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Abstract: *This manuscript's primary goal was to empirically analyze the dynamic interrelation among tourism, innovations and trade openness on economic stability using panel data spanning the years 2000-2023 in the context of eight East Asia Pacific countries. The panel data, which was created using the WDI. The gathered data was analyzed using the panel unit root test, PMG/ARDL, and further diagnostic tests. When, innovation, tourism, and trade openness work together they create a powerful cycle of economic growth. In the econometric equation, the dependent variable was economic growth, the independent variables were innovations, tourism, and trade openness, and the control variable was inflation. Immediate effects exist for nearly all variables, with particularly strong impacts from tourism and trade and the interaction between modifier as innovations and human capital (R&D and HC1). The relation between R&D and human capital enhances growth outcomes more effectively than R&D alone. The study conveys that the region's innovations, tourism, and trade revenues boost GDP. Therefore, any expansion in the East Asia Pacific region's trade, tourism, and innovation sectors boosts the region's economic growth.*

Introduction

Economists generally use the term "innovation" to refer to advances in the quality and diversity of goods and services that the market offers, as well as price reductions, despite the fact that the concept is difficult to define (Broughel and Thirer 2019). Due to their critical role in attaining economic growth—both directly via increased productivity and indirectly through increased trade openness—innovation activities have become increasingly important. More people live in Asia than in Africa, the Americas, and Europe put together.

In the ten years leading up to 2024, the Asia-Pacific region accounted for more than 70.4% of the growth in the global GDP, with China alone contributing 30.8%. Asia's GDP per capita is expanding far more quickly than other regions.

(Zhongve and Liu (2021), Solovera et al., 2017). Innovation that is a component of China's innovation

policy has developed into hubs for regional technical advancement, which attracts significant foreign investment. Additionally, foreign businesses are encouraged to support research and development in China and transfer technological innovation. The state's financial assistance to small and medium-sized businesses, R&D expenditures (2% of GDP in 2016), and strong collaboration between research institutions and regional universities are all factors in growth of industrial and innovation clusters in China (Nguyen et al. 2021). In terms of gross domestic investment on research and development (3.14% of GDP), Japan has been the most economically developed country in recent years. The state contributes 19–20% of the funding. South Korea's economy ranks 11th globally and fourth in Asia in terms of GDP. The growth of South Korea is astounding. In just a few generations, it has transformed from one of the world's poorest nations to a high-income one (Singh et al, 2023). A sizeable amount of the nation's GDP is allocated to research and development. In 2016, according to figures published by Organization for Economic Cooperation and Development (OECD), South Korea allocated 4.2% of its GDP on research and development. Biomedical research and development is being actively developed and promoted in Singapore. Beginning in 2001, the investment has persisted ever since. The government spent \$13.5 billion on research and development between 2006 and 2010, which was more than twice as much as it had spent over the preceding five years. The biomedical industry received 25.3% of this total. Singapore has a lot of R&D potential. This facilitated the establishment of connections between academia and business, as well as the expansion of collaborations between public and private sectors (Yin and Wang 2020). Certain social, political, and economic traits are ingrained in regions, which may affect their capacity to transform R&D expenditures into economic expansion and innovation (Bilbao and Pose 2004). Innovations have not only reduced poverty but also increased economic participation, improved productivity, and created new opportunities across East Asia and the Pacific (Jia et al. 2022). It is often acknowledged that innovation and economic growth are significantly influenced by technology and technical advancements. Technology has been the real force behind perpetually rising standards of living Grossman and Helpman (1994). Trade openness expands market access, attracting foreign investment and driving economic integration. This work clarifies the relationship between innovations and trade openness, which has rarely been studied empirically before. Despite this research on connection among inventions and economic growth is accessible. One of main reason for the current study is the paucity of research on the connection between trade openness and innovative activities (Qureshi et al., 2021). By concentrating on a novel and intriguing topic in the literature, the current study significantly adds to the context of East Asia-Pacific economies, which makes it significant for a number of reasons. To put it another way, technological advancements have a significant role in international trade between nations. In the contemporary globalized world, innovation rather than notions of comparative or absolute advantage—is the main driver of international trade, particularly intra-industry trade (Ridwan et al., 2024). As a result, inventions are crucial to nations' economies both globally and regionally, and their significance is only increasing as public spending on research, education, and innovation sector assistance rises (Gavurova et al., 2021). The 21st century has seen a global spread of technological advancements. Overcoming geographic borders, global and regional collaboration and coordination initiatives provide a glimpse of mutually beneficial trade, prosperity, and cooperation. One Belt One Road (OBOR) is a prospective global project for regional coordination and collaboration. Innovation is main motivator of economic growth by improving efficacy, creating new industries and expanding financial inclusion. Innovation boosts economic growth by increasing productivity and efficiency, which leads to more goods and services being produced (Bakari 2024). This in turn increases wages and business profitability, which can lead to

more investment and hiring. In addition to increasing their companies' headroom for expansion, creative business executives can alter the course of their industries by investing in daring inventions that open up new markets and customers and thus ignite new waves of industry growth.

The foundation of innovation and technological diffusion theory is economic innovation. This idea describes how innovation and the spread of technologies can be used by research and development to promote economic growth. According to this hypothesis, firms and entrepreneurs are more inclined to spend in research and the development of contemporary technologies since innovation gives them greater access to financial services (Adeleye 2023). Similarly, more technological opportunities help individuals and businesses to adopt latest innovations across various sectors. Automation, AI, and digital technologies enhance efficiency in industries like manufacturing and services. Tech-driven sectors like fintech, health tech, and e-commerce generate employment and attract investment. Countries that invest in R&D and innovation improve their position in global markets. China's Tech Companies like Alibaba, Tencent, and Huawei have driven digital transformation and global competitiveness. Singapore's Government investments in AI and IT have created a high-tech economy. Economic openness facilitates the importation and adoption of technological breakthroughs from trading partners with higher productivity hence increasing the growth rate (Karras 2023). Since the tourism industry is one of the biggest and fastest-growing socioeconomic sectors, it offers practically every nation in the globe substantial chances to attain overall economic growth. Numerous studies, like those by Hardi et al. (2023) and Shan and Wilson (2021) explore the correlation between commerce and tourist flows. Due to the volume of foreign visitors, the tourism industry helps to generate foreign exchange earnings. The process of economic expansion proceeds more smoothly and steadily as a result of the rise in foreign exchange earnings. By generating many opportunities for employment in economy, the tourism industry indirectly lowers the unemployment rate (Ady et al., 2022). The application of technical and intellectual advancements greatly benefits tourists worldwide. Denmark (Dueholm et al. 2014) and Korea (Chung et al. 2021) have several intriguing examples. The technology and information readiness of tourists varies, and as a result, so does their propensity to embrace innovation (Chung et al. 2015). The induced method, known as the tourism sector's economic impact, gauges GDP and employment supported by individuals who work in the tourism industry directly or indirectly (Ozturk et al. 2019). According to study, the region's export earnings and tourism receipts boost GDP (Ozturk et al. 2019).

Two fundamental ideas are included in trade openness: high trade volumes and minimal trade barriers. Trade openness promotes businesses to increase efficiency through economies of scale, which furthers economic expansion in addition to facilitating resource reallocation (Grossman and Helpman, 1993). By placing a strong emphasis on exports, economies can focus on sectors in which they have a comparative advantage. For nearly two decades, Singapore has kept its tariff rate below 1%, and other members have consistently reduced their tariff rates as well. Between 2000 and 2020, the average ASEAN tariff rate decreased from 7.99% to 3.97% (Mitra et al., 2021, Kim et al., 2011, Nam et al., 2024). Trade openness reducing barriers to imports and exports stimulates economic expansion by enhancing competition, efficiency, and access to global markets. The state's trade openness also reflects a nation's comparative advantage when it comes to investment. Increased trade & investment fueled rapid economic expansion (Iftikhar et al., 2025). Open trade policies attract multinational companies, boosting capital inflows and technology transfer. Exposure to international competition forces businesses to improve efficiency and innovation (Saleem et al., 2020). Countries can specialize in high-value industries, reducing dependence on a single sector. South Korea's Export-Led Growth, increased trade and investment fueled rapid economic expansion. ASEAN Free Trade Agreements and regional trade pacts

have boosted intra-Asian trade and economic integration. The theories of endogenous growth highlight that by reallocating inputs of production to industries with comparative advantages in trade, a more openness of trade policy encourages allocative improvement of investment and consequently economic growth. Additionally, Edwards (1992) notes that a nation with greater economic stability can grow more quickly by assimilating modern technology more quickly than a nation with less openness. The more trade openness, the more technology flows from the leader to the follower. A faster rate of technology absorption and diffusion aids in the accumulation of technical and human capabilities that ultimately contribute to growth over time (Adhikari et al., 2020). A nation's comparative advantage in terms of investment is also shown by its degree of trade openness. According to Grossman & Helpman (1991), a nation with a higher degree of openness is better able to absorb technological advancements made in the world's most developed nations, which causes it to grow faster than nation with a lower degree of openness. Furthermore, a nation running higher degree of economic openness, grows and develops more quickly because it adopts new technologies more quickly as compared to a nation with a lower degree of openness (Edwards 1992).

Table. No1

Countries	GDP Annual Growth Rate	Inflation Rate
China	5.4	-0.1
Japan	1.7	3.6
South Korea	-0.1	2.1
Malaysia	4.4	1.4
Singapore	3.8	0.9
Thailand	3.1	-0.22
Indonesia	-0.98	1.95
Hongkong	1.9	1.4

When businesses invest in R&D, they develop new production methods that lower costs. This can reduce prices over time, leading to lower inflation. Technological advancements make high-quality products more affordable (Hadi et al., 2024). When innovation leads to new products (e.g., electric vehicles, 5G technology), increased demand can push up prices before supply catches up. Some R&D-driven industries (e.g., pharmaceuticals, semiconductor technology) may experience price hikes due to high research costs and intellectual property protections (patents). R&D generally lowers inflation in the long run by increasing productivity and efficiency but may cause short-term price increases in high-tech sectors.

Literature review

The effects of tourism and technical advancement on economic growth have been the subject of numerous empirical investigations. Most research focused on the role that trade openness and tourism have in economic growth. Other studies examined the relationship between tourism, trade openness, innovation, and economic expansion, while others examined the Panel ARDL and quantile regression models.

Ozturk et al., (2019) examined the link between ASEAN member nations' tourism industries and economic expansion. The most accessible technique for researching the shared traits of nation group's panel data was applied. There are significant relationships between GDP, export, and tourism, according to results of panel data analysis conducted using E Views. However, the GDP is not significantly

impacted by foreign direct investment. The ASEAN countries' diverse economies may be the reason for the low export and tourism coefficients. While some ASEAN nations focus on tourism, others are more focused on exports.

Gallego et al. (2022) examined how commerce and tourism are related in OECD nations. For the OECD case study, they used dynamic heterogeneous panel data approaches, such as DOLS and FMOLS, to examine both short & long-term relationships. The findings indicate a beneficial long-lasting association in between trade and tourism. The findings also indicate that trade and tourism have a short-term link and are cointegrated. They discovered that tourism can boost global trade and that the movement of products across borders necessitates and may stimulate traveler arrivals and departures.

Rodriguez et al. (2020) examined if tourism stimulates economic expansion. The empirical study's foundation was a quarterly record of GDP and visitors arrival for 14 European-nations between 1995-2019. Both the standard panel cointegration model and the Pedroni and Ergemen panel fractionally cointegrated models were used to estimate the association between log (GDP) and log (tourism). Tourism and economic growth have a weakly positive long-term correlation, according to data, with the case being slightly stronger for years 2007–2010, prior to the global financial and economic crisis.

Gavurova et al., (2021) investigates, from a macroeconomic standpoint, the relationship between tourism expenditures and inventions. The research sample consisted of 36 countries that were members of the Organization for Economic Co-operation and Development (OECD) between 2010 and 2019. The analytical methods included robust panel regression and cluster analysis. According to the findings, initiatives for the expansion of the tourism sector should include innovations. These national innovation projects have the potential to boost tourism spending, which appears to have a favorable economic impact.

Ridwan et al., (2024) this study explores the complex relationships between tourism, globalization, technological development, and energy consumption in the most popular tourist destinations, US, Mexico, Austria, France, Germany, Greece, Italy, Spain, and the UK between 1990 and 2019. The research used the Panel Autoregressive Distributive Lag Model (ARDL) in conjunction with Quantile Regression techniques to examine the intricate interactions between the explanatory and dependent variables. The findings show that energy consumption in the popular tourist area rose as a result of globalization, technical advancement, and economic expansion. Conversely, it was shown that energy usage was negatively correlated with both tourism and trade openness.

Zheg et al., (2024) investigates the relationship between CO2 emissions, trade openness (TR), corruption (IQ), ecological innovation (EI), financial development (FD), economic policy uncertainty (EPU), and natural resource rent (NRR). From 2003 to 2021, the Organization for Economic Cooperation and Development (OECD) member countries provided them with longitudinal data. The causality test results showed that while trade openness, foreign direct investment, and strict environmental rules also have reciprocal links with ED, FD and corruption did.

Rigelsky et al., (2022) purpose of their study is to evaluate the relationships between visitor expenditure in a sample of affluent nations and technical innovation and knowledge. Their study used annual data from a subset of 36 OECD nations from 2010 to 2019. Significant negative correlations were found between the indices of knowledge generation and visitor exports, as well as between the distribution of information and domestic tourism spending, according to the panel regression analysis.

Elfaki and Ahmed (2024) their study aims to explore the impact of globalization innovation and adoption on green, sustainable economic growth in a selection of Asian Pacific countries (Malaysia, Indonesia, Singapore, Philippines, Thailand, Japan, India, Korea, China, New Zealand, and Australia) by combining

digital technology adoption (digitalization and digitization), globalization, and environmental quality. The Hausman test indicates that digital technology adoption boosts economic growth in Asian Pacific countries. It was found that the favorable effects of globalization on the economic development of Pacific countries were minimal.

Rafique et al., (2025) the purpose of this study is to look into how investments, innovation, and growth relate to the blue economy in Southeast Asia. From 2010 to 2023, eight countries in Southeast Asia are the subjects of the study. The pooled mean group (PMG) is used in this work to take Southeast Asian cross-country heterogeneity into consideration. Cointegration checks, cross-sectional independence checks, and panel unit root tests are a few statistical estimate methods. The results show that the most important factor influencing the blue economy's growth is trade openness.

Senar and Delican (2019) investigated the causal linkage between innovation, competitiveness and foreign trade for 31 developed and 26 developing states using panel causality between 2007 and 2017. Their results found that the innovations, trade and competitiveness in developed as well as in developing countries can enhance economic growth. At the end they suggest some implications for experts to improve innovations and trade among countries.

Bakari (2024) investigates the effects of trade openness, labor, capital, digitalization, financial development, and natural resources on economic growth in 17 East Asia-Pacific countries between 2004 and 2023. Through the use of descriptive statistics, correlation analysis, the Generalized Method of Moments (GMM), the Static Gravity Model and Two Stage Least Squares (2SLS), the study offers significant insights into the local economy. While digitization and natural resources have little to no impact on economic success, the results of the Static Gravity Model and GMM confirm the critical roles that labor, capital, financial development and trade openness play.

Ozturk et al., (2019) examined connection between ASEAN countries' tourism sector and economic expansion. Panel data analysis is utilized for it. The unit root and ADF-Fisher Chi-square PP were applied. The statistical software Eviews 8 was used to analyze the panel data. The analysis's findings indicate that the relationships between GDP, exports, and tourism are statistically significant. However, the GDP is not significantly impacted by foreign direct investment.

Ady et al., (2022) investigated the effects of growing sustainable tourism on emerging countries' economic development. From 1991 to 2020, they used secondary data collected from the World Development Indicators (WDI). Using the Quantile Autoregressive Distributed Lag (QARDL) model and the Augmented Dickey-Fuller (ADF) test to determine the unit root, they examined the relationship between the variables. The findings demonstrated a positive relationship between economic growth and foreign direct investment, inflation, international tourism earnings, expenditures and arrivals and departures.

Hardi et al., (2023) studied economic expansion and innovation on top five economies in Southeast Asia. Innovation has a major impact on economic growth, according to both panel analysis and country-specific evaluations. Innovation has major impact on economic growth, according to panel analysis and country-specific evaluations. The findings show that in order to boost economic growth, innovation-friendly policies that remove obstacles to innovation, focus investments, and support education and skill development must be put into place immediately.

Iftikhar et al., (2025) explore the relation of trade openness (TO) and innovation in driving of total factor productivity (TFP) on D-8 and BRICS nations. Strong econometric methods are used in the study to overcome panel data issues. A heterogeneous analysis is also included in the study to take into consideration the variations in the developmental contexts of the D-8 and BRICS nations. The findings

highlight the importance of integrating trade and innovation policy by showing that TO positively affects TFP for both groups. The study's useful suggestions can be used by policymakers to tailor trade and innovation strategies for the D-8 and BRICS countries.

Econometric Analysis

Data set and variables

The data set used in the analysis covers 88 observations for the economic growth and the tourism receipts for the period from 2012 to 2022 of the selected 8 East-Asia Pacific Economies. Economic growth, which represents with GDP (annually %) was defined as the dependent variable of the model, while trade-openness and tourism which represents with TO (number of arrivals) and TR (% annually) as the independent variables. The dataset was obtained from the World development indicators database.

Table:2 Variables, Source and Description

Variables	Description	Logarithm form	Unit of measurement	Source
GDP	Economic Growth (GDP)	LGDP	GDP (Annual %)	WDI
R&D	Research and Development	LR&D	R&D (per year)	WDI
TO	Tourism	LTO	Tourism (number of arrivals per year)	WDI
TR	Trade	LTR	Trade (Annual %)	WDI
INF	Inflation	LINF	Inflation (consumer prices)	WDI
L	Labor	LL	Labor force participation rate, total (% of total population ages 15-64) (modeled ILO estimate)	WDI
K	Capital	LK	Gross fixed capital formation (% of GDP)	WDI
HC	Human capital	LHC	School enrollment, tertiary (%gross)	WDI

Sample of East Asia Pacific countries

China, Japan, Korea republic, Hongkong, Malaysia, Thailand, Indonesia, Singapore

Source: Authors construct (2025)

Methodology

An economic equation is presented economic growth was used as the dependent variable, R&D, TO, TR were used as the independent variables, and INF was used as the control variable.

The typical form, as stated below, serves as the basis for the production function used in this study.

$$EG = f(INO, TOR, TR, INF, L, K) \dots\dots\dots (1)$$

GDP are taken as a proxy for economic stability

R&D taken as a proxy for innovations so the model can be shown as

$$GDP_{t,i} = f(R\&D_{t,i}, TO_{t,i}, TR_{t,i}, INF_{t,i}, L_{t,i}, K_{t,i}, \mu_{t,i})$$

Where i stands for nation, t for time, GDP for real GDP, which is an indicator of total output, L for labor force, and K for physical capital.

In this work, we used dynamic panel regression model that links GDP to R&D, TO, TR, and INF as control indicator:

Econometric Model

Model 1

$$GDP_t = \beta_1 + \beta_2 R\&D_t + \beta_3 TO_t + \beta_4 TR_t + \beta_5 INF_t + \beta_6 L + \beta_7 K + \mu_t \dots\dots\dots (2)$$

Equations (1) and (2) are combined to provide the moderating impact assessment equation.

Model 2

Moderating effect: R&D*HC, TOR, TR, INF, L, K on GDP

$GDP = f(R\&D*HC, TOR, TR, INF, L, K)$

$$GDP = \beta_1 + \beta_2 R\&D*HC + \beta_3 TO_t + \beta_4 TR_t + \beta_5 INF_t + \beta_6 L + \beta_7 K + \mu_t \dots (3)$$

$$\Delta \ln GDP_{i,t} = \alpha + \beta \Delta \ln R\&D_{t,i} + \phi \Delta \ln TO_{t,i} + \delta \Delta \ln TR + \vartheta \Delta \ln INF_{i,t} + \rho \Delta \ln L_{i,t} + \gamma \Delta \ln K_{i,t} + \mu_{i,t} \dots (4)$$

In this case, α stands for constant, β for research and development output elasticity, ϕ for tourism output elasticity, δ for trade output elasticity, ϑ for inflation output elasticity, ρ for labor output elasticity, γ for capital output elasticity, and μ for the residual term. The operator of difference, denoted by Δ , indicates a proportionate change rate, whereas the logarithm, represented by $\ln$, is used to convert the series.

Model 1

Model 2

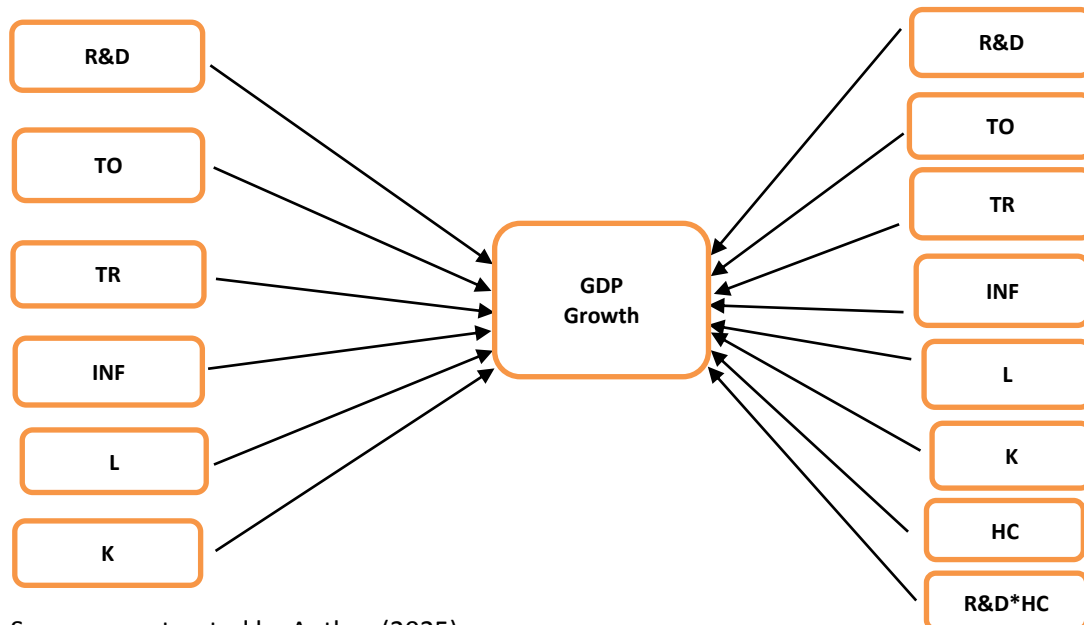


Fig:1: Source: constructed by Author (2025)

Unit root tests on panels are comparable to those on a single series. For panel data, the ADF model can be stated as follows:

$$\Delta x_t = \beta + \sum_{i=1}^n \Delta x_{t-1} + e_t \dots (5)$$

Standard Panel Cointegration Test

PPedroni (2001) proposed the associated estimator of the panel cointegration relationship, whereas Erdori (1999, 2004) proposed the (standard) panel cointegration test. The test is a panel configuration variation of the Engle and Granger (1987) cointegration test. Specifically, take into account allowing for different trend coefficients and intercepts across cross-sections.

Panel PMG/ARDL Test

Pesaran et al. (1999) proposed the panel mean group auto-regressive distributed lags (PMG/ARDL) model, which was applied in this investigation. This model is used when there is no $I(2)$ but the variables are stationary at $I(0)$, $I(1)$, or both. This is now admissible in this study since the variables are either stationary at levels, at first difference, or both, as shown by the results of our unit root tests in Table

4. This econometric model examines the variables' short- and long-term relationships. The lagged values of the dependent variables are represented by the AR component in the ARDL model. There are numerous benefits to this relatively new approach over traditional co-integration tests.

Findings and discussions

Descriptive statistics

Table 3 presents the results of the summary statistics. Out of the entire sample, the region's GDP has the highest standard deviation, while trade has the lowest. Examining variables and completely comprehending their properties—such as mean, skewness, minimum and maximum values, standard deviation, etc.—begins with this inquiry. With a mean value of 16.54819, LTR has the highest value among all the variables. On the other hand, LR&D has the lowest average value. Similarly, the median values with the highest value (16.43825). Every variable exhibits positive skewness in this regard.

Table. 3 Results of descriptive statistics

	LGDP	LR&D	LTOR	LTR	LINF	LL	LK	LHC
Mean	0.9560770	0.023827	16.54819	4.639710	0.488829	4.270831	3.283346	0.208771
Median	1.487119	0.214010	16.43825	4.658828	0.693211	4.265324	3.237733	0.002623
Maximum	2.675510	1.650735	19.35202	6.092712	2.573274	4.400726	3.795911	0.053351
Minimum	6.544768	3.593933	14.37547	2.973466	3.685504	4.152834	2.776940	6.074846
Std. Dev.	1.583779	1.242872	1.095174	0.894625	1.047866	0.062550	0.218538	0.903812
Skewness	2.562387	1.123969	0.524480	0.131778	0.865585	0.021624	0.533109	4.837476
Kurtosis	10.29061	3.636407	2.731684	1.779786	4.292584	2.009366	3.003151	25.85250
Jarque-Bera	635.3309	43.66588	9.378495	12.46707	37.34179	7.865804	9.094651	4926.732
Probability	0.000000	0.000000	0.009194	0.001962	0.000000	0.019587	0.010596	0.000000
Sum	183.56674	5.74849	3177.252	890.8244	93.85522	819.9995	630.4023	40.08401
Sum Sq. Dev.	479.0962	295.0436	229.0865	152.8676	209.7226	0.747299	9.121911	156.0234
Observations	192	192	192	192	192	192	192	192

Source: Authors Construct (2025)

Multi-collinearity problems between the variables are not present, according to the correlation matrix, which is displayed in Table 3. Since all correlations are less than 0.80, it may be concluded that the

variables are not overly collinear. In economic interactions, capital and trade openness play more robust and steady positive functions.

Table: 4 Correlation matrix results

	LGDP	LR_D	LTOR	LTR	LINF	LL	LK	LHC1
LGDP	1							
LR_D	-0.1928	1						
LTOR	0.2521	0.100647	1					
LTR	0.0374	-0.013715	0.0096756	1				
LINF	0.3363	-0.3972581	-0.0480053	0.0006359	1			
LL	-0.0989	0.1384994	0.344373	-0.218329	-0.203880	1		
LK	0.3066	0.2075166	0.3821478	-0.526634	0.103726	0.183961	1	
LHC1	0.1405	-0.198497	0.1946557	0.3192258	0.2655388	-0.0659229	0.0068767	1

Source: Authors Construct (2025)

Panel unit root test Results

Before looking at the inferential estimation among the variables, it is necessary to look at their time series qualities. This was an appropriate use of the panel ARDL, which is suitable for strictly I (0) and strictly I (1) variables but not for I (2) variables. The Phillip-Perron (PP, 1988) and Augmented Dickey Fuller (ADF, 1979) tests were among the panel unit root tests that were performed (Sohag et al., 2015). While LGDP and LHC are stationary at level, the LR&D, LTOR, LTR, and LINF variables are stationary at the first difference in the ADF test, the table indicates. The PP test shows that LGDP, LINF, and LHC are stationary at level, while LR&D, LTOR, and LTR are stationary at the first difference. Based on these unit root results, the variables are of mixed stationary, or I (0) and I(1) processes, which fit the PMG/ARDL model.

Table: 5 Results of Panel unit root test

Variables	ADF			PP		
	Level	1 st Difference	Decision	Level	1 st Difference	Decision
LGDP	0.0001		I(0)	0.0000		I(0)
LR&D		0.0000	I(I)		0.0008	I(I)
LTOR	0.8763	0.0000	I(I)	0.9300	0.0000	I(I)
LTR	0.1993	0.0000	I(I)	0.5124	0.0000	I(I)
LINF	0.0185	0.0000	I(I)	0.0000		I(0)
LL	0.9847	0.0000	I(I)	0.9868	0.0000	I(I)
LK	0.0460	0.0000	I(0)	0.0792	0.0000	I(I)

LHC	0.0000	I(0)	0.0000	I(0)
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Source: Authors Construct (2025)

Panel cointegration tests

Once the mixed stationary status of the variables was established by the panel unit root test, we employed the Pedroni (1999) and Kao (1999) panel co-integration tests to examine the co-integrating relationship between the variables. The features of residual-based tests for the null hypothesis of no co-integration for dynamic panels, in which individual panel members are permitted to have distinct short-run dynamics and long-run slope coefficients, are examined by Pedroni (1999). Both pooled within-dimension testing with individual intercepts and group mean between-dimension tests are considered in the Pedroni test. According to the Kao residual panel co-integration test, the null hypothesis that there is no co-integration is rejected, as indicated in Tables 5 and 6.

Table: 6 Pedroni cointegration test result

	<u>Statistic</u>	<u>Prob.</u>	<u>Statistic</u>	<u>Prob.</u>
Panel v-Statistic	1.413404	0.0788	-0.897757	0.8153
Panel rho-Statistic	-1.345233	0.0893	-0.339380	0.3672
Panel PP-Statistic	-7.460258	0.0000	-9.224047	0.0000
Panel ADF-Statistic	-1.732446	0.0416	-3.912090	0.0000
Between-dimension				
	<u>Statistic</u>	<u>Prob.</u>		
Group rho-Statistic	-0.193124	0.4234		
Group PP-Statistic	-20.18482	0.0000		
Group-ADF-Statistic	-3.420065	0.0003		

Source: Authors Construct (2025)

Table: 7 Kao test results

ADF	t-Statistic	Prob
	1.950750	0.0255

Dynamic results of Pooled Mean Group

After verifying cointegration between the variables using the Pedroni test, this study employed the Pool Mean Group (PMG) estimator to further examine the long-term relationship between innovations, tourism, and trade on economic growth (Nayede 2023). For the entire area sample, Table 7 demonstrates a significant positive correlation between economic growth and inventions, tourism, and trade. This implies that any expansion in trade, tourism, and innovation will boost economic growth.

Table: 8 Results of Dynamic pooled Mean group

Long Run Results				
	Model 1		Model 2	
Variables	Coefficient	Std. Error	Coefficient	Std. Error

Error-correction	-0.7075***	0.2130	-0.7864	0.1704
LR&D	0.2640***	0.0922		
LTOR	0.2949***	0.0790	0.2321**	0.0921
LTR	0.2351**	0.1081	0.6847**	0.2980
LINF	0.3496***	0.0852	0.1976**	0.0861
LL	0.2968***	0.0826	0.2608***	0.0890
LK	0.4827***	0.0487	0.6745*	0.3913
LR&D*LHC			0.64221**	0.2990
Short run Results				
D(LR&D)	0.2581**	0.1092		
D(LTOR)	0.8390***	0.1242	0.3903***	0.0816
D(LTR)	0.2967***	0.0876	0.1424*	0.0813
D(LINF)	0.4520***	0.1005	0.1976**	0.0861
D(LL)	0.2754**	0.1077	0.6422**	0.2990
D(LK)	0.2772**	0.1229	0.3903***	0.0816
D(LR&D*LHC)			0.4217***	0.0845
Source: Authors Construct (2025)				

Long run results

There was a long-term equilibrium link between the two models, as evidenced by the statistically significant negative error correction term (ECT). The ECT of -0.7075 in Model 1 indicates that almost 71% of disequilibrating motions are eliminated each cycle. Since -0.7864 denotes a 79% speed to equilibrium; it records a higher adjustment rate in Model 2. The dependent variable in Model 1 is positively and significantly impacted by LR&D (coefficient = 0.2640), suggesting that more R&D improves long-term economic success.

In all models, LTOR has a positive and significant relationship with the dependent variable (Model 1, 0.2949; Model 2, 0.2321), indicating that more trade openness eventually fosters economic growth. Additionally, both models exhibit a positive and substantial effect from LTR, with Model 2 showing a greater impact (0.6847) than Model 1 (0.2351). This implies that tourism has a beneficial impact on long-term growth. In both models, the dependent variable has a positive relationship with inflation.

This outcome would suggest that growth is accompanied by mild inflation, even though it is usually a negative influence. In both models, labor exhibits a strong and significant positive effect, suggesting that labor plays a large role in both models' long-term productivity. In Model 1, capital has the strongest

long-term influence (0.4827), while in Model 2, its coefficient is much bigger (0.6745). R&D and human capital (LHC) have a positive and statistically significant relationship in Model 2 (0.6422). This suggests that human capital and R&D work together to improve long-term economic growth more than R&D works alone.

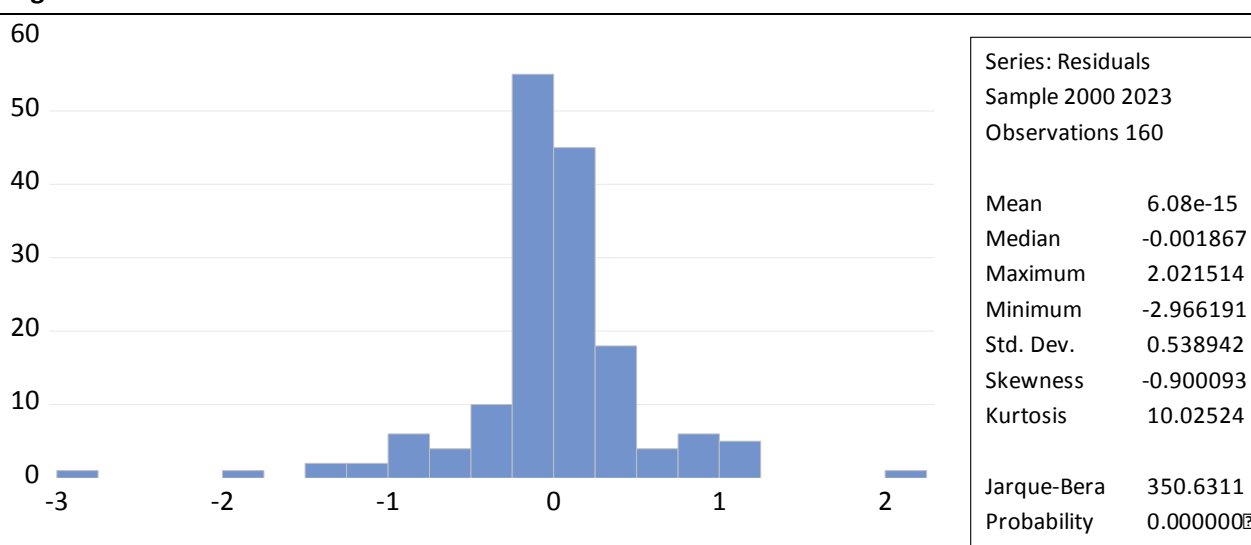
Short run results

R&D also has positive short-term impact in Model 1 (0.2581), indicating that innovation has immediate effects in addition to its long-term benefits (Gardezi & Samar Abbas, 2021; Godil et al., 2020; Wang, 2023). Trade openness has strong-significant short-term impact in both models Model 1 (0.8390), Model 2 (0.3903), supporting its dynamic role in boosting short-run growth (M. Asghar et al., 2022; Ismahene, 2022; Önder & Sunel, 2021; Tran, 2023). Tourism contributes positively in the short run too, though the impact is slightly reduced in Model 2 (Godil et al., 2020; Khoshnevis Yazdi et al., 2017). Inflation remains significant and positive. Labor has a statistically significant impact in both models in the short term as well, particularly in Model 2 (0.6422), emphasizing the responsiveness of labor to short-run growth (Farooq et al., 2020; Önder & Sunel, 2021). Capital has a consistent positive short-run impact, further underlining its vital role (Asghar et al., 2020; Farooq et al., 2022; Yang, 2020). The interaction term in Model 2 (0.4217) is also significant in the short run, indicating that synergistic effects for R&D and human capital contribute not only to long-run but also to immediate growth improvements.

Interaction term between LR&D and HC has statistically significant long-run impact. All variables exert positive and economically meaningful long-run impacts. For faster sustained growth, R&D investments are multiplied by human capital. Investments or improvements in human skills and R&D synergies can push growth quickly. Similarly, as by shown in PMG/ARDL results (R&D*HC) significant short-run and long run results shows that immediate improvements in human capital or R&D collaboration trigger faster economic growth responses as shown by results of long run and short run by model 2. The interplay between (LR&D) and human capital (HC) is especially important for maximizing growth outcomes.

The images of fig 3 show a residual plot from a regression analysis with the residuals of the log of GDP (LGDP) over time or observations. The residuals oscillate around the zero line, which is expected in a well-fitted regression model.

Fig: 3 Result of Residuals



Source: Authors constructed (2025)

Conclusion and policy implications

Using panel causality and panel cointegration methodologies, the study has attempted to examine the relation between R&D and tourism and commerce of eight countries in East Asia-Pacific region. For the 2000–2023 data, the panel cointegration and panel causality approaches were applied. In this regard, ADF&PP tests have been used to examine the series degree of stationary level (Erdel and Gocer 2015). Additionally, unit root and correlation analysis have been examined. Both at level and on the first difference, every variable is stationary. So it was mixed stationarity levels then we apply PMG/ARDL method for long & short run analysis. From long run results obtained from the PMG/ARDL, innovations, tourism and trade is found to have positive impact on economic growth of East Asia Pacific countries. Overall, the results reveal that both in the short & long run, R&D, trade openness, tourism, inflation, labor, and capital significantly affect economic growth. Notably, the interaction between R & D and human capital (Model 2) enhances growth outcomes more effectively than R&D alone. This underscores the importance of investing not only in innovation but also in human capital development to maximize economic performance. As a result, any expansion of the commerce, tourism, and innovation sectors in East Asia Pacific nations boosts regional economic growth. The study came to the conclusion that economic growth is positively impacted by the variables used. The findings demonstrated that research and development significantly increased GDP. This means that advancement of system in innovations, tourism and trade system in East Asia Pacific countries makes it possible for acquiring fast economic growth. When combined, these components are critical to a nation's economic growth and GDP growth. According to the study's findings, policymakers should implement the following methods to boost commerce and tourism, and government should allocate sufficient funds for R & D carried out in the public sector.

1. In order to profit from commerce with outside world in area of innovation and economic growth, countries should promote their economic openness policies by implementing reform measures at different levels.
2. By increasing research and development expenditures and safeguarding intellectual property rights, efforts should be made to foster an atmosphere that encourages innovation.
3. Expand technical and vocational training to align with innovation and industry needs.
4. Adopt a balanced monetary policy that supports growth without allowing inflation to rise uncontrollably.
5. Reduce barriers to labor market participation, promote flexible work policies and strengthen labor market institutions to ensure fair wages.
6. Adopt a balanced monetary policy to ensure food and energy price stability through targeted subsidies and buffer stocks.
7. Establish and strengthen regional trade agreements and encourage export diversification to reduce dependence on a few commodities or partners.

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