. Moreover, it implied that the economic successes of individuals could be attained through a lifelong investment of a person in themselves. Investing in education is widely recognized as a crucial aspect of human capital development. (Benos & Zotou, 2014). Some examples of investment include on-the-job training, schooling, medical care, and acquiring knowledge of the economic system.

As described in the original model of Nelson and Phelps (1966), education is a significant factor in accumulating human capital. Effective production management requires adapting to change in an evolving economy, which implies that educated individuals are more likely to be effective innovators and agents of change in a technologically dynamic economy. Furthermore, the benefits of higher technological achievement increase as the economy becomes more technologically advanced. This hypothesis opposes the neoclassical view put forth by Solow (1956, 1957), where technological progress is viewed as a product of exogenous factors and neglects endogenous processes such as human capital, which is seen as solely a factor of production. (Akhvlediani & Cieślik, 2019) In the neoclassical model, Solow describes capital stock as a central factor in economic growth in which it must expand at the same rate as the labor force to maintain a constant capital-to-labor output in the long run growth of an economy. Furthermore, it views changes in technology as independent of economic agents.

Mincer's (1958) seminal study on human capital highlights the importance of education in contributing to an individual's ability to earn income. Educational policies aimed at improving the quality of education can have a significant impact on human capital accumulation. Similarly, Watchekon et al. (2015) emphasized the positive outcomes associated with education, including higher living standards, and increased political participation, which are positive externalities that contribute to economic development. The widely recognized role of knowledge in the formation of human capital and the subsequent benefits for economic development underscores the need for policy interventions that improve access to education and its quality.

A recent study by Zapata et al. (2023) examined the factors influencing high-tech exports within a panel of 35 countries belonging to the Organization of Economic Cooperation and Development (OECD), employing panel data analysis. Results revealed substantial evidence that human capital, measured by the percentage of university students in the population, has a positive and statistically significant effect on total high-tech exports. The findings suggest that implementing policies to enhance and promote higher education can lead to several economic benefits. Specifically, these policies can increase the number of exports that possess advanced technology and a greater degree of specialization in manufacturing sectors that produce high-tech goods.

Moreover, Akhvlediani and Cieślik (2019) examined the impact of human capital on the growth of total factor productivity in European countries, revealing that human capital, as an enabler of technological advancement, has a statistically significant effect on technological progress. Likewise, in the paper of Asif and Lahiri (2019), measuring human capital in both qualitative and quantitative measures such as educational attainment, literacy rates, cognitive skills, and health status, discovered that the most impactful method is the learning-by-doing mechanism, which implies that individuals learn how to produce more goods efficiently and effectively by increasing their engagement in productive activities.

The study by Manuelli and Seshadri (2014) highlights the crucial role of human capital in economic development and indicates that the quality of human capital varies considerably across different countries. The study's results suggest that the effective human capital per worker varies significantly, which can have significant implications for a country's economic growth and overall welfare.

In a similar study, Ogundari and Awokuse (2018) utilized the Solow neoclassical model to investigate the link between human capital and economic growth in sub-Saharan African (SSA) countries. Three education metrics were employed: primary and secondary school enrollment, average years of adult schooling, and government expenditure on education. Results indicated that primary and secondary school enrollment and average years of schooling had a positive and statistically significant impact on economic growth in SSA. However, tertiary school enrollment and government expenditure on education showed no statistically significant effect. Based on the literature reviewed, the following hypothesis is proposed:

H_1: An improvement in human capital leads to an increase in high-tech exports

B. Foreign Direct Investment on High-Tech Exports

Several studies have concluded that FDI is one of the factors driving developing nations' economic growth and development. The benefits of FDI include increased employment, technology spillovers, transfer of managerial practices, and improved integration with international markets, which ultimately contribute to economic growth and development. (Parcon-Santos, 2021) Given the substantial role of multinational firms in technology transfer and trade, FDI may also enable economies to achieve competitiveness in industries that entail complex processes with high learning and skill demands. (Kizilkayavd et al., 2017) Hence, high-tech investments and direct exports to the country must be focused on high-tech sectors.

One of the earliest studies in analyzing the drivers of high-tech exports is the research conducted by Seyoum (2004). The study used multiple regression analysis to ascertain the implications of the indicated factor variables, including FDI, on high-tech exports in 60 sample countries, including the ASEAN 5. According to the study, countries must provide favorable factors and conditions to attract high-technology investment and exports. The results provided compelling evidence that some factor variables, such as foreign direct investment, significantly impact high-tech exports.

Seyoum's research served as a reference for preceding research analyzing the variables impacting high-tech exports, and it all remains consistent with the conclusion that there is a direct association between FDI and high-tech exports. Pooled Mean Group Cointegration Analysis was conducted in a related study by Duran et al. (2017) to examine the factors influencing high-technology exports in selected OECD countries. The study found that while the GDP growth rate has not been associated with a rise in high-tech exports, patent applications and foreign direct investments considerably boost the high-tech exports of selected OECD nations. Further, they discovered that FDI generates knowledge and technological spillovers to local businesses operating in the same industry. Several studies have demonstrated the benefits of FDI in increasing host countries' high-tech exports.

Likewise, Gokmen and Turen (2013) assessed the relationship between inward FDI, Human Development Level (HDL), and the Economic Freedom Level (EFL) on the innovation capacity of the EU-15 Countries. The study used the Index of Economic Freedom (IEF) to measure EFL, while the Human Development Index (HDI) for HDL. Using a cointegration analysis, the researchers have determined that FDI, HDI, and IEF significantly and favorably impact high-tech exports. The Panel Granger's causality test was also used to establish the long-term causality relationships between variables. Nonetheless, the conclusion showed that FDI, HDI, and IEF all had substantial long-term causal effects on high-tech exports.

Furthermore, a study by Mahmoodi and Mahmoodi (2016) used panel-VECM causality to determine the causative relationship between FDI, exports, and economic growth for two panels of emerging nations (eight Asian and seven European). The findings showed that, in the short term, for the developing countries of Europe, there is a unidirectional causal relationship between GDP and FDI and a bidirectional causal relationship between GDP and exports. On the other hand, short-run causality data in developing Asian nations suggested an inverse relationship between exports and economic growth.

On the other hand, Tebaldi (2011) utilized fixed effect estimates to investigate the factors affecting high-tech exports. Tebaldi (2011) claimed that the key determinants influencing a country's high-tech industry success in the global market include human capital, foreign direct investment inflows, and openness to international trade. The analysis also shows that macroeconomic volatility, savings, and gross capital formation have no significant impact on exports of high-technology products.

Despite that, the effect of inward FDI on high-tech exports may vary depending on the country's FDI type, human capital level, location, trade rules, economic and social problems, and technological advancement. (Bayar et al., 2020) Despite the triangle link between FDI, exports, and growth, FDI affects growth directly and indirectly through exports. (Hsiao & Hsiao, 2006) By restricting them to traditional production, other sorts of FDI inflows may negatively affect the country's technological advancement. (Bayar et al., 2020)

Research conducted by Gunes et al. (2020) delves into the primary determinants of high-technology exports using an extensive panel dataset and a diverse set of economic, political, and institutional variables across 48 countries. The findings indicate that trade openness, FDI inflows, per capita income, and schooling significantly influence the high-technology export performance of the countries under study. However, FDI inflows emerge as statistically significant but exhibit a slightly negative impact on high-technology export performance. The research also highlights a predominant focus of FDI on the service sector over the manufacturing sector, contributing to the observed lower FDI inflows in manufacturing compared to the service sector.

Eryigit (2012) also argued that uncertainty encompasses the relationship between exports, GDP, and FDI and that some studies focusing on the long-term relationship between FDI, export volume, and GDP revealed inconsistent findings. While there are several advantages associated with FDI, it is emphasized that there is also a source of negative aspects (Bayar & Gavriletea, 2018). For instance, negative effects were found in some similar studies (Bayar et al., 2020; Suyanto et al.,2011; Yew et al., 2011), concentrating on the long-term link between FDI and HTX. The causality between FDI, exports, and GDP has been the subject of numerous theoretical and empirical studies; however, most of these studies mainly concentrate on developed countries and do not offer any consistent implications about these connections, which means that further research and writing are required on the relationship between FDI and high-tech exports in developing nations. Thus, based on the existing literature above, a hypothesis was suggested:

H_2: An increase in FDI raises high-tech exports.

C. R&D Expenditure on High-Tech Exports

Robert Solow's groundbreaking work in 1956 emphasized the crucial role of research and development (R&D) in driving innovation, technological progress, and economic growth. This has motivated extensive theoretical and empirical studies on the economic effects of R&D expenditure, focusing on its impact on high-tech exports.

In support of that, Sozen and Tufaner (2019) also claimed that R&D expenditure is also considered a key variable in achieving innovative development, as it often leads to an increase in the number of patents filed in a country which, in turn, contributes to the shift of a country's exports from low-tech to high-tech products. (Ozkan, 2017) As stated on the World Bank website, high-tech exports are defined as products that have undergone extensive R&D. Thus, according to Sandu and Ciocanel (2014), R&D and innovation intensity are often used as predictors for high-tech exporting, as they are believed to stimulate firm production of high-tech goods, enhance a nation's intellectual capital, increase patent applications, and promote innovation in businesses. From this, we can say that R&D expenditures and high-tech exports are two closely related concepts that play a significant role in a country's innovation and economic development.

Numerous studies have examined the relationship between R&D expenditure and high-tech exports, and all have concluded that both have positive relationships with each other. For instance, Topcu (2018) utilized Panel Ordinary Least Squares (OLS), Fixed Effects (FE), and Random Effects (RE) Models to examine the impact of R&D expenditure on high-tech exports for the 24 OECD nations between 1996 and 2015. As per the findings derived from the Fixed Effects Model, which is considered the most suitable for the dataset, a significant and positive correlation has been identified between R&D expenditures and high-tech exports in the OECD nations under examination. In addition, a study by Gurler (2021) also used OLS regression to analyze cross-section data for 48 OECD countries and a few developing countries, including the BRICS (Brazil, Russia, India, and China). The study demonstrated that R&D expenditures, patents, and FDI strongly affect high-tech exports.

Similarly, still using a fixed effect model, the causal link between R&D expenditure and high-tech exports in EU nations has been confirmed by Sandu and Ciocanel (2014), which showed a positive association between R&D expenditure and high-tech exports. The study also highlighted that private R&D expenditure has a more significant impact on high-tech exports than public R&D expenditure. Correspondingly, Moiseeva and Mazol (2013) examined the relationship between the share of public and private R&D expenditure on high-tech exports for 20 nations between 2000 and 2005 and found that a higher share of private sector spending on R&D was associated with more significant high-tech exports. This implies that governments should focus on increasing private sector spending on R&D to implement a "high-tech policy" effectively.

On the other hand, Bayar et al. (2020), Gocer (2013), and Kılıc et al. (2014) used panel data analysis in their studies. Bayar et al. (2020) investigate the impact of intellectual property rights, R&D expenditures, and FDI inflows on the high-tech exports of EU transition economies from 2000 to 2016. The findings indicated that FDI has a long-term negative effect on high-tech exports, while intellectual property rights and R&D spending have positive effects. Gocer (2013) explored the relationship between R&D spending, overall export, information communication technology export, high technology export, and economic development in 11 emerging Asian nations between 1996 and 2012 and found that a 1%-point increase in R&D spending led to a significant increase in high-tech exports, compared to other variables. Kılıc et al. (2014) also found a positive association between R&D expenditure and high-tech exports and a two-way causal relationship between the two variables in their study of G-8 countries from 1996 to 2011. In conclusion of the reviewed studies, the following hypothesis was created:

H_3: An increase in R&D expenditure leads to a greater level of high-tech exports.

D. High-Technology Exports on Economic Growth

The model from Romer (1990) states that technological change lies at the heart of economic growth. As new technologies are developed, this incentivizes firms and businesses to invest in new capital equipment, resulting in more capital accumulation and increased productivity. This cycle of technological development and capital investment is what drives economic growth.

Similarly, in his seminal 1983 article, Feder proposed a theoretical model highlighting the positive relationship between high-tech exports and economic growth. Feder's model posits that countries specializing in high-tech exports are likely to experience higher economic growth rates than countries that do not. Feder's model is built upon the premise that high-tech exports can act as a catalyst for technological progress and innovation, leading to increased productivity and the creation of new industries. By focusing on high-tech exports, countries can generate more significant revenue and investment in research and development, which can help create new technologies and industries, thereby contributing to economic growth. Furthermore, Feder's model emphasizes the importance of human capital and access to capital for countries to benefit from high-tech exports. Countries with robust education systems and greater access to capital are more likely to benefit from high-tech exports, which can further drive innovation and economic growth.

A four-way classification developed by The Organization for Economic Cooperation and Development (OECD) categorizes exports into high, medium-high, medium-low, and low-technology. The classification of exports is determined by analyzing the significance of research and development expenses relative to the total output and value added of various industries that manufacture goods for export purposes. This analysis determines the level of technological intensity of the exported products. Industries such as aircraft, computers, and pharmaceuticals are considered high-tech industries. Moreover, the World Bank defines high technology as products with high R&D intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

According to Domazet et. al (2021), the global market gives greater importance to the competitiveness of high-technology products (HTP) than those of medium or low quality. Enhancing innovation performance should result in greater utilization of high technology in manufacturing processes, consequently boosting the export of high-tech products, which is crucial in enhancing overall competitiveness.

For example, Ekananda and Parlinggoman (2017) conducted a study using Feder's (1983) model to investigate the impact of high-tech exports and FDI on the economic growth of 50 countries. The study employed panel data regression analysis and found that high-tech exports, productivity, and FDI significantly affect GDP growth in countries with large or small portions of high-tech exports. Moreover, non-high-tech exports were also found to impact economic growth positively through externalities.

The results from the study of Ekananda and Parlinggoman (2017) suggest that while high-tech exports may be a significant driver of economic growth, as Feder's model suggests, non-high-tech exports can still positively impact economic growth. In addition, it also highlights the importance of considering externalities, such as knowledge spillovers and network effects, in analyzing the relationship between exports and economic growth.

Contrary to the results of Ekananda and Parlinggoman (2017), a recent study by Bonsay et al. (2021) investigated the relationship between Artificial intelligence using High-tech exports as a proxy variable to determine its impact on labor productivity and economic growth in China, India, Japan, and Singapore revealed that, except for Japan, high-tech exports were not found to have a significant impact on the gross domestic product of these countries. However, in the case of Japan, the study found that high-tech exports, along with the unemployment rate and inflation, had a significant effect on the country's economic growth. These results show that the relationship between high-tech exports and economic growth is complex and context-specific and that other factors may play a role in determining the impact of high-tech exports on a country's economy. Adding to this, Khanh Doanh Nguyen et al. (2022) revealed that maximizing the untapped potential of high-tech exports in ASEAN countries will depend on the supply competencies and the bilateral linkages between countries: Trade liberalization and the free flow of trade.

Following the results of Bonsay et al. (2021), considering other factors affecting economic growth, Usman (2017) assessed the effect of high-tech exports on the economic growth of Pakistan using the Ordinary-Least Squares (OLS) method with robust standard error. The study discovered that despite Pakistan's primary focus on the agricultural sector, high-tech exports positively and significantly affect the nation's economic development. However, the study also reveals that agricultural productivity per worker has a more significant impact on GDP than high-tech exports, suggesting that investing in the agricultural sector remains crucial for overall economic development in Pakistan. This implies the importance of developing the high-tech export industry while simultaneously focusing on increasing agricultural productivity to promote sustainable economic growth in the country.

Moreover, it was revealed by Domazet et al. (2022) that exporting high-tech products and developing the high-tech industry can bring better competitiveness and support a nation's balance of payments.

Correspondingly, based on the findings of a recent study by Sahin (2019), utilizing the Granger Causality analysis, variance decomposition, and impulse-response analysis to examine the impact of HTX on economic growth in Turkey from 1989 to 2017 revealed the significance of HTX on sustainable economic growth. As a result of the analysis, it has been concluded that there is a causal relationship between the examined variables.

Additionally, a study done by Domazet et al. (2022) aimed to examine the impact of high-tech product exports on the economic growth of Serbia, Bulgaria, Romania, and Hungary revealed that in the case of Bulgaria, it was confirmed that there is a positive impact of high-tech exports on GDP growth as a result of innovation in the country. Given the literature above, a hypothesis has been proposed as follows:

H_4: An increase in high-tech exports leads to increased economic growth.

E. Synthesis

This research aims to analyze the connection between HTX and GDP, as well as the variables that may affect HTX, namely FDI, R&D expenditure, and human capital. Several academic publications have shown empirical evidence for Romer's endogenous growth model. Empirical evidence suggests that human capital and R&D investments positively correlate with economic growth. Romer's model has also been used to explain variations in economic growth rates between countries, emphasizing the significance of innovation and knowledge creation in boosting economic performance. Thus, the three factors (FDI, R&D, and human capital) should positively affect HTX as they are critical drivers for economic growth.

F. Theoretical Framework

This section presents the authors' fundamental theory to analyze the relationship between foreign direct investment, research and development, human capital on high-tech exports, and its subsequent effect on economic growth.

Based on the endogenous growth model by Romer (1990, 1994), technological change is driven by profit-maximizing economic agents. Market incentives play an essential role in the diffusion of technology as the accumulation of knowledge drives long-run economic growth, and ideas, as a non-rival good, stimulate growth in the market.

Romer's (1990) neoclassical model presents technological change as endogenous, which includes inputs to economic production such as capital, labor, human capital, and technological progress. In particular, human capital is a distinct measure of the cumulative effect of activities capturing the changes in workers' skill level and experience resulting from factors such as education and work experience. Technological progress is represented by an index that measures the level of technology in the economy. (Schilirò, 2019)

The endogenous growth model provides a framework that predicts continuous investment in research and development to drive long-term economic growth. As an example, the study conducted by Apostol et al. (2022) utilized the endogenous growth model developed by Romer to investigate the relationship between innovation and economic growth and found that R&D activities have no significance on GDP per capita. The inconsistent results may be explained by the fact that the examined countries are developing countries, and it would take some time for R&D to influence development in this context.

G. Simulacrum

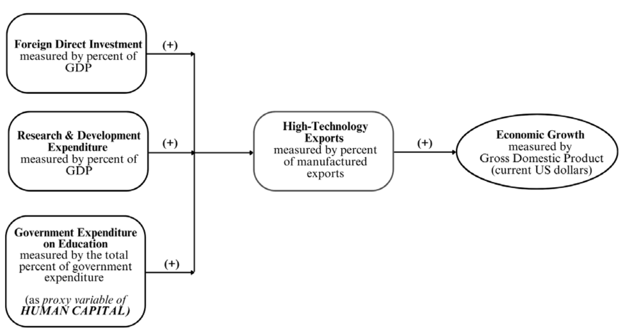

Fig. 1. Conceptual framework

To determine the relationship between FDI, R&D, and human capital on HTX to economic growth, the framework of this study was designed based on the study by Bonsay et al. (2021). FDI, R&D expenditure, and human capital are expected to have an effect on high-tech exports. On the other hand, HTX is also expected to influence economic growth, which is measured by the countries' GDP.

3. Methodology

A. Research Methods

This paper looked at how high-tech exports affected the economies of the ASEAN 5 members, namely Indonesia, Philippines, Thailand, Malaysia, and Singapore. These countries were chosen because they were regarded as the more developed ASEAN members, with larger populations, higher GDPs, and more technologically advanced buildings and innovations than the other ASEAN members. They were also a key player in the world economy as they increased living standards significantly, partly because of the significant benefits of their integration into the global economy, primarily through trade. (Baek, 2023) The authors also analyzed how FDI, R&D, and human capital affected the economies and some sectors (such as the export industry) in the corresponding nations and had knowledge of the potential economic consequences for each of them.

Furthermore, the authors utilized electronic data sources from statistical websites or databases. Most data for GDP, HTX, FDI, and the proxy variable for human capital—government spending on education (GOVEXP)—were sourced from the World Bank's Databank website. On the other hand, the Euromonitor, UNESCO Institute for Statistics (UIS), and World Bank's websites were utilized to complete the statistics for R&D expenditure. The period of the study covers the year 2000 up until 2022, with a specific focus on the ASEAN 5 countries.

B. Mode of Analysis

The researchers employed panel data to estimate the variables, a method extensively employed in accounting and finance research, as emphasized by Gujarati (2003). This approach is widely accepted for its versatility, with pooled panel data being particularly favored. This method proves advantageous as it provides comprehensive insights, surpassing the more limited perspectives offered by either cross-sectional or time series data structures.

This research study conducted a two-stage regression analysis to estimate the relationship between an independent variable and an intermediate variable to the dependent variable of interest. The intermediate variable acts as a mediator or confounding variable hypothesized to explain or modify the relationship between the independent and dependent variable. The researchers used FDI, R&D expenditure, and human capital as the independent variables, high-tech exports as a mediator, and GDP as the dependent variable.

Furthermore, the study utilized a quantitative research method applying descriptive and inferential statistics to achieve the research objectives. Descriptive statistics were used to describe and explain the behavior and basic characteristics of

Table 1
Dataset summary

Variables	Measurement	Source	Symbol
Economic growth	GDP (current USD)	World Bank Databank	GDP
High-technology exports	(% of manufactured exports)	World Bank Databank	HTX
Foreign Direct Investment	(inflows, % of GDP)	World Bank Databank	FDI
Research & Development Expenditure	(% of GDP)	Euromonitor, UNESCO-UIS, World Bank Databank	R&D
Human Capital	Government expenditure on education (% of government expenditure)	World Bank Databank	GOVEXP

the determinants, while inferential statistics was used to measure the relationship between the explanatory and dependent variables and draw conclusions. (May, 2017; Guetterman, 2019)

Thus, the econometric model of this paper is presented as follows:

$$HTX_{it} = \beta_0 + \beta_1 FDI + \beta_2 GOVEXP + \beta_3 R\&D + \varepsilon_1 \quad (1)$$
$$GDP_{it} = \alpha_0 + \alpha_1 HTX + \varepsilon_2 \quad (2)$$

Whereas:
i = ASEAN 5 country
t = time period

In *Equation 1,* our dependent variable is represented by HTX, while FDI, GOVEXP, and R&D are our independent variables. This step assessed the direct relationships between the aforementioned variables. HTX represents high-tech exports measured by the percentage of manufactured exports. FDI represents foreign direct investment, measured by foreign direct investment as a percentage of GDP. GOVEXP represents the government expenditure on education as a proxy variable for human capital measured by the percentage of government expenditures. R&D represents research and development, measured by R&D expenditures as a percentage of GDP. In *Equation 2*, GDP is the dependent variable, while HTX is our independent variable. GDP represents economic growth measured by GDP in the current USD. This allowed for evaluating the combined effect of High-tech Exports, FDI, R&D, and Human Capital on GDP while controlling for their interrelationships.

Additionally, in *Equation 1*, β_0 refers to the intercept or the value of HTX when FDI, GOVEXP and R&D are equal to zero. β_1, β_2, and β_3 are the coefficients that indicate the impact of each corresponding variable on high-tech exports. ε_1 signifies the error term that captures any other factors that are omitted in the model that affect our output. On the other hand, in *Equation. 2*, α_0 refers to the intercept or the value of GDP when HTX is equal to zero, and $\boldsymbol{\alpha_1}$ is the slope that indicates the impact of high-tech exports on economic growth. $\boldsymbol{\varepsilon_2}$ signifies the error term that captures any other factors omitted in the model that affect our output.

Furthermore, the selection between random or fixed effects models involved critical consideration. A fundamental assumption in random effects estimation is the independence of random effects from the explanatory variables. To assess this assumption, the Hausman (1978) test was conducted to compare the coefficients estimated by fixed and random effects models. The test results, found to be statistically significant at our predetermined level of significance, suggest that the fixed effect model is more appropriate and, therefore, has been the final model in our analysis.

1) Fixed Effect Model

A Fixed Effects Model (FEM) comprises independent variables with fixed or constant values, while the dependent variable changes in response to variations in these fixed levels of independent variables. In Tebaldi's (2011) study, a Fixed Effect Model is employed to investigate the determinants of high-tech exports through panel data analysis. The utilization of fixed effects focuses on addressing significant trade-related determinants that remain constant over time, including factors like the landlocked effect and the distance among trade partners. This strategic choice contributes to the production of robust coefficient estimates in the analysis.

Similarly, in this study, FEM is also utilized in order to address individual effects and in the presence of correlated explanatory variables. Moreover, the study employs the Diagonal (cross-section cluster) method, which assumes that errors within a cross-section exhibit both heteroskedasticity and serial correlation. This estimator is specifically designed to handle diverse forms of heteroskedasticity and serial correlation within individual cross-sections.

4. Results and Discussions

The results of the statistical tests, encompassing regression analyses and descriptive statistics along with their interpretations, are detailed and discussed in the subsequent sections.

A. Descriptive statistics

1) Philippines

Table 2 shows that out of the ASEAN 5 countries, the Philippines has the lowest mean GDP at $320 billion, representing low economic production for 2000–2022. Furthermore, the range of GDP spans from a minimum of $79 billion to a maximum of $404 billion, suggesting low variability in economic performance. The standard deviation of $113 billion implies low fluctuation or volatility in the Philippines' economic performance over the years. During the same period, high-tech exports, on average, constituted 59.84% of manufactured exports. The maximum value recorded for high-tech exports was 74.18%, and a standard deviation of 15.80%. Meanwhile, FDI averaged 1.71%, with a standard deviation of 0.79% of GDP. For R&D expenditure, the low mean at 0.16% of GDP and a low standard deviation of 0.10% implies low variability in R&D expenditure. Lastly, the average government expenditure on education stood at 15.53%, while the standard deviation of 1.97%, which is the lowest, suggests moderate government spending on education.

The low mean GDP indicates the Philippines' relatively small average economic size among the ASEAN 5. Moreover, the Philippines' mean high-tech exports demonstrate a certain level of technological competitiveness despite the country's primary focus on industry, services, and agriculture. It may also be essential to investigate ways or policies to improve the attractiveness of foreign investment and technical innovation in the face of low mean FDI and mean R&D expenditure. Lastly, the government's modest but steady spending on education shows a moderate but stable commitment to supporting national educational programs that can enhance the Philippines' educational outcomes and foster the long-term development of human capital.

2) Indonesia

From the data shown in Table 2, it is evident that throughout

Table 2
Cross-sectional descriptive statistics for individual ASEAN 5 countries

Variables	Mean	Maximum	Minimum	Std. Dev
PH_GDP	230,470,715,497	404,284,327,312	78,921,234,458	113,335,376,477
PH_HTX	59.8375	74.1785	0.0000	15.7952
PH_FDI	1.7068	3.1224	0.5137	0.7939
PH_RD	0.1610	0.4000	0.0000	0.1023
PH_GOVEXP	15.5344	19.8319	12.4224	1.9693
IND_GDP	697,776,384,138	1,319,100,220,389	160,446,947,785	372,468,942,847
IND_HTX	10.2354	16.6700	0.0000	4.2994
IND_FDI	1.3323	2.9161	-2.7574	1.4162
IND_RD	0.1288	0.3000	0.0000	0.1051
IND_GOVEXP	13.8443	21.2198	0.0000	6.8577
MYS_GDP	249,838,407,108	406,305,924,656	92,783,947,368	102,981,862,329
MYS_HTX	47.9634	59.5693	0.0000	12.0730
MYS_FDI	3.2144	5.0745	0.0567	1.3070
MYS_RD	0.9062	1.4152	0.4690	0.2739
MYS_GOVEXP	18.8032	25.9036	0.0000	5.0175
THA_GDP	335,371,721,436	543,976,695,639	120,296,476,180	140,113,456,207
THA_HTX	23.1645	33.3591	0.0000	8.2174
THA_FDI	2.5583	4.3396	-0.9886	1.3439
THA_RD	0.5464	1.3303	0.2008	0.3946
THA_GOVEXP	19.3448	28.3886	14.6416	3.2355
SGP_GDP	249,387,675,301	466,788,539,652	89,793,815,728	116,436,416,368
SGP_HTX	52.7000	98.7291	0.0000	22.6556
SGP_FDI	20.7403	32.6912	6.6537	6.6822
SGP_FDI	2.0394	2.5967	1.8000	0.1822
SGP_GOVEXP	21.6707	31.3717	11.9120	5.0094

the period, Indonesia has consistently exhibited the highest average GDP ($697.78 billion) as well as having the most comprehensive range value from $160 billion to $1.32 trillion, and the highest standard deviation for GDP at $372 billion which implies a significant dispersion in the economic output of the country among the ASEAN 5 countries. On the other hand, the mean value of high-tech exports is the lowest at 10.23% of the manufactured exports, with a range of up to 16.67% and a low standard deviation of 4.29%. Furthermore, the value for the mean of FDI is 1.33%, ranging up to 2.92% of GDP, with a relatively high standard deviation of 1.42%. Meanwhile, the R&D expenditure average was lowest among the five countries at 0.129%, reaching a maximum of 0.3% of the GDP and exhibiting a low standard deviation of 0.1051%. Finally, Indonesia's average government expenditure on education was also the lowest at 13.84%, with a high standard deviation of 6.86%, indicating significant fluctuation in government spending on education.

Its high GDP statistics reflect Indonesia's vast and varied economic landscape. Regarding high-tech exports, Indonesia has the lowest mean, suggesting improved technological competitiveness. Likewise, Indonesia, with the lowest mean FDI, still attracts a moderate level of FDI, with some variability; however, there is still room for targeted policies to enhance FDI inflows. As with the Philippines, the R&D spending patterns in Indonesia are modest but with more fluctuations. Meanwhile, Indonesia's government's average spending on education is relatively small but has a significant variability in the actual spending level over the period.

3) Malaysia

Over the past 23 years, Malaysia has maintained a relatively low average GDP of $249.84 billion, a maximum of $406.31 billion, and a low standard deviation of $102.98 billion. Additionally, the average proportion of high-tech exports to manufactured exports in Malaysia is 47.96%, with a standard deviation of 12.07%. The mean value for FDI is high at 3.21%, ranging up to 5.07% of the GDP, with a standard deviation of 1.31%. Likewise, the mean value of R&D expenditure is high at 0.906%, reaching a maximum of 1.42% and exhibiting a high standard deviation of 0.2739% of GDP. Lastly, the mean for government expenditure on education is 18.80%, with a maximum of 25.90% and a standard deviation of 5.02%.

Malaysia sustains a reasonably sized and stable economy with a moderate mean GDP over the specified period. At the same time, it showcases a relatively high mean in high-tech exports, indicating viability in the technology-driven sector. Furthermore, Malaysia attracts a significantly higher amount of FDI on average than the Philippines, Indonesia, and Thailand and has a more substantial dispersion in FDI levels. Also, Malaysia has a higher mean in R&D expenditure, which suggests a relatively higher investment in R&D and innovation than the other three countries (Philippines, Indonesia, Thailand) which implies that Malaysia invests significantly in R&D, but there is significant variability in R&D investment levels. Moreover, the country demonstrates a substantial and consistent commitment to education, albeit with moderate variability in government spending.

4) Thailand

Thailand's descriptive analysis from 2000 to 2022 can be seen in Table 2. Thailand's GDP varies significantly in terms of economic activity as it goes from a high average of $335.37 billion to a high range of $120.296 billion to $543.98 billion to a high significant standard deviation of $140.11 billion. In contrast, the high-tech exports' mean, maximum, and standard deviation are 23.16%, 33.36%, and 8.22%, respectively. FDI as a percentage of GDP has a low mean value of 2.56%, a range of up to 4.34%, and a standard deviation of 1.34%. With a maximum amount spent of 1.33% and a high standard deviation of 0.3946% of GDP, the average R&D spending is 0.546%, which is relatively low among the other ASEAN 5's GDP. As

Table 3
Panel descriptive statistics for ASEAN 5 countries

Variable	Mean	Maximum	Minimum	Std. Dev
GDP	352,568,580,714	1,319,100,000,000	78,921,234,458	262,851,641,720
HTX	38.78017	98.72905	0.00000	23.47513
FDI	5.91044	32.69117	-2.75744	8.10567
R&D	0.75634	2.59674	0.00000	0.74272
GOVEXP	17.83949	31.37175	0.00000	5.42618

for government spending on education, the country exhibits a high mean of 19.34%, a wide range of up to 28.39%, and a relatively high standard deviation.

Thailand's high mean GDP indicates that the country has a significant economic scale. With a modest mean in high-tech exports, Thailand maintains a moderate level of technological competitiveness with the ASEAN 5 countries and exports a moderate number of high-tech products. Additionally, Thailand draws a moderate amount of FDI, demonstrating its stability and attractiveness to foreign investments. On average, it also possesses a lower R&D expenditure compared to Singapore and Malaysia but has more FDI variability than Indonesia and the Philippines. Furthermore, results showed that, on average, Thailand has high spending on education, the same as Malaysia, which suggests that both countries are focusing on developing their human capital, which will result in a more skilled and adaptive workforce.

5) Singapore

As shown in Table 2, on average, the GDP of Singapore is $249.39 billion, reaching a maximum of $466.79 billion and displaying a standard deviation of $116.44 billion. It has the second-highest mean of 52.70% for high-tech exports, next to the Philippines, with a maximum of 98.73% and a high standard deviation of 22.66% for manufactured exports. The country also exhibits the highest average FDI at 20.74%, ranging from 6.65% to 32.6%, and a high standard deviation of 6.68%. In addition, the R&D expenditure has a mean of 2.04%, the highest among the ASEAN 5 countries, reaching a maximum of 2.60% and exhibiting a standard deviation of 0.1822%. Finally, with a maximum amount of 31.37% and a standard deviation of 5.01%, the average government spending on education is 21.67%.

Singapore and the Philippines exhibit a relatively lower average GDP, which suggests that the two countries have a lower average economic output than Indonesia, Thailand, and Malaysia. Moreover, even though the Philippines has the highest value in high-tech exports, Singapore still leads the ASEAN 5 countries since the country has strategically positioned itself as a hub for high-tech industries, unlike the Philippines, which has a greater emphasis on sectors such as services, manufacturing, and agriculture. In addition, Singapore had the best results among the nations regarding FDI, R&D expenditure, and government spending on education. These statistics paint a comprehensive image of a country that is economically successful and well-positioned for long-term progress. Furthermore, Singapore is a model for effectively combining economic policies that support innovation, draw in foreign capital, and prioritize human capital development.

6) Panel Data

The findings of the descriptive analysis of the panel data from the ASEAN five countries are shown in Table 3. The table serves as a reference point for assessing and examining a comparative perspective on the combined performance of the ASEAN 5 nations.

From 2000 to 2022, the average GDP for the ASEAN 5 region was about $352.57 billion. This represents the average economic output that captures the total worth of goods and services produced by these countries and reflects the general economic health of the region. Moreover, the $262.85 billion regional variability highlights the disparities in these countries' economic sizes and growth paths.

As a proportion of total manufactured exports, high-tech exports (HTX) averaged 38.78%, which indicates the region's dispersed dependence on technology-intensive industries. The standard deviation of 23.48% displays the significant variability in high-tech export trends throughout the region.

Likewise, the regional average of FDI at 5.91% indicates the average annual growth or decline in FDI across the ASEAN 5. Comparably, the 8.11% standard deviation highlights the various FDI levels and the distinctive investment patterns and economic resiliency across the member countries.

As perceived on the ASEAN 5 countries' average R&D spending of 0.76%, countries are dedicated to innovation and technical advancement. The heterogeneity in R&D expenditure is highlighted by the standard deviation of 0.74%, which reflects varying regional goals and approaches to promoting innovation.

Lastly, the 17.84% regional average of government expenditure on education (GOVEXP) represents the average level of commitment to developing human capital through educational investments. The government's varied approaches to funding education are also shown by the standard deviation of 5.43%, which reflects various policy priorities and socioeconomic factors.

In comparison with Table 2, the regional average for GDP ($352.57 billion) is more significant compared to the cross-sectional data for PH_GDP ($230 billion), MYS_GDP ($250 billion), THA_GDP ($335 billion), and SGP_GDP ($249 billion). However, IND_GDP had a higher mean GDP of $697.78 billion. Moreover, the regional average of HTX (38.78%) is lower than PH_HTX (59.84%), MYS_GDP (47.96%), and SGP_GDP (52.7%). Meanwhile, FDI's regional average (5.91%) is higher than the mean FDI of all ASEAN 5 countries except for SGP_FDI (20.74%). SGP_RD (2.04%) and MYS_RD (0.91%) exhibit a higher average expenditure in R&D, while PH_RD (0.16%) and THA_RD (0.55%) are relatively consistent with the regional average (0.76%). At the same time, MYS_GOVEXP (18.80%), THA_GOVEXP (19.34%), and SGP_GOVEXP (21.67%) show higher average government expenditure on education compared to the regional mean of 17.84% while the PH_GOVEXP (15.34%) and

IND_GOVEXP (13.84%) results are lower than the regional average.

B. Regression

The pooled effect model generates results incorporating all variations in the data, implying that the intercept and the slope remain constant across units and over time (Rahim et al., 2018). The findings in Table 4 revealed statistically insignificant results across the variables FDI, GOVEXP, and RD with p-values of 0.9816, 0.2052, and 0.1420, respectively. Employing the panel least squares method, the Durbin-Watson value is at 0.33823, indicating the presence of autocorrelation issues within the variables. Furthermore, the low R-squared value of 0.096020 suggests that the model lacks consideration of additional factors with a significant impact on our dependent variable. Consequently, corrective measures are imperative, which are reflected in Table 5, including incorporating a lagged dependent variable into our model to create a dynamic panel regression and utilizing either the Random or Fixed Effect model.

To evaluate the suitability of the models, the researchers employed the Breusch-Pagan Lagrange Multiplier (LM) test, a widely recognized diagnostic tool for detecting cross-section dependence. This checks whether the Random effects or Pooled OLS models are more appropriate. The test results show that the p-value is less than the critical value. Hence, the random effects model is utilized. *(see Appendix B)*

The analysis progresses by implementing the Hausman test to determine whether the more fitting model is the random or fixed effects model. A fundamental assumption in random effects estimation is that the random effects are not correlated with the explanatory variables. (Wooldridge, 2001) A commonly employed technique for testing this assumption involves using a Hausman test to compare the coefficient estimates between fixed and random effects models. If the p-value of the Hausman test is below 0.05, we can reject the null hypothesis. The rejection of the null hypothesis leads us to conclude that the fixed effects model is more suitable than the random effects model.

Conversely, if the null hypothesis cannot be rejected, the random effects model is deemed the more appropriate model. The test results indicate a p-value below our chosen level of significance, affirming the use of the fixed effects model. *(see Appendix A)*

The regression results using the Fixed Effects Model with Cross-section weights and White Cross-section method for our first stage are shown in Table 5. The addition of the lagged values of high-tech exports is to capture the dynamic aspect of the regression in addition to being a corrective measure to address potential autocorrelation, ensuring that the model appropriately accounts for any systematic patterns in the time series of the data.

The R-squared value of 0.886 displayed on Table 5, indicates that the included independent variables account for approximately 88.6% of the variability in the high-tech export, as explained by our model incorporating FDI, R&D expenditure, and human capital with government expenditure on education as a proxy variable. This suggests a strong explanatory power of the model in capturing the observed variations in high-tech exports among the entities in the study. The Durbin-Watson score of 1.824201 falls within the acceptable range of 1.5 to 2.5, indicating no significant autocorrelation in the residuals. This result supports the assumption of independence among residuals in stage 1, strengthening the reliability of the regression analysis in our study.

Table 4
Balanced panel regression for first stage

Variable	Coefficient	Std. Error	t-Statistic	Prob
GOVEXP	0.550556	0.432030	1.274347	0.2052
FDI	-0.010149	0.440080	-0.023061	0.9816
RD	7.7475667	5.055242	1.478795	0.1420
C	23.36434	7.331205	3.186971	0.0019
R-squared	0.096020		Mean dependent var	38.78.017
Adjusted R-squared	0.071588		S.D. dependent var	23.47513
S.E. of regression	22.61926		Akaike info criterion	9.109644
Sum squared resid	56791.02		Schwarz criterion	9.205120
Log likelihood	-519.8045		Hannan-Quinn criter.	9.148397
F-statistic	3.930106		Durbin-Watson stat	0.338323
Prob(F-statistic)	0.010424			

Table 5
Dynamic panel regression, using fixed effect model with GLS cross-section weights for first stage

Variable	Coefficient	Std. Error	t-Statistic	Prob
GOVEXP	0.161822	0.073911	2.189407	0.030870
FDI	-0.866384	0.321463	-2.695127	0.008243
RD	-6.954318	2.873773	-2.419926	0.017311
HTX(-1)	0.678763	0.105676	6.423041	0.000000
C	18.422421	7.045456	2.614795	0.010295
R-squared	0.885645		Mean dependent var	46.51538
Adjusted R-squared	0.876587		S.D. dependent var	17.31907
S.E. of regression	11.44804		Sum squared resid	13236.82
F-statistic	97.7766		Durbin-Watson stat	1.824201
Prob(F-statistic)	0.000000			

Human Capital, proxied by Government Expenditure on Education (as a percentage of total government expenditure), showed statistical significance in its association with High-tech exports, as indicated by a p-value of 0.030 below the 5% significance level. Furthermore, the coefficient of 0.161822 suggests that for every 1% increase in Government Expenditure on Education as a proportion of total government expenditure, there is a corresponding increase of 0.161822% in High-tech Exports. This aligns with the null hypothesis, which suggests that an improvement in human capital leads to an increase in high-tech exports, affirming that an enhancement in human capital leads to increased high-tech exports. Moreover, several studies (Nelson & Phelps, 1966; Becker, 1964, 2002; Akhvlediani & Cieślik, 2019) support the notion that human capital is an educational investment aligned with our chosen proxy variable, Government Expenditure on Education. This emphasizes the importance of lifelong learning in a person. However, investment in human capital can manifest in various forms, including formal schooling and access to acquiring knowledge of the economic system. (Benos and Zotou, 2014). Hence, policies and interventions fostering education accessibility and quality contribute significantly to human capital development and high-tech exports. This is evidenced by Zapata et al. (2023), who demonstrate the positive impact of higher education on high-tech exports. Akhvlediani and Cieślik (2019) further support this, revealing that human capital enables technological progress. In summary, our results reinforce the significance of human capital in driving the high-tech industry, supporting the need for educational policies and interventions to foster economic development.

Similarly, R&D expenditure produced statistically significant results in their association with high-tech exports, as evidenced by a p-value of 0.017311, below the 5% significance level. Furthermore, the coefficient of -6.954318 indicates a negative relationship, suggesting that for every 1% increase in R&D expenditures, there is an expected decrease of 6.954318% in high-tech exports. Thus, the research findings refute the null hypothesis, which holds that an increase in R&D expenditure leads to more significant high-tech exports. The extensive research body establishing a positive link between R&D spending and high-tech exports, as evidenced by studies like those led by Topcu (2018), Gurler (2021), Sandu and Ciocanel (2014), and Moiseeva & Mazol (2013), underscores the crucial role of innovation in propelling economic growth. These studies consistently affirm that heightened R&D expenditure correlates with an increase in high-tech exports, emphasizing the impact of innovation on the production of technologically advanced goods.

On the other hand, in the study by Yew et al. (2011), in the context of China's exports to ASEAN-5 countries, an inverse relationship is identified with Intellectual Property Rights (IPRs), consistent with the findings from the regression analysis. This suggests that the protective legal framework offered by IPRs, typically fostering innovation and technological progress, may not positively influence China's export performance to these nations. Despite the well-established association between R&D spending and high-tech exports globally, the specific link with IPRs in the context of China's exports to ASEAN-5 countries appears to diverge.

While the correlation between R&D spending and high-tech exports is firmly established globally, the observed negative link between China's exports to ASEAN-5 countries and Intellectual Property Rights indicates a nuanced dynamic that needs further exploration. Within the extensive body of literature reviewed, only one study has reported a significant but negative relationship between R&D expenditure and high-tech exports. This singular instance of a negative correlation highlights the distinctive nature of the present findings and emphasizes the necessity for a careful reevaluation of the factors influencing this relationship. This suggests that no conclusive evidence supports the notion, underscoring the need for further studies to draw more definitive conclusions.

Furthermore, the p-value of 0.008243 for FDI falls below the 5% significance level, indicating that the relationship between FDI and high-tech exports is statistically significant. However, the coefficient of -0.866384 implies that for every one percent increase in FDI, there is an expected decrease of 0.866384% in high-tech exports. Hence, the findings contrast with the null hypothesis that states an increase in FDI raises high-tech exports. FDI decisions are influenced by various factors, including economic conditions, regulatory frameworks, and geopolitical stability, which may be a source of negative association with FDI and high-tech exports (Bayar & Gavriletea, 2018). This is consistent with the findings of Bayar (2020), in which FDI negatively affects high-tech exports in the long run because other types of FDI inflows may negatively affect the country's technological advancement.

Moreover, the relationship implies that, on balance, the presence of FDI may not be conducive to the growth or competitiveness of high-tech exports in these countries. This is evidenced by Gunes et al. (2020), which reveals that negative relationship analysis of FDI inflows in the countries reveals a predominant focus on the tertiary sector, encompassing finance, wholesale and retail trade, and business activities. Given that the measure used for high-tech exports is the percentage of manufactured exports, the focus of FDI is more directed towards the service sector than the manufacturing sector, which justifies the result of the study: the FDI inflows are sharply lower than the service sector. Significantly, findings from the study conducted by Yew et al. (2011) reveal that a rise in FDI in the ASEAN-5 nations is associated with a decline in China's exports to these countries, excluding Indonesia. To overcome this adverse impact of FDI, China actively encourages its foreign investments in the ASEAN-5 countries. The augmentation of Chinese FDI is anticipated to mitigate the risk of export substitution from other nations and foster a mutually beneficial relationship. Likewise, the ASEAN-5 countries are encouraged to view Chinese FDI as an opportunity for a cooperative and advantageous partnership.

In the second stage of our analysis, high-tech exports (as a percentage of manufactured exports) were employed as the independent variable to predict Gross Domestic Product (GDP). For our regression analysis, we established the Pooled OLS model as the baseline model, and the results are detailed in

Table 6
Balanced panel regression for second stage

Variable	Coefficient	Std. Error	t-Statistic	Prob
HTX	-7.01E+09	9.39E+08	-7.471182	0.0000
C	6.10E+11	3.99E+10	15.28805	0.0000
R-squared	0.330642		Mean dependent var	3.53E+11
Adjusted R-squared	0.324719		S.D. dependent var	2.63E+11
S.E. of regression	2.16E+11		Akaike info criterion	55.05397
Sum squared resid	5.28E+24		Schwarz criterion	55.10171
Log likelihood	-3163.603		Hannan-Quinn criter.	55.07335
F-statistic	55.81856		Durbin-Watson stat	0.189362
Prob(F-statistic)	0.000000			

Table 7
Dynamic panel regression using fixed effect model with white diagonal coefficient covariance (cross-section cluster) for second stage

Variable	Coefficient	Std. Error	t-Statistic	Prob
HTX	-4.26E+08	2.82E+08	-1.509484	0.1342
GDP(-1)	0.980585	0.023773	41.24801	0.0000
C	4.59E+10	1.71E+10	2.679414	0.0086
R-squared	0.980296		Mean dependent var	4.55E+11
Adjusted R-squared	0.979148		S.D. dependent var	2.25E+11
S.E. of regression	3.45E+10		Sum squared resid	1.23E+23
F-statistic	854.0439		Durbin-Watson stat	1.966895
Prob(F-statistic)	0.000000			

Table 6. The Durbin-Watson value's indication of autocorrelation issues remains a concern, which led the researchers to adopt corrective measures, including incorporating a lagged dependent variable into the model. To determine the most suitable model, the researchers also conducted both the Breusch-Pagan Lagrange Multiplier (LM) test (see Appendix D) and the Hausman test (see Appendix C), which revealed that the Fixed Effect Model is the most appropriate to utilize.

Given that the model employed in this study encounters heteroscedasticity issues, addressing this concern involves applying weighted factors. Subsequently, the Ordinary Least Squares (OLS) method is applied to the weighted data, as proposed by Maziyya et al. (2015). In the second stage, the Fixed effect model added cross-section weights and applied the White Diagonal cross-section covariance method.

As can be seen from Table 7, the R-squared value of 0.980296 indicates that approximately 98.03% of the variability in Gross Domestic Product (GDP) is explained by the fitted values derived from the first regression model, which represents high-tech exports. The high R-squared value suggests the model's strong explanatory power in capturing the observed variations in GDP based on the adjusted high-tech export values. The Durbin-Watson score for our second model is 1.966895, which falls within the acceptable range of 1.5 to 2.5. This suggests that there is no autocorrelation in the residuals of the second stage, reinforcing the assumption of independence among residuals.

Based on the findings, High-tech exports (HTX) do not exhibit statistical significance with GDP, as indicated by a probability value of 0.1342, greater than our chosen significance level. These results align with research conducted by Bonsay et al. (2021), where high-tech exports were observed to lack a significant impact on the gross domestic product of India, Singapore, and China. This highlights the context-specific role of high-tech exports, demonstrating variations across countries. While acknowledging the potential significance of high-tech exports for economic development, it becomes evident that their influence differs among nations and is contingent upon factors such as agricultural productivity, innovation emphasis, and the broader economic landscape. A study by Usman (2017) provides evidence for this notion, revealing that, although high-tech exports positively impact GDP, the more substantial effect is attributed to agricultural productivity per worker. This finding is particularly relevant for our study on the ASEAN 5, which comprises primarily agricultural economies such as Thailand, Philippines, Malaysia, and Indonesia, except Singapore. The research by Khanh Doanh Nguyen et al. (2022) also suggests that in order for ASEAN countries to utilize their untapped potential fully depends on supply competencies, which suggests that there are inefficiencies in leveraging the human capital to translate to the production of high-tech products in the country. Moreover, trade agreements and bilateral linkages play a role in the export of high-tech goods. Thus, the intricate dynamics of the relationship between high-tech exports and GDP underscore the need for a nuanced understanding, recognizing the diverse economic contexts within the ASEAN 5 nations.

5. Summary, Conclusion, and Discussions

A. Summary and Conclusion

This paper explored the influence of high-tech exports on the economies of the ASEAN 5 members. It also analyzed the impact of FDI, R&D, and human capital on specific sectors within these nations. The researchers employed a two-stage regression analysis to determine the relationship between independent variables (FDI, R&D expenditure, and government expenditure on education as a proxy for human capital) and an intermediate variable (High-tech Exports as a percentage of manufactured exports), ultimately affecting the dependent variable, GDP (measured in current USD).

The initial regression analysis employed the panel least square method, but corrective measures were implemented due to autocorrelation and a low R-squared value. This included incorporating a lagged dependent variable and transforming it into a Dynamic panel regression. Model suitability was assessed using the BP-LM test to compare Random Effects and Pooled OLS models. Then, the Hausman test determined the more fitting model between random and fixed effects, with a p-value below 0.05 indicating the preference for the fixed effects model. Thus, the final regression for the first stage was the Fixed Effects Model with Cross-section weights and White Cross-section, with lagged values of high-tech exports included to address potential autocorrelation.

Results from the first stage established a significant and positive relationship between Human Capital, represented by Government Expenditure on Education, and High-tech exports. It implies the importance of investing in education as a catalyst for fostering high-tech exports. A well-educated and skilled workforce is a critical factor in the success of high-tech sectors. If government spending on education results in a more skilled workforce, it increases the likelihood of producing high-quality, technologically advanced products that are competitive in the global market. Moreover, increased government spending on education correlates with a considerable rise in high-tech exports and has broad implications for policy and practice, suggesting that prioritizing human capital development through enhanced education accessibility and quality is instrumental in driving economic growth, technological progress, and competitiveness in the high-tech industry. The positive relationship identified highlights the pivotal role of educational policies and interventions in shaping a conducive environment for sustained economic development by expanding high-tech exports.

In contrast, there was a significant negative relationship between FDI and RD to high-tech exports. Certain types of FDI, including investments in traditional or service-oriented sectors, do not contribute significantly to technological advancement. ASEAN-5 nations may need to encourage a more balanced distribution of FDI across sectors, emphasizing attracting investments in high-tech industries. Also, fostering cooperative relationships, particularly with multiple countries like China, can help diversify their high-tech export markets and provide access to a broader range of technologies and expertise. While increased R&D spending can drive the creation of advanced technologies, their alignment with market demands may not always be guaranteed, signaling potential inefficiencies. Poor allocation of R&D funds can also impede the development and commercialization of technology. As R&D spending increases, the corresponding benefits for high-tech exports may not increase proportionally also and could reach a point of diminishing returns.

On the other hand, in the second stage analysis, high-tech exports were used as the independent variable to predict GDP. Using also a similar methodological approach from stage one, the final regression model for the second stage led to FEM with Cross-section Weights and applied the White Diagonal Cross-section covariance method. The findings from the second stage show us that high-tech exports have no significant effect on the Gross Domestic Product of ASEAN 5. This emphasizes the context-specific influence of HTX that varies among different countries. The observed variations can be caused by factors such as agricultural productivity, such as in the case of our study, where 4 out of 5 countries in our scope are primarily engaged in agriculture. The reliance on agriculture can influence the allocation of resources, technological adoption, and overall economic strategies. Furthermore, this highlights the pivotal role played by bilateral linkages and supply competencies. It becomes imperative to strategically channel efforts toward effectively transforming the nation's human capital and R&D infrastructure into the production of high-tech products.

Thus, we reject the following null hypotheses: H1, which posits that an increase in high-tech exports leads to increased economic growth; H2, which suggests that an increase in FDI raises high-tech exports; and H3, which posits that an increase in R&D expenditure leads to a greater level of high-tech exports. Conversely, we accept null hypothesis H4, which states that an improvement in human capital leads to an increase in high-tech exports.

B. Policy Implication

From a policy perspective, our findings highlight the importance of enhancing human capital, mainly through government spending on education, to drive high-tech exports. Moreover, the authors recommend that policies should not only focus on investing in human capital through formal schooling but should also involve investments in technology and knowledge-intensive activities. To propel the high-tech industry forward, it is imperative to allocate substantial resources and funding for foundational improvements in research capabilities, particularly within universities and companies. This necessitates the creation of collaborative initiatives that integrate academic institutions and industry players conducive for robust research and development. Moreover, fostering public-private partnerships is crucial to amplify the synergy between academic research and practical applications in the high-tech sector. For example, in the Philippines, governments should prioritize establishing the essential foundations of innovation to support businesses engaged in high-technology activities.

6. Limitations of the Study

Firstly, the proxy utilized for human capital, 'government expenditure on education' measured by the percentage of total government expenditure, is recognized as an imperfect measure of human capital. This choice was necessitated by the limited availability of data within the study's scope. It is important to note that the inclusion of a measure accounting for the quality of education could potentially enhance the explanatory power of human capital concerning high-tech exports since several studies support that human capital can be viewed in a holistic manner. Another limitation is the use of total FDI as opposed to innovation specific FDI inflows. Utilizing a more granular variable, such as innovation specific FDI, has the potential to refine the model, offering increased robustness and significance regarding its impact on high-tech exports. The limitation is due to the availability of the data provided by the World Bank. Finally, the study's scope is confined to the ASEAN 5 countries, and it's essential to recognize that these countries may not fully represent the diversity of all Asian nations. Consequently, caution should be exercised when attempting to generalize the study's results beyond the specific ASEAN 5 context.

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Appendix

Appendix A
Hausman Test for First stage

Test Summary	Chi-Sq Statistic	Chi-Sq d.f.	Prob
Cross-section random	16.452455	4	0.0025

Source: Author's estimation

Appendix B
Breusch-Pagan Lagrange Multiplier Test for First stage

Test Summary	Cross-section	Test Hypothesis Time	Both
Breusch-Pagan	420.9888	1.408781	422.3975
	(0.0000)	(0.2353)	(0.0000)

Source: Author's estimation

Appendix C
Hausman Test for Second stage

Test Summary	Chi-Sq Statistic	Chi-Sq d.f.	Prob
Cross-section random	8.118304	2	0.0173

Source: Author's estimation

Appendix D
Breusch-Pagan Lagrange Multiplier Test for Second stage

Test Summary	Cross-section	Test Hypothesis Time	Both
Breusch-Pagan	24.55173	45.05397	70.60571
	(0.0000)	(0.0000)	(0.0000)

Source: Author's estimation