AgBioForum, 25(1): 87-96. ©2023 ***AgBioForum***

The role of agriculture growth, technological innovation, and forest cover toward economic development: Evidence from Vietnam

Ho Thi Hien
Nghe An University of Economics (NAUE), Vinh City, Viet Nam
Email: hothihien@naue.edu.vn

Bui Thi Minh Nguyet*
Vietnam National University of Forestry (VNUF), Xuan Mai, Ha Noi, Vietnam
Email: minhnguyetfuv@gmail.com

Nguyen Van Song
Viet Nam National University of Agriculture (VNUA), Ha Noi, Viet Nam
Email: nguyensonghua@gmail.com

Dao Thu Tra
Hong Duc University (HDU), Thanh Hoa City, Viet Nam
Email: daothutra@hdu.edu.vn

Nguyen Cong Tiep
Viet Nam National University of Agriculture (VNUA), Ha Noi, Viet Nam
Email: nctiep@vnua.edu.vn

Thai Van Ha
Ha Noi University of Business and Technology (HUBT), Ha Noi, Viet Nam
Email: vanha280182@gmail.com

** Corresponding Author: Bui Thi Minh Nguyet,*
Email: minhnguyetfuv@gmail.com

This study investigates the influence of agricultural expansion, technological innovation, and forest cover on Vietnam's economic development. To accomplish this, the research considers data from 1990 to 2020. Empirical estimation utilizes the Augmented Dickey-Fuller (ADF) test for unit root testing, the Johansen Juselius test for co-integration, and the Fully Modified Ordinary Least Square (FMOLS), Dynamic Ordinary Least Square (DOLS), and Canonical Co-integration Regression (CCR) for long run coefficient estimation. In CCR, FMOLS, and DOLS regressions, the study reveals a significant and positive impact of forest cover and technological innovations on economic development, whereas agriculture growth has no significant impact on economic development in Vietnam across all three specifications. The study recommends that the government formulate and implement stringent policies to preserve forest wealth and promote research and development activities to achieve sustainable economic development.

Keywords: Technological innovations; agriculture growth; forest cover; economic development; FMOLS; DOLS; Canonical Co-integration regression.

1. Introduction

Economic development refers to an economy's profound structural transformation. Economic development transforms low-income and basic economies into industrialized, modern economies. It is the process of augmenting people's living standards, independence, and self-esteem to improve their quality and capabilities (Akram, Siddiqui, Nawaz, Ghauri, & Cheema, 2011; Todaro & Smith, 2020). In contrast, economic growth is defined as the long-term expansion of an economy's productive capacity required to meet the requirements of its citizens. The sustainable economic growth of a country is a prerequisite for economic development because it positively impacts the employment rate and the national income, thereby raising the living standards of the community (Bhatti & Nawaz, 2020; Mohamed, Liu, & Nie, 2021).

Significant factors, such as government expenditures, population, education, health, institutions, human capital, and natural resources, are cited in the literature as influencing economic development. The significance of natural resource capital for economic development has been consistently acknowledged over the years, and forest capital's positive impact on economic growth in any economy has been extensively documented. Forests are one of the most significant natural resources present in every nation. Forest-covered regions provide the region for resource extraction, tree harvesting, and wildlife hunting (Chien, Kamran, et al., 2022; Oyetunji, 2019; Shah, Hussain, Nawaz, & Iqbal, 2021). However, it remains unclear what role forest cover plays in the growth of an economy. Regarding option value, direct use value, positive externality, existence value, etc., forest resources contribute considerably to economic value (Chien, Pantamee, et al., 2021; Pak, Türker, & Öztürk, 2010). The more forest areas and resources an economy has, the more productive its forestry sector and the greater the income generated from the extraction of precious and non-precious wood (Chien, Sadiq, et al., 2021; Zhang, Tang, & Boamah, 2022). In addition, forest cover positively affects economic growth by increasing labor employment and income (Li, Mei, & Linhares-Juvenal, 2019). In addition, oil extraction, forest resource, and mineral resource rents substantially contribute to economic expansion. Forest resources are also closely associated with a reduction in destitution. Forests and tree systems sustain levels of welfare by primarily assisting households to increase their income and meeting their requirements in terms of food, health, and humanistic values (Chien, Hsu, Zhang, Vu, & Nawaz, 2022; Xiang et al., 2021; Zhang et al., 2022).

However, forests also have some negative consequences on economic development. Forest cover and resources are associated with the resource curse hypothesis predominantly due to the inefficiency of the forestry industry, which results in unexpected industrial benefits (Liu, Yao, & Liu, 2015). The Dutch Disease is also associated with forest resources. The primary source of revenue for regions with abundant forest resources is the export of forest products. However, when international trade conditions are unfavorable, exporting countries may experience a significant decline in income. The finite supply of natural resources must also be considered, policies must be devised, and natural resource rents must be utilized to stimulate the economy and enhance the business climate (Hanif, Bakar, & Nawaz, 2022; Zhang et al., 2022).

Similarly, no one can refute that agriculture plays a preeminent and crucial role in sustaining economic growth. Its importance in the economic development of industrialized countries has been widely acknowledged, and it also plays an essential role in the development of developing nations. In other words, agriculture or other primary industries are prioritized in economies with limited income. It is argued that agriculture is the economy's backbone by providing basic ingredients and raw materials for industry and humanity. This sector creates jobs, provides raw materials to industry, ensures agricultural security, and generates foreign exchange (Hanif, Nawaz, Fazal, & Ibraheem, 2022; Van Huong et al., 2022). Agriculture is the source of food for all countries in the globe. The agriculture sector's contribution to increasing food supply is essential for a nation's economic growth.

Additionally, agriculture plays a significant function in the capital formation of countries. The agriculture sector is also a source of employment and income for rural households, and as agriculture grows, so does the income of rural households, leading to an increase in demand and a rapid acceleration of industrialization. Economic growth is impossible without expanding the agricultural sector (Hussain, Bhatti, Nawaz, & Ahmad, 2019; Praburaj, Design, & Nadu, 2018).

In the same context, technological innovation is also a significant factor in economic growth. Innovation is "any activity that aims to create new or improved goods (including services), marketing methods, processes, or business organizations." It is defined as "the thriving exploitation of novel ideas" that includes technological, scientific, organizational, and financial activities that lead to new product and service provision (Jianjun et al., 2021; Mohamed, Liu, & Nie, 2022). Innovation encompasses institutional, theoretical, technological, ecological, and cultural innovation. In a contemporary economy, technological innovations are essential for economic growth, value creation, and employment at the regional, national, and enterprise levels. Through market value and productivity, technological innovation promotes the development of society and industry, and it is also essential for avoiding economic recession (Wusiman & Ndzembanteh, 2020). Innovations also result in the formation of new businesses and enhance the competitiveness of existing businesses. Importantly, it assists a nation in attaining its goals by increasing output by enhancing input productivity, which can only be accomplished by inventing new products or industrial processes. Therefore, innovation significantly contributes to a nation's long-term productivity and consistent economic growth (Khan & Nawaz, 2010; Washima, 2019). Considering the abovementioned arguments, this study aims to investigate the impact of technological innovations, agricultural growth, and forest cover on Vietnam's economic development from 1990 to 2020. Vietnam is a fascinating case study because it is one of Southeast Asia's lower-middle-income countries and is considered one of the world's emergent nations. Vietnam ranks 23rd and 36th in purchasing power parity and nominal gross domestic product, respectively. Vietnam's GDP amounted to $369.494 billion in 2019, but its development rate is not constant and fluctuates significantly over time. Agriculture, services, and industry are Vietnam's three primary economic sectors (Mirza, Abbas, & Nawaz, 2020). The agriculture sector accounts for 15.3% of the annual GDP. About 38.6% of the workforce is employed in the agricultural sector. However, agriculture's status as the most significant industry is diminishing. In Vietnam, the services and manufacturing sectors produce more than agriculture. However, agriculture continues to supply industries and export sectors with basic materials. Vietnam's primary agricultural products include rice, coffee, maize, tea petals, pepper, cassava, sweet potato, and cashew nut. As a result, Vietnam still holds the top position among agricultural nations (Linh et al., 2019; Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021).

About two-thirds of Vietnam's total geographical area is covered by forests. However, the forest cover continuously decreases due to a swiftly expanding population illegally clearing forests for agriculture. Approximately 24 million people reside near or in forests and rely on these resources for their subsistence, leading to wood exploitation. Forest assets are essential for both people's livelihoods and the country's economic development, but excessive exploitation of forest resources may be one of the reasons for the country's economic stagnation (Luong, 2014; Nawab, Bhatti, & Nawaz, 2021). Moreover, if the economic growth rate is inconsistent, it is imperative to improve domestic innovative capabilities to increase economic development. Figure 1 demonstrates that, thankfully, the Vietnamese government is adopting initiatives to increase technological innovation.

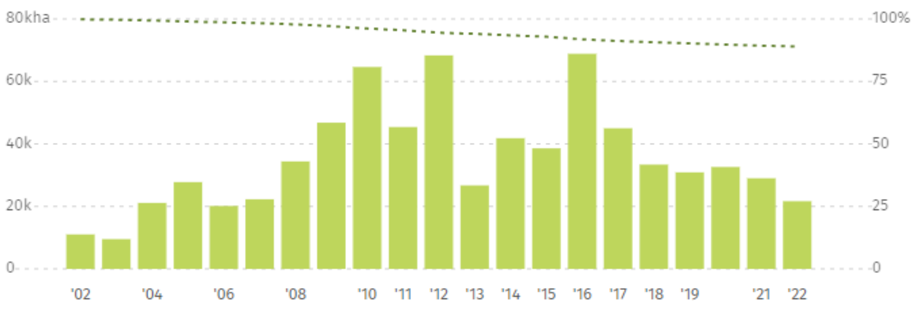

Figure 1: Loss in forest cover area from 2002 to 2023 in Vietnam
Source: Global Forest Watch (2023)

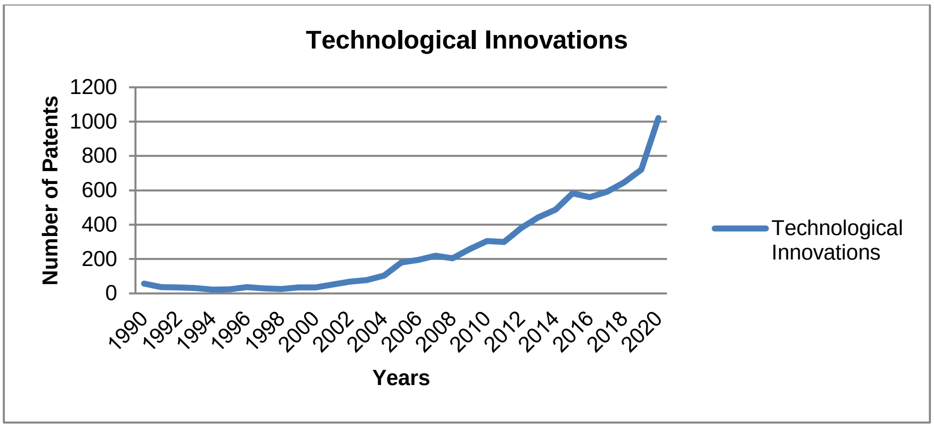

Figure 2: Technological Innovations in Vietnam from 1990 to 2020 period.
Source: WDI (2023)

By empirically estimating the role of forest cover, technological innovations, and agriculture growth, this study makes the following contributions to the body of knowledge: First, despite numerous studies on the role of technological innovations, forest cover, and agriculture growth in economic growth or development, the number of studies analyzing the role of these factors in Vietnam's economic development is nearly nonexistent. Second, to our knowledge, these nexuses have never been empirically evaluated using CCR, FMOLS, or DOLS estimations. The findings of this research can be effectively utilized by policymakers in Vietnam and other developing nations to address economic development issues.

The remainder of the investigation is organized as follows: The second section examines existing research. The third section provides data and employs estimation techniques. The fourth section includes results and discussions. The fifth section concludes with policy recommendations.

2. Existing Literature

To create a thorough and comprehensible review, we divide the literature into three distinct strands: The first section examines the relationship between forest cover and economic growth. The second thread examines the literature on technological innovations and economic development, while the third examines the connection between agriculture and economic development.

2.1 Forest Cover and Economic Development / Economic Growth

Numerous studies on the relationship between forest cover and economic growth or development have been published, but they do not provide sufficient evidence for a conclusion. Some researchers believe that abundant forest resources will aid economic development, whereas others argue that forestation can result in economic instability. For example, Oyetunji (2019) analyzed the function of forests in Nigeria's economic development from 1990 to 2015. The study utilized the ARDL estimation method, which revealed forests' positive and insignificant function in economic development. Naidoo (2004) estimated the impact of forests on economic growth in seventy nations. Regression analysis revealed a negative relationship between forests and economic growth, as countries with a high forestation rate had a low economic growth rate, whereas countries with a high deforestation rate had a higher economic growth rate. Likewise, Xie, Irfan, Razzaq, and Dagar (2022) estimated the impact of forest and mineral resource volatility on economic performance. Using ARCH, TARCH, and EARCH approaches for empirical estimations, the study demonstrated the unidirectional causality between mineral and forest resources and economic performance, demonstrating that forests and mineral resources contributed positively to economic performance. Similarly, Zhang et al. (2022) also estimated the relationship between forest resources and economic development in the Yangtze River Delta from 2007 to 2019. Using a spatial econometric approach, it was discovered that forest resources had a U-shaped relationship with economic development, i.e., forest resources generated benefits for regional economic development. Hernawati (2010) examined the relationship between deforestation and household incomes in Indonesia using primary data from 1998 to 2004. A Spatial Econometric estimation method discovered a U-shaped non-linear relationship between deforestation and household incomes. Initially, as deforestation increased, household income decreased, but after a certain threshold was crossed, household income began to rise, and deforestation increased. In the case of Vietnam, Tru (2018) analyzed the key determinants of economic development, such as the added value of agriculture and the forest and fishery sectors. The results of the ARDL method indicated that the forest and fishery sectors and the value added to agriculture had a significant positive impact on Vietnam's economic growth.

Hence, we formulate the first hypothesis of the study as follows:

H1: *Forest cover has a significant impact on economic development in Vietnam.*

2.2 Technology Innovations and Economic Development / Economic Growth

Second, the literature is replete with studies on the relationship between technological innovation and economic growth. In the current era of globalization, differences in technological innovation between nations characterize disparities in income inequality and economic growth. Technological and scientific innovations enable businesses and individuals to use technology more effectively, reducing costs and increasing production (Mohamed et al., 2021; Nawaz, Hussain, & Hussain, 2021). Among the studies examining the relationship between technological innovation and economic growth or economic development, Adak (2015) estimated the impact of technological innovations on Turkey's economic growth. The study's OLS estimation method revealed the positive impact of technological innovation on Turkey's economic growth. Mohamed et al. (2022) estimated the relationship between technological innovation and economic development using a panel of developing nations from 1990 to 2018. The authors estimated using the ECM method. The study revealed long-term and short-term positive effects of technological innovation on economic growth.

Furthermore, bidirectional causality was found between technology innovations and economic development in the long run, whereas short-run causality ran from technology innovations to economic development. Mohamed et al. (2021) analyzed the impact of innovations and foreign direct investment on Egypt's economic development from 1990 to 2019. Using the ARDL Co-integration method, the study determined that technological advancements harmed economic growth. Using panel data from 19 European countries, Maradana et al. (2017) analyzed the relationship between innovations and economic growth from 1989 to 2014. Granger Causality analysis revealed a bidirectional and unidirectional causal association between various innovations and economic growth indicators. Pece, Simona, and Salisteanu (2015) estimated the effect of technological innovations on economic growth in Central and Eastern European countries from 2000 to 2013. Using regression analysis, the findings indicated that innovations contribute positively to economic development. In Pakistan, Saeed and Awan (2020) analyzed the impact of technological advances on the country's economic growth as measured by R&D and innovation. The authors used the ARDL estimation method, which revealed the positive impact of research, development, and innovation on Pakistan's economic growth.

Thus, we formulate the second hypothesis of the study:

There is a significant impact of technological innovations on economic development.

2.3 Agriculture Growth and Economic Development

Similar to the relationship between forest cover and economic growth and development, the relationship between agriculture and economic growth and development remains controversial, particularly in developing nations that rely heavily on the agriculture sector for their economic sustenance (Nawaz et al., 2021; Runganga & Mhaka, 2021). Awan and Aslam (2015) analyzed the impact of agricultural productivity on Pakistan's economic development from 1972 to 2012. The ARDL Co-integration method was used to determine long- and short-term estimates. It was discovered that agricultural expansion contributed positively to economic expansion. Ansari and Jadaun (2022) estimated the relationship between agricultural growth and economic development in India from 1991 to 2020. The ARDL estimation method was also utilized in the study to demonstrate the positive impact of agricultural productivity in India. Runganga and Mhaka (2021) examined the role of the agricultural growth-economic growth relationship from 1970 to 2018 using data from Zimbabwe. The ARDL estimation method indicated a positive influence of agriculture productivity on growth in the short run, but no significant impact was observed in the long run. In continuation, Chaudhary and Mishra (2021) investigated the relationship between economic growth and agriculture in Nepal. The findings disclosed that the agriculture sector's contribution to economic development has diminished. Izuchukwu (2011) investigated the relationship between agriculture and economic development in Thailand from 1961 to 2009. Using OLS and Granger causality techniques, the authors determined that agriculture positively influenced the country's economic development. In Thailand, there was also a bidirectional causal relationship between them.

Thus, the third hypothesis of the study is formulated as follows:

H3: *Agricultural growth has a significant effect on economic development in Vietnam.*

2.4 Research Gaps

The comprehensive evaluation of the prior literature revealed several significant gaps that require the attention of researchers. First, despite extensive literature on the relationships between agriculture growth, forest cover, technological innovations, and economic development, the empirical estimation of these relationships in Vietnam has been neglected. To the best of our knowledge, except for Tru (2018), no study has ever explored the relationship between agricultural growth, forest sector growth, and economic growth in Vietnam. In addition, the significance of technological innovations in Vietnam's economic growth has never been studied. Second, the earlier time series studies, such as Tru (2018), have utilized ARDL bound testing extensively for empirical analysis. Again, to our knowledge, previous researchers have never examined the impact of the abovementioned variables on economic development using the FMOLS, DOLS, and Canonical regression methods. Therefore, the current study seeks to fill in these research gaps and contributes significantly to the literature regarding Vietnam's economic development.

3. Data and Methodology

The study's primary aim is to analyze the effect of technological innovations, agricultural growth, and forest cover on economic development in Vietnam from 1990 to 2020. For this purpose, the study considers GDP per capita as the measurement of economic development following

(Su, Li, Tao, & Lobonţ, 2019). The model for empirical assessment is specified as follows:

ED= f (TINOV, AGR, FCOV) (1)

While its econometric form is given as:

$$ED_t = \beta_0 + \beta_1 TINOV_t + \beta_2 AGR_t + \beta_3 FCOV_t + \mu_t \quad (2)$$

Where TINOV denotes technological innovations, AGR shows agriculture growth, and FCOV shows forest cover. t denotes the time subscript, and μ shows the disturbance term. The measurement and their data sources of variables are provided in Table 1 below.

Table 1: Operational Definitions of Study Variables and their Data Source

Variables	Measurement	Data Source
Economic Development	GDP per capita constant (2015 US$)	WDI
Technological Innovations	Number of patents, residents	WDI
Agriculture Growth	Agriculture value added (% of GDP)	WDI
Forest Cover	Forest area (square km)	WDI

WDI= World Development Indicator

3.1 Estimation Techniques

Unit root test

Applying criteria for stationarity or unit roots is the first step in empirical analysis. Unit root or stationarity tests disclose the order of variables' integration. Before applying the chosen estimation methods, all study variables must be integrated in order 1, i.e., I(1). The order of integration of 1 is also required for co-integration and estimation of long-run coefficients. Also, the FMOLS, DOLS, and CCR methods require that none of the series be integrated in order 2. To apply FMOLS, DOLS, and CCR regressions, it is necessary to determine that all series have an integration order of 1 and that no series has an integration order of 2. For this purpose, the current study employs the ADF test, which implies that all series are AR (1) processes.

FMOLS and DOLS Estimations

The present analysis uses three distinct estimation approaches to calculate long-run coefficient estimates. Among these techniques are the CCR by Park (1992) and FMOLS and DOLS by Pedroni (2001). The FMOLS and DOLS methods employ parametric and nonparametric methodologies, respectively. In addition, they are dependable estimators for long-term evaluation due to their enhanced capacity to resolve serial correlation and endogeneity issues. Certain adjustments are made to the traditional OLS estimator to develop the FMOLS estimator, which enables the FMOLS estimation method to assess the co-integration relationship. It generates the same problems of endogeneity and serial correlation as the conventional OLS method and is incapable of addressing them.

Regarding addressing endogeneity and serial correlation issues for computing long-run coefficients and co-integration, FMOLS is preferable to other estimation techniques (Valenzuela, Rojas, Pomares, & Rojas, 2019). In addition, DOLS estimation is an efficient method for time series estimation because it can address the non-stationarity issue in a parametric estimation that addresses the autocorrelation problem by including lagged values in the model. DOLS estimation has the following advantages over FMOLS estimation: (i) the ability to use limited sample sizes (ii) the presence of dynamic factors (iii) the ability to resolve refractions in a static regression; (iv) the applicability in the presence of multiple variables (You, Khattak, & Ahmad, 2022).

The following Equations 3 and 4 present FMOLS and DOLS, respectively

$$\widehat{\emptyset} = \left[\frac{\beta}{\widehat{\gamma}}\right] = \left(\sum_{t=2}^{T} Z_t Z_t'\right) \left(\sum_{t=2}^{T} Z_t y_t^{+} - T\left[\frac{\lambda_{12}+}{0}\right]\right) \quad (3)$$

Where Z_t is (X'_t, D'_t). The FMOLS estimation analysis mainly relies on the long-run covariance matrix.

$$y_t = x_t'\beta + D_{it'\gamma 1} + \sum_{j=q}^{r} \Delta X_{t+j} + v_{it} \quad (4)$$

Because of the orthogonal co-integration error term equation, the DOLS estimation approach augments co-integration analysis while considering both the lags and leads $\Delta' X_t$.

Canonical Co-integration Regression

In contrast to the FMOLS approach, CCR utilizes a stationary adaptation method to resolve the long-term correlation between the co-integration equation and stochastic regression errors. It generates square estimates with an asymptotically normal distribution. This estimator eliminates endogeneity and corrects for asymptotic bias caused by synchronous correlation among regressors (You et al., 2022). Moreover, the CCR estimation method relies exclusively on regression (Park, Shin, & Whang, 2010). This is an essential and effective strategy for fitting the linear regression component. Therefore, the most difficult aspect of the asserted method is precisely identifying lags and lead orders. The estimation of the CCR is given in equation (5) below:

$$y_t^{*} = \beta_{pq}' z_{pqt}^{*} + \mu_{pqt}^{*} \quad (5)$$

The above equation shows that z^*_{pqt} and y^*_t both are stationary transformations of z_{pqt} and y_t, respectively.

4. Results and Interpretation

The variables' descriptive statistics are illustrated in Table 2. Among all survey variables, forest cover has the highest mean or average value, while agriculture growth has the lowest value, according to these statistics. According to standard deviation statistics, forest cover has the highest standard deviation value, while agricultural growth has the lowest. The data range for forest cover is the greatest, while the data range for agricultural growth is the smallest. In addition, the Jarque-Bera test for normality reveals that only technological advancements and agricultural growth have normally distributed data.

Table 2: Descriptive Statistics

Data Series	Average or Mean	Std.Deviation	Minimum value	Maximum value	J-B test
ED	1722.2	811.60	673.38	3352.06	2.370
TINOV	250.483	264.24	22.000	1021.00	7.373***
FCOV	124032.1	16082.58	93759.60	146430.9	1.996
AGR	22.526	6.6771	13.574	40.485	6.649***

Before proceeding with the estimation of the relationship between forest cover, technology innovations, agriculture growth, and economic development, unit root or stationary tests are used to determine the integration order of the variables, as this information is crucial for selecting the most suitable estimation approach for long run coefficient estimation. The Augmented Dickey-Fuller (ADF), the most common unit root test, is used for this purpose. Table 3 displays the corresponding findings. According to the results, all variables are unit root and stationary after the difference at the level.

Since the ADF test revealed that all series are integrated of order 1, there is a possibility of a long-run co-integration relationship between variables. Before estimating the long-term relationship, we evaluate it using the Johansen Co-integration test. The results are presented in Table 4. We can reject the null hypothesis of no co-integration based on Trace and Maximum Eigen Values statistics, as the probability values are less than 0.05. In both trace statistics and maximal Eigen statistics, the results indicate the presence of at least three cointegrating equations.

Table 3: Stationarity or Unit Root Findings

Series	ADF Test		
	Level	First Difference	Decision
ED	7.412	-3.625***	I(1)
TINOV	4.6558	-4.8444***	I(1)
FCOV	-0.624	-5.447***	I(1)
AGR	-2.797	-5.6708***	I(1)

Table 4: Johansen Co-integration Test Findings

Cointegrating Equations	ED = f (TINOV,FCOV, AGR)	
	Trace	Max Eigenvalues
None	92.058*** (0.000)	51.649*** (0.000)
At most 1	40.409*** (0.0021)	18.598 (0.1090)
At most 2	21.810*** (0.0049)	16.064*** (0.0257)
At most 3	5.745*** (0.0165)	5.745*** (0.0165)

The FMOLS, DOLS, and CCR results are listed in Table 5 below. Surprisingly, we find that the significance and signatures of the coefficients are identical across all three specifications, whereas the sizes of the coefficients vary slightly across regressions. First, we discover that technological innovation positively and significantly impacts Vietnam's economic development. In FMOLS, DOLS, and CCR regressions, economic development increases by 1.75, 2.17, and 1.88 units for each unit increase in technological innovation. Thus, we conclude that adopting technological innovations is a significant means of fostering economic growth in Vietnam. The result suggests that innovation generates new enterprises and enhances the competitiveness of existing ones. Significantly, innovation helps an economy achieve its goals by increasing output through enhanced input productivity, which can only be achieved by inventing new products or manufacturing techniques (Washima, 2019). The study finding is in line with several previous studies, including Bakpa, Xuhua, and Aboagye (2021) for Ghana, Wusiman and Ndzembanteh (2020) for Turkey and Malaysia and (Washima, 2019) for Sri Lanka but in contrast to Shukla (2017) and Rahman, Suwitho, Oh, and Purwati (2019) as negative association between economic growth and technology innovations was observed unexpectedly for India and high innovative countries respectively.

Table 5: Findings of DOLS, FMOLS, and CCR

Series	FM-OLS		D-OLS		CCR	
	Coefficients	Prob value	Coefficients	Prob value	Coefficients	Prob value
AGR	5.222	0.5660	-12.656	0.2402	-0.0888	0.9928
TINOV	1.751***	0.000	2.171***	0.000	1.885***	0.000
FCOV	0.0258***	0.000	0.0131***	0.011	0.022***	0.0003
C	2042.1***	0.0088	75.999	0.9221	-1544.8**	0.0843
R^2 value	0.989		0.998		0.988	
Adjusted R^2 value	0.988		0.998		0.986	

The results of the three specifications disclose the long-term contribution of forest cover to economic growth. Regarding the coefficients, we discover that forest cover increases economic development by 0.025, 0.013, and 0.022 units in FMOLS, DOLS, and CCR, respectively. The conclusion is plausible because forest area in Vietnam is associated with the provision of subsistence for numerous rural communities (Sunderlin & Huynh, 2005). Poor people in remote rural areas often rely heavily on natural forests' products and environmental services for their subsistence. Moreover, forest cover is associated with employment creation, foreign exchange, exports, industries, tourism, the provision of sustenance minerals and timber, and wildlife, which are significant determinants of a country's economic development (Oyetunji, 2019). Previously, there have been several studies that conclude the positive role of forest cover in economic development, such as Oyetunji (2019) for Nigeria, (Jaunky & Lundmark, 2016) for a panel of 22 countries, and Tru (2018) for Vietnam. However, the study of Naidoo (2004) contradicts our conclusion as it reveals a negative association between forestation and economic development in a panel of 70 countries.

Contrary to our third hypothesis of the study, which assumes a considerable impact of agricultural growth on economic development, the estimated results indicate that agriculture has a negligible impact on Vietnam's economic development. This is a surprising finding that is supported by the research of Uma, Eboh, and Obidike (2013) and Ugwu and Kanu (2012) for Nigeria, who find that agriculture contributes minimally in terms of foreign exchange, capital transfer and formation, and output, as a result of poor policy coordination, policy instability, poor mismanagement and implementation of policies, and a lack of transparency. Another possible explanation for the finding is that various agricultural leaders' political pledges, policies, and programs lacked a realistic approach that could increase agricultural productivity (Uma et al., 2013). According to Awan and Aslam (2015) for Pakistan and Ansari and Jadaun (2022) for India, agriculture positively influences the economic development of their respective nations.

5. Conclusion and Recommendations of the Study

Given the widely acknowledged importance of technological innovations, forests, and agriculture sectors to the growth of any economy, the existing literature lacks empirical estimates of these factors about Vietnam's economic development. To address this gap in the literature, the primary objective of this study is to estimate the role of technological innovations, forest cover, and agricultural expansion in Vietnam's economic development. To this purpose, the study considers World Development Indicator data from 1990 to 2020. Based on the Johansen Juselius Co-integration test findings, empirical estimation is conducted using FMOLS, DOLS, and CCR regressions, as the study variables are found to be integrated of order 1 and have long-run relationships. According to all three estimates, the study's findings indicate that agriculture growth has no significant effect on economic development, whereas technology innovations and forest cover play a significant, positive role in Vietnam's economic development. Thus, the study concludes that technological innovations and forest cover can play a dominant role in augmenting Vietnam's economic development, whereas the agriculture sector requires additional government attention due to its insignificance in the country's economic development.

The study findings result in several valuable recommendations for the Vietnamese government and policymakers. There is a need for policymakers to consolidate the technological innovations in Vietnam's economic development, which requires the formulation and implementation of a rigorous policy agenda. For this reason, the Vietnamese government should expand the industrial sector that engages in innovative activities more frequently. Or, to put it another way, there must be more opportunities for innovative concepts supporting high-tech product development. Government assistance in the form of increased funding for research and development in innovations is also required. The findings also demonstrate the positive contribution of forest cover area to economic development. To prevent deforestation, the study suggests that the Vietnamese government should formulate and implement policies to preserve forests from illegal tree cutting. The Vietnamese government must increase funding for the forest sector to increase its productivity. Rural communities should be educated on the significance of forests to prevent the unsustainable exploitation of forest resources.

As with all investigations, some limitations must be addressed in future research. Due to data availability, the study only considers the effects of forest cover, agricultural expansion, and technological advancements on economic development. Future research must consider additional relevant aspects of economic growth, such as capital formation, industrialization, trade, employment, etc. The effects of agriculture employment, research and development, and deforestation on economic development can also be considered. Different country groups can also be considered, such as developing countries, developed countries, ASEAN countries, BRICS countries, and N-11 countries. In conclusion, future research may employ various methodological techniques, such as ARDL, CS-ARDL, AMG, CCEMG, VAR, VECM, etc., to generate more reliable results.

References

Adak, M. (2015). Technological progress, innovation and economic growth; the case of Turkey. *Procedia-Social and Behavioral Sciences*, *195*, 776-782. doi: https://doi.org/10.1016/j.sbspro.2015.06.478

Akram, K., Siddiqui, S. H., Nawaz, M. A., Ghauri, T. A., & Cheema, A. K. H. (2011). Role of knowledge management to bring innovation: an integrated approach. *Cell*, *92*(333), 6183035. Retrieved from https://www.econ-jobs.com/research/9515-Role-of-Knowledge-Management-to-Bring-Innovation-An-Integrated-Approach.pdf

Ansari, S., & Jadaun, K. K. (2022). Agriculture productivity and economic growth in India: an Ardl model. *South Asian Journal of Social Studies and Economics*, *15*(4), 1-9. doi: https://doi.org/10.9734/sajsse/2022/v15i430410

Awan, A. G., & Aslam, A. (2015). Impact of agriculture productivity on economic growth: A case study of Pakistan. *Global Journal of Management and Social Sciences, 1*(1), 57-71. Retrieved from https://www.academia.edu/download/51016882/Ateeqa_Aslam_paper.pdf

Bakpa, E. K., Xuhua, H., & Aboagye, A. K. (2021). Ghana's economic growth: Directing our focus on the contributing influences of innovation activities and trade. *Growth and Change, 52*(4), 2213-2237. doi: https://doi.org/10.1111/grow.12533

Bhatti, M. A., & Nawaz, M. A. (2020). The impacts of tourism risk management, IT adoption, agility and resilience on the sustainable tourism supply chain performance of Maldives' tourism industry. *iRASD Journal of Management, 2*(2), 100-108. doi: https://doi.org/10.52131/jom.2020.0202.0020

Chaudhary, K. K., & Mishra, A. K. (2021). Impact of Agriculture on Economic Development of Nepal Using Statistical Model. *Journal of Advanced Research in Alternative Energy, Environment and Ecology, 8*(2), 1-3. doi: https://doi.org/10.24321/2455.3093.202101

Chien, F., Hsu, C.-C., Zhang, Y., Vu, H. M., & Nawaz, M. A. (2022). Unlocking the role of energy poverty and its impacts on financial growth of household: is there any economic concern. *Environmental Science and Pollution Research, 29*(9), 13431-13444. doi: https://doi.org/10.1007/s11356-021-16649-6

Chien, F., Kamran, H. W., Nawaz, M. A., Thach, N. N., Long, P. D., & Baloch, Z. A. (2022). Assessing the prioritization of barriers toward green innovation: small and medium enterprises Nexus. *Environment, Development and Sustainability, 24*(2), 1897-1927. doi: https://doi.org/10.1007/s10668-021-01513-x

Chien, F., Pantamee, A. A., Hussain, M. S., Chupradit, S., Nawaz, M. A., & Mohsin, M. (2021). Nexus between financial innovation and bankruptcy: evidence from information, communication and technology (ict) sector. *The Singapore Economic Review*, 1-22. doi: https://doi.org/10.1142/S0217590821500181

Chien, F., Sadiq, M., Nawaz, M. A., Hussain, M. S., Tran, T. D., & Le Thanh, T. (2021). A step toward reducing air pollution in top Asian economies: The role of green energy, eco-innovation, and environmental taxes. *Journal of environmental management, 297*, 113420. doi: https://doi.org/10.1016/j.jenvman.2021.113420

Hanif, S., Bakar, A., & Nawaz, M. A. (2022). Relationship between Information and Communication Technologies and Sustainable Development: Fresh Evidence from Group of Seven (G-7) Countries. *iRASD Journal of Economics, 4*(3), 517-526. doi: https://doi.org/10.52131/joe.2022.0403.0096

Hanif, S., Nawaz, M. A., Fazal, S., & Ibraheem, R. (2022). Role of Natural Resources and Eco-Innovations in Determination of the Environmental Quality of Pakistan: Evidence through Vector Autoregressive (VAR) Estimation. *iRASD Journal of Economics, 4*(1), 127-140. doi: https://doi.org/10.52131/joe.2022.0401.0067

Hernawati, J. (2010). *The Dynamics of Forest Clearance and Socio-Economic Development in West Kalimantan* (Master's Thesis, International Institute of Social Studies). Retrieved from http://hdl.handle.net/2105/13593

Hussain, A., Bhatti, M. A., Nawaz, M. A., & Ahmad, T. I. (2019). The influence of geography and its information management system on tourism planning: Mediating role of institutional factor. *PalArch's Journal of Vertebrate Palaeontology, 16*(1), 1-16. Retrieved from https://archives.palarch.nl/index.php/jvp/article/view/9132

Izuchukwu, O.-O. (2011). Analysis of the contribution of agricultural sector on the Nigerian economic development. *World review of business research, 1*(1), 191-200. Retrieved from https://www.researchgate.net/publication/264887608

Jaunky, V. C., & Lundmark, R. (2016). Forest products exports and economic growth: Evidence from rich countries. *The Journal of Developing Areas, 50*(4), 443-458. Retrieved from https://www.jstor.org/stable/26415543

Jianjun, H., Yao, Y., Hameed, J., Kamran, H. W., Nawaz, M. A., Aqdas, R., et al. (2021). The role of artificial and nonartificial intelligence in the new product success with moderating role of new product innovation: a case of manufacturing companies in China. *Complexity, 2021*, 1-14. doi: https://doi.org/10.1155/2021/8891298

Khan, R. E. A., & Nawaz, M. A. (2010). Economic determinants of foreign direct investment in Pakistan. *Journal of Economics, 1*(2), 99-104. doi: https://doi.org/10.1080/09765239.2010.11884929

Li, Y., Mei, B., & Linhares-Juvenal, T. (2019). The economic contribution of the world's forest sector. *Forest Policy and Economics, 100*, 236-253. doi: https://doi.org/10.1016/j.forpol.2019.01.004

Linh, D. H., Cuc, N. T. T., Tiep, N. C., Diep, N. X., Diep, V. B., Busung, K., et al. (2019). The impact of agricultural growth on the rural development in Vietnam. *AgBioForum, 21*(3), 48-56. Retrieved from https://agbioforum.org/menuscript/index.php/agb/article/view/24

Liu, Z., Yao, S., & Liu, Y. (2015). Forest resource curse based on spatial panel modeling. *Resource Science, 37*(2), 379-390. Retrieved from http://www.cqvip.com/qk/90831a/20152/1005690964.html

Luong, T. H. (2014). Forest resources and forestry in Vietnam. *Journal of Vietnamese Environment, 6*(2), 171-177. doi: https://doi.org/10.13141/jve.vol6.no2.pp171-177

Maradana, R. P., Pradhan, R. P., Dash, S., Gaurav, K., Jayakumar, M., & Chatterjee, D. (2017). Does innovation promote economic growth? Evidence from European countries. *Journal of Innovation and Entrepreneurship, 6*(1), 1-23. doi: https://doi.org/10.1186/s13731-016-0061-9

Mirza, A., Abbas, J., & Nawaz, M. A. (2020). Which financial information leads to better market valuation and economic decision making in malaysian main market listed firms? A value relevance perspective. *Pakistan Journal of Social Sciences, 40*(2), 995-1006. Retrieved from http://pjss.bzu.edu.pk/index.php/pjss/article/view/905

Mohamed, M. M. A., Liu, P., & Nie, G. (2021). Are technological innovation and foreign direct investment a way to boost economic growth? an egyptian case study using the autoregressive distributed lag (ardl) model. *Sustainability*, *13*(6), 3265. doi: https://doi.org/10.3390/su13063265

Mohamed, M. M. A., Liu, P., & Nie, G. (2022). Causality between technological innovation and economic growth: Evidence from the economies of developing countries. *Sustainability*, *14*(6), 3586. doi: https://doi.org/10.3390/su14063586

Mohsin, M., Kamran, H. W., Nawaz, M. A., Hussain, M. S., & Dahri, A. S. (2021). Assessing the impact of transition from nonrenewable to renewable energy consumption on economic growth-environmental nexus from developing Asian economies. *Journal of environmental management*, *284*, 111999. doi: https://doi.org/10.1016/j.jenvman.2021.111999

Naidoo, R. (2004). Economic growth and liquidation of natural capital: the case of forest clearance. *Land Economics*, *80*(2), 194-208. doi: https://doi.org/10.2307/3654738

Nawab, T., Bhatti, M. A., & Nawaz, M. A. (2021). Does Technological Innovation Advance Environmental Sustainability in ASEAN Countries? *Pakistan Journal of Humanities and Social Sciences*, *9*(3), 425–434. doi: https://doi.org/10.52131/pjhss.2021.0903.0148

Nawaz, M. A., Hussain, M. S., & Hussain, A. (2021). The effects of green financial development on economic growth in Pakistan. *iRASD Journal of Economics*, *3*(3), 281–292. doi: https://doi.org/10.52131/joe.2021.0303.0044

Oyetunji, P. (2019). The effects of forests on economic growth in Nigeria (1990–2015). *World News of Natural Sciences*, (23), 254-265. Retrieved from https://bibliotekanauki.pl/articles/1077356.pdf

Pak, M., Türker, M. F., & Öztürk, A. (2010). Total economic value of forest resources in Turkey. *African Journal of Agricultural Research*, *5*(15), 1908-1916. Retrieved from https://hdl.handle.net/11494/519

Park, J. Y. (1992). Canonical cointegrating regressions. *Econometrica: Journal of the Econometric Society*, *60*(1), 119-143. doi: https://doi.org/10.2307/2951679

Park, J. Y., Shin, K., & Whang, Y.-J. (2010). A semiparametric cointegrating regression: Investigating the effects of age distributions on consumption and saving. *Journal of Econometrics*, *157*(1), 165-178. doi: https://doi.org/10.1016/j.jeconom.2009.10.032

Pece, A. M., Simona, O. E. O., & Salisteanu, F. (2015). Innovation and economic growth: An empirical analysis for CEE countries. *Procedia Economics and Finance*, *26*, 461-467. doi: https://doi.org/10.1016/S2212-5671(15)00874-6

Pedroni, P. (2001). Fully modified OLS for heterogeneous cointegrated panels. In B. H. Baltagi, T. B. Fomby, & R. Carter Hill (Eds.), *Nonstationary Panels, Panel Cointegration, and Dynamic Panels* (Vol. 15, pp. 93-130). Emerald Group Publishing Limited. doi: https://doi.org/10.1016/S0731-9053(00)15004-2

Praburaj, L., Design, F., & Nadu, T. (2018). Role of agriculture in the economic development of a country. *Shanlax International Journal of Commerce*, *6*(3), 1-5. doi: https://doi.org/10.5281/zenodo.1323056

Rahman, S., Suwitho, S., Oh, A., & Purwati, A. A. (2019). *Commercialization of High-Tech Innovations and Economic Growth in The Worldwide Most Innovative Countries*. University Library of Munich, Germany. Retrieved from https://mpra.ub.uni-muenchen.de/97766

Runganga, R., & Mhaka, S. (2021). *Impact of Agricultural Production on Economic Growth in Zimbabwe*. University Library of Munich, Germany. Retrieved from https://mpra.ub.uni-muenchen.de/106988

Saeed, F., & Awan, A. G. (2020). Does technological advancement really affects economic growth of Pakistan? *Global Journal of Management, Social Sciences and Humanities*, *6*(1), 134-156. Retrieved from https://gjms.b-cdn.net/2020/Volume%206/Issue%201,%202020/Fouzia%20saeed%20final%20paper.pdf

Shah, A. A., Hussain, M. S., Nawaz, M. A., & Iqbal, M. (2021). Nexus of renewable energy consumption, economic growth, population growth, FDI, and environmental degradation in south asian countries: New evidence from Driscoll-Kraay standard error approach. *iRASD Journal of Economics*, *3*(2), 200-211. doi: https://doi.org/10.52131/joe.2021.0302.0037

Shukla, S. (2017). Innovation and economic growth: A case of India. *Humanities & Social Sciences Reviews*, *5*(2), 64-70. doi: https://doi.org/10.18510/hssr.2017.521

Su, C.-W., Li, Z.-Z., Tao, R., & Lobonț, O.-R. (2019). Can economic development boost the active female labor force? *Quality & Quantity*, *53*, 1021-1036. doi: https://doi.org/10.1007/s11135-018-0800-z

Sunderlin, W. D., & Huynh, T. B. (2005). *Poverty alleviation and forests in Vietnam*. CIFOR. Retrieved from https://www.cifor.org/knowledge/publication/1660/

Todaro, M. P., & Smith, S. C. (2020). *Economic development*. Pearson UK. Retrieved from https://www.pearson.com/en-us/subject-catalog/p/economic-development/P200000005609

Tru, N. A. (2018). Determinants affecting economic growth: The case of Viet Nam. *International Journal of Business & Economics (IJBE)*, *3*(1), 1-11. Retrieved from http://www.ijbe.ielas.org/index.php/ijbe/article/view/40

Ugwu, D. S., & Kanu, I. O. (2012). Effects of agricultural reforms on the agricultural sector in Nigeria. *Journal of African studies and Development*, *4*(2), 51-59. doi: https://doi.org/10.5897/JASD11.029

Uma, K. E., Eboh, F. E., & Obidike, P. C. (2013). Appraisal of the influence of agriculture on economic growth: Empirical evidence from Nigeria. *IOSR Journal of Economics and Finance*, *1*(1), 73-79. Retrieved from https://www.iosrjournals.org/iosr-jef/papers/vol1-issue1/J0117379.pdf

Valenzuela, O., Rojas, F., Pomares, H., & Rojas, I. (2019). *Theory and Applications of Time Series Analysis*. Springer. doi: https://doi.org/10.1007/978-3-030-56219-9

Van Huong, N., Nguyet, B. T. M., Van Hung, H., Duc, H. M., Van Chuong, N., & Van Hien, P. (2022). Economic Impact of Climate Change on Agriculture: A Case of Vietnam. *AgBioForum, 24*(1), 1-12. Retrieved from https://agbioforum.org/menuscript/index.php/agb/article/view/72

Washima, M. N. F. (2019). Impact of innovation on economic growth of Sri Lanka: an empirical study. *International Journal of Accounting and Business Finance*, *5*(1), 60–71. doi: http://doi.org/10.4038/ijabf.v5i1.39

Wusiman, N., & Ndzembanteh, A. N. (2020). The impact of human capital and innovation output on economic growth: comparative analysis of Malaysia and Turkey. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi*, *8*(1), 231-242. doi: https://doi.org/10.18506/anemon.521583

Xiang, H., Ch, P., Nawaz, M. A., Chupradit, S., Fatima, A., & Sadiq, M. (2021). Integration and economic viability of fueling the future with green hydrogen: An integration of its determinants from renewable economics. *International Journal of Hydrogen Energy*, *46*(77), 38145-38162. doi: https://doi.org/10.1016/j.ijhydene.2021.09.067

Xie, M., Irfan, M., Razzaq, A., & Dagar, V. (2022). Forest and mineral volatility and economic performance: evidence from frequency domain causality approach for global data. *Resources Policy*, *76*, 102685. doi: https://doi.org/10.1016/j.resourpol.2022.102685

You, C., Khattak, S. I., & Ahmad, M. (2022). Impact of innovation in renewable energy generation, transmission, or distribution-related technologies on carbon dioxide emission in the USA. *Environmental Science and Pollution Research*, *29*(20), 29756-29777. doi: https://doi.org/10.1007/s11356-021-17938-w

Zhang, Q., Tang, D., & Boamah, V. (2022). Exploring the role of forest resources abundance on economic development in the Yangtze River delta region: Application of spatial Durbin SDM model. *Forests*, *13*(10), 1605. doi: https://doi.org/10.3390/f13101605