

INDUSTRIALIZATION, URBANIZATION, TOURISM, AND INSTITUTIONAL QUALITY IN ECONOMIC GROWTH: AN FE-DKSE MODEL ANALYSIS IN CENTRAL VIETNAM

CÔNG NGHIỆP HÓA, ĐÔ THỊ HÓA, DU LỊCH VÀ CHẤT LƯỢNG THỂ CHẾ TRONG TĂNG TRƯỞNG KINH TẾ: PHÂN TÍCH BẰNG MÔ HÌNH FE-DKSE TẠI MIỀN TRUNG VIỆT NAM

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Abstract - This study investigates the impacts of industrialization (IND), urbanization (URBAN), tourism, and institutional quality (PCI) on economic growth in 11 provinces of Central Vietnam during 2009-2024. Employing a Fixed Effects Model with Driscoll-Kraay standard errors (FE-DKSE), the analysis accounts for heteroskedasticity, serial correlation, and cross-sectional dependence in panel data. Results indicate that both IND and URBAN significantly promote growth, with IND as the primary driver while URBAN enhances resource allocation and market expansion. Tourism is identified as an additional growth engine, though its effectiveness diminishes at higher urbanization levels. PCI improves the business environment but does not produce a clear threshold effect. These findings highlight the need for an integrated strategy linking IND, URBAN, tourism, and institutional reforms to foster sustainable regional growth in Central Vietnam.

Keywords - Industrialization; urbanization; tourism; institutional quality; FE-DKSE

1. Introduction

Over the past three decades, industrialization (IND) and urbanization (URBAN) have emerged as two central drivers of economic growth and the reconfiguration of development space in transition economies, particularly in Southeast Asia. According to endogenous growth theory, the combination of physical capital accumulation, human capital, and institutional improvement plays a decisive role in sustaining long-run development [1], [2]. In Vietnam, IND and URBAN not only drive structural transformation in the economy but are also integrally linked to tourism (TOUR) development strategies, thereby shaping regional spatial structures and enhancing competitiveness.

Strategically positioned as an economic corridor linking the North and the South and serving as a key trade gateway, Central Vietnam also possesses rich natural resources and a distinctive cultural heritage. It therefore plays an important role in the country's sustainable development strategy. During the period 2009-2024, the region witnessed a number of positive changes in IND, URBAN, and TOUR development. However, development has remained uneven, as reflected in differences across localities in economic scale, income levels, the pace of IND, the quality of URBAN, the capacity to attract TOUR, and institutional

Tóm tắt - Nghiên cứu này phân tích tác động của công nghiệp hóa (CNH), đô thị hóa (ĐTH), du lịch và chất lượng thể chế (PCI) đến tăng trưởng kinh tế tại 11 tỉnh miền Trung Việt Nam giai đoạn 2009-2024. Sử dụng mô hình hiệu ứng cố định với sai số chuẩn Driscoll-Kraay (FE-DKSE), nghiên cứu xử lý đồng thời hiện tượng phương sai thay đổi, tự tương quan và phụ thuộc chéo trong dữ liệu bảng vùng. Kết quả cho thấy, CNH và ĐTH đều có tác động tích cực, trong đó CNH giữ vai trò trụ cột, còn ĐTH hỗ trợ phân bổ nguồn lực và mở rộng thị trường. Du lịch được xác nhận là động lực bổ sung nhưng hiệu quả giảm dần khi mức độ ĐTH tăng cao. PCI góp phần cải thiện môi trường kinh doanh song chưa tạo ra hiệu ứng ngưỡng rõ rệt. Phát hiện này nhấn mạnh sự cần thiết của chiến lược phát triển tích hợp CNH-ĐTH gắn với du lịch và cải thiện thể chế, nhằm hướng tới tăng trưởng bền vững tại miền Trung.

Từ khóa - Công nghiệp hóa; đô thị hóa; du lịch; chất lượng thể chế; FE-DKSE

quality. Although the Government has implemented various regional development programs, fundamental challenges persist, including governance constraints, high transaction costs, and vulnerability to macroeconomic fluctuations, as reflected in the consumer price index (CPI). Addressing these limitations is not only important for regional economic growth but also decisive for the national objective of balanced and sustainable development.

From a theoretical perspective, IND, URBAN, and TOUR may reinforce one another in promoting growth through the expansion of production, improved resource efficiency, and stimulation of domestic demand. However, these effects depend on institutional quality - measured by PCI - to ensure transparency, reduce informal costs, and encourage competition. In addition, CPI reflects macroeconomic stability, thereby moderating the quality of growth.

Although numerous studies have examined the relationships among IND, URBAN, institutions, and growth, most have focused on the national level or have not sufficiently exploited an interregional perspective. Empirical evidence for Central Vietnam remains limited, particularly in the context where 11 provinces - now constituting a unified analytical unit following the 2025 administrative reorganization - have not been jointly

examined. Moreover, many previous studies have primarily applied pooled OLS or conventional FEM/REM approaches, paying limited attention to heteroskedasticity, serial correlation, and cross-sectional dependence - features that are common in regional panel data.

2. Theoretical background of the study

2.1. Theoretical foundations related to the research topic

The relationships among IND, URBAN, TOUR, institutions, and economic growth are grounded in development theory. The model of [3] treats capital, labor, and technology as the pillars of long-run growth; however, divergence in growth rates across countries gave rise to endogenous growth theory, in which innovation, human capital, and institutions serve as internal drivers [2], [4].

Within the structural transformation frameworks of [5] and [6], IND is identified as the core mechanism driving labor reallocation from low-productivity agriculture to higher-productivity industry and services, thereby generating spillover effects and enhancing competitiveness [7]. URBAN is explained by urban economics [8] and spatial concentration theories [9], which highlight agglomeration economies, lower transaction costs, and incentives for innovation; nevertheless, URBAN may also entail nonlinear consequences such as congestion, pollution, and inequality, as reported in [10], [11].

From a service-led growth perspective, TOUR contributes to economic growth through investment attraction, employment creation, and foreign-exchange earnings [12]. In developing economies, TOUR also serves as a tool for structural diversification [13], whereas the sustainability approach emphasizes balancing resource exploitation with cultural preservation [14].

Institutional quality, as argued in [15], shapes the “rules of the game” in the economy; furthermore, [16] and [17] affirm that inclusive institutions are a necessary condition for IND and URBAN to be effective. Study [18] contends that institutional differences explain growth better than investment or trade. At the subnational level, PCI captures transparency, land access, and public service quality, thereby directly influencing investment decisions and economic growth [19].

At the same time, macroeconomic stability is a foundational condition for long-run growth. Studies [20], [21], and [22] indicate that high inflation and price volatility reduce the efficiency of resource allocation, impede investment, and constrain growth. Accordingly, the consumer price index (CPI) is often used as a proxy for macroeconomic stability, because price fluctuations directly affect purchasing power, market confidence, and the orientation of monetary policy in an open economy.

Beyond the direct effects of individual factors, this study further considers interaction effects among development factors - an aspect that is important for regional analysis but has not been widely explored in the Vietnamese literature.

(i) Interaction between IND and URBAN ($IND \times URBAN$):

According to [9] and [10], IND and URBAN exhibit a bidirectional reinforcing relationship. IND generates

employment, attracts population inflows, and stimulates urban expansion; conversely, URBAN supplies the infrastructure, population density, and market scale necessary for IND to realize agglomeration economies. When these processes advance simultaneously, their impact on growth may exceed that of each factor in isolation. Therefore, the interaction term $IND \times URBAN$ is included in the model to test for synergistic or offsetting effects between these two drivers.

(ii) Interaction between URBAN and TOUR ($URBAN \times TOUR$):

Studies [12], [23], and [24] suggest that URBAN can promote TOUR development by improving infrastructure, transportation, and services; however, it may also reduce the effectiveness of TOUR when urbanization proceeds too rapidly, leading to congestion, pollution, and the loss of cultural identity. Accordingly, the interaction term $URBAN \times TOUR$ is used to test this nonlinear effect - namely, whether URBAN strengthens or weakens the positive impact of tourism on regional economic growth.

Including these interaction terms is not merely a statistical technique; it also reflects the nature of spatial spillovers and cross-sectional dependence in the development of Central Vietnam, where provinces are strongly interconnected through industry, urban systems, and services.

2.2. Review of related empirical evidence

International empirical studies provide multifaceted evidence on the roles of IND, URBAN, TOUR, and institutions in growth. Studies [25] and [26] confirm IND as a primary driver, while [27] warns that premature deindustrialization may have adverse effects in Latin America. Findings from [10] and [11] indicate that the impact of URBAN is nonlinear and depends heavily on infrastructure and governance. In addition, TOUR has been shown to be a leading sector in Spain [12], Latin America [13], and many emerging economies [28]; studies [29] and [30] emphasize the role of the tourism sector in post-COVID-19 recovery.

From an institutional perspective, [17] and [19] highlight the importance of inclusive institutions and local governance, whereas [31] argues that green industrialization is effective only under a transparent policy environment. Study [32] further adds that macroeconomic stability is a necessary condition for these factors to exert their effects.

In Vietnam, pre-2010 studies mainly focused on IND and structural transformation, such as [33]. In the subsequent period, many studies expanded to examine factors such as URBAN, institutions, and TOUR. Study [34] finds that foreign direct investment (FDI) promotes URBAN in Ho Chi Minh City. Regarding institutions, [35] shows that PCI positively affects FDI attraction, while [36] uses a GMM approach to confirm the role of PCI in explaining differences in provincial growth. More recently in Central Vietnam, [37] provides empirical evidence that IND and URBAN are key drivers of economic growth, while also clarifying the moderating roles of PCI and CPI in the context of regional development.

The above review indicates that the four factors - IND, URBAN, TOUR, and institutions - are all important;

however, most studies have examined them independently or within relatively simple linear frameworks. No study has simultaneously assessed interaction effects (IND × URBAN, URBAN × TOUR) within a model that incorporates an interprovincial perspective and cross-sectional dependence - features that characterize the provinces of Central Vietnam. This gap motivates the contribution of the present paper.

3. Research methodology

3.1. Analytical framework and model

The study's analytical framework is grounded in endogenous growth theory [1], [4], theories of urbanization and spatial/urban economics [8], and new institutional economics [15]. These theories suggest that regional growth depends not only on physical capital accumulation but also on institutional quality, the level of IND, the process of URBAN, and the ability to leverage service-sector advantages. In addition, macroeconomic stability - captured by the consumer price index (CPI) - plays an important moderating role by ensuring a favorable environment for investment and long-term development.

The framework emphasizes the relationships among four core factors and one macro-level control variable: (i) IND, (ii) URBAN, (iii) TOUR, (iv) institutional quality (PCI), and (v) macroeconomic stability (CPI). IND and URBAN are considered growth drivers in both extensive and intensive dimensions; TOUR is treated as a leading service sector with spillovers to investment, employment, and foreign-exchange earnings; PCI helps ensure transparency, competition, and efficient resource allocation; and CPI reflects the stability of the macroeconomic environment.

3.2. Research hypotheses

Based on the theoretical framework, the study formulates the following testable hypotheses:

- H1: IND has a positive effect on regional economic growth.
- H2: URBAN has a positive effect on regional economic growth.
- H3: TOUR has a positive effect on regional economic growth.
- H4: Institutional quality strengthens and enhances the positive effects of IND and URBAN on growth.
- H5: Macroeconomic stability moderates and reinforces the combined effects of the above factors on growth.

These hypotheses are tested using the fixed-effects model with Driscoll-Kraay standard errors (FE-DKSE), augmented with interaction terms (IND × URBAN, URBAN × TOUR) to assess both individual effects and synergy effects. Each hypothesis is either supported or rejected based on the sign, magnitude, and statistical significance of the corresponding estimated coefficients.

3.3. Research model specification

Based on the analytical framework and hypotheses, the study proposes the following general functional form:

$$\text{Ln}y = f(\text{ind_index}, \text{urban_index}, \text{tour}, \text{economic factors}, \text{social factors}..) + \varepsilon \quad (1)$$

Table 1. Variable definitions and data sources

Variable	Symbol	Definition/ Measurement	Data Source
Natural logarithm of GRDP per capita	lnpergrdp	GRDP per capita at constant 2010 prices, transformed using the natural logarithm (ln) to stabilize variance and interpret in percentage terms	[36]
Industrialization	cnh_index	Composite index of 11 weighted sub-indicators covering industrial scale, efficiency, labor structure, and human capital accumulation; normalized using min-max; weights assigned via Delphi/AHP or PCA; higher values indicate a higher degree of industrialization	[6], [7], [37], [38], Author's calculation
Weighted urbanization index	urban_index_w	Composite index of four components: urban population share (0.35), industrial labor share (0.35), service labor share (0.15), and trained labor share (0.15); normalized using min-max; Cronbach's Alpha = 0.732	[39], [40], Author's calculation
Institutional quality	pci	Provincial Competitiveness Index (PCI), reflecting transparency, quality of governance, and business environment	[41]
Inflation	cpi	Consumer Price Index (CPI), reflecting the macroeconomic environment	[36]
Tourism	lntour	Natural logarithm of tourism revenue (billion VND), representing tourism development	[36]

Building on prior studies [10], [12], [19], [25], and [37], the baseline empirical model using the variables in Table 1 (where i denotes province and t denotes year) is specified as:

$$\text{Lnpergrdp}_{it} = \beta_0 + \beta_1 \text{ind}_{it} + \beta_2 \text{urban}_{it} + \beta_3 \text{pci}_{it} + \beta_4 \text{cpi}_{it} + \beta_5 \text{lntour}_{it} + \varepsilon_{it} \quad (2)$$

To evaluate synergy effects, the study extends the model by adding interaction terms:

$$\text{Lnpergrdp}_{it} = \beta_0 + \beta_1 \text{ind}_{it} + \beta_2 \text{urban}_{it} + \beta_3 \text{pci}_{it} + \beta_4 \text{cpi}_{it} + \beta_5 \text{lntour}_{it} + \beta_6 (\text{Ind} \times \text{Urban})_{it} + \beta_7 (\text{Urban} \times \text{Tour})_{it} + \varepsilon_{it} \quad (3)$$

Model (2) tests the standalone effect of each factor, while model (3) examines interaction effects that reflect synergistic or offsetting relationships among IND, URBAN, and TOUR.

3.4. Estimation method

In panel-data analysis, ordinary least squares (OLS) is commonly adopted as a benchmark estimator; however, its classical assumptions are frequently violated when applied to

regional data exhibiting spatiotemporal features. Preliminary diagnostics indicate that OLS violates assumptions of heteroskedasticity (reflecting differences in provincial scale), serial correlation (due to time-dependent economic shocks), and cross-sectional dependence (reflecting economic linkages and spatial spillovers among Central Vietnamese provinces). To address these violations, the study considers generalized least squares (GLS) to adjust the error covariance structure and improve estimation efficiency.

However, conventional GLS typically assumes a homoskedastic or known covariance matrix - an assumption that is difficult to justify under complex cross-sectional dependence. Therefore, the study employs the FE-DKSE proposed by [44], which simultaneously corrects for heteroskedasticity, serial correlation, and cross-sectional dependence without imposing a specific error structure. This approach is particularly well-suited to panels with a small cross-sectional dimension but a relatively long time dimension ($N = 11, T = 16$), thereby yielding more robust and reliable statistical inference. FE-DKSE not only improves precision relative to conventional models but also better reflects spatial linkages and temporal persistence across provinces, providing a consistent framework for analyzing regional growth dynamics in Central Vietnam.

This approach removes bias arising from time-invariant provincial characteristics while ensuring robust standard errors - well suited to a context in which IND, URBAN, and TOUR exhibit strong spillover effects. FE-DKSE has also demonstrated effectiveness in international studies [44], [45].

3.5. Diagnostic tests and model robustness

To ensure reliability, the study conducts key diagnostic tests for panel data. First, the Hausman test is used to choose between the fixed-effects model (FEM) and the random-effects model (REM); FEM is appropriate when province-specific effects are correlated with explanatory variables. Next, the Modified Wald test detects heteroskedasticity, while the Wooldridge test assesses serial correlation in the error process - a common issue in time-series panel data.

The results indicate the simultaneous presence of heteroskedasticity, serial correlation, and cross-sectional dependence; therefore, FE-DKSE is selected to control for fixed provincial heterogeneity while ensuring robust standard errors.

To strengthen robustness, the study conducts sensitivity checks. Robustness is further assessed by replacing key variables with alternative proxies - for instance, substituting the industrial share of GRDP for the IND composite index, or tourist arrivals for TOUR revenue. In addition, FE-DKSE is compared with REM-PCSE, which also addresses heteroskedasticity and serial correlation. Consistency in coefficient signs and statistical significance across models confirms the robustness of the results.

Moreover, variables are kept in their original scales to preserve the economic meaning of regression coefficients. Accordingly, the models are estimated using unstandardized coefficients, allowing direct interpretation of each factor's impact on GRDP in percentage-change terms. Using

unstandardized coefficients also ensures consistency for interaction terms and avoids distortions when comparing coefficients across variables measured in different units.

Overall, the combination of diagnostic and robustness procedures ensures that the model is appropriate for provincial panel data and strengthens the credibility of the analysis of how IND, URBAN, TOUR, and institutions affect economic growth in Central Vietnam.

3.6. Research data

The study uses a balanced panel dataset covering 11 provinces in Central Vietnam under the current administrative boundaries. The provinces include Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Hue City, Da Nang City, Quang Nam, Quang Ngai, Binh Dinh, and Phu Yen. The observation period spans 2009-2024 ($T=16$), enabling analysis of both temporal variation and spatial heterogeneity, for a total of 176 observations ($N \times T$).

Data are compiled from the Vietnam Statistical Yearbook, reports by the General Statistics Office (GSO), the PCI database published by VCCI, and annual CPI reports from the State Bank of Vietnam. Tourism data are sourced from the Vietnam National Administration of Tourism (VNAT) and local financial and budget reports.

4. Results and discussion

4.1. Descriptive statistics and preliminary tests

During 2009-2024, Central Vietnam recorded relatively stable GRDP growth, averaging around 6-7% per year - higher than the national average. Several localities stood out, such as Quang Ngai and Khanh Hoa, benefiting from key economic zones including Dung Quat and Van Phong. The URBAN process also accelerated, with the urban population share increasing from approximately 30-35% in 2010 to 40-45% in 2024; Da Nang City maintained an urbanization rate above 87% - among the highest nationwide - alongside major urban centers such as Hue City, Quy Nhon, and Nha Trang. IND exhibited clear heterogeneity: Binh Dinh, Quang Ngai, and Quang Nam led in industrial shares and trained labor, while Phu Yen, Ninh Thuan, and Binh Thuan experienced slower structural shifts but gradually improved thanks to new investment inflows.

To provide an overview of the dataset, Table 2 presents descriptive statistics for all 176 observations ($N = 11$ provinces, $T = 16$ years). The dependent variable $\ln\text{pergrdp}$ (the natural logarithm of GRDP per capita at constant 2010 prices) has a mean of 11.045 and a standard deviation of 0.501, ranging from 9.791 to 12.107, indicating substantial differences in economic scale across provinces. The ind_index has a mean of 0.444 ($SD = 0.165$), suggesting uneven industrial development. The urban_index_w has a mean of 0.487 ($SD = 0.283$), spanning 0 to 1, reflecting significant heterogeneity in URBAN progress across the region.

Regarding control variables, PCI averages 63.002 (min 52.380; max 71.890), highlighting notable differences in the local business environment. CPI averages 91.448 (ranging from 84.070 to 97.890), implying relatively high macroeconomic stability. Finally, Intour has a mean of

4.169 (SD = 1.559), ranging from 0.747 to 8.172, indicating the growing role of TOUR alongside large cross-province disparities.

Table 2. Descriptive statistics

Variable name	Mean	Standard deviation	Minimum value	Maximum value
Lnpergrdp	11.045	0.501	9.791	12.107
ind_index	0.444	0.165	0.030	0.848
urban_index_w	0.487	0.283	0.000	1.000
pci	63.002	4.327	52.380	71.890
cpi	91.448	3.036	84.070	97.890
Intour	4.169	1.559	0.747	8.172

(Source: Processed from Statistical Yearbooks of Central provinces and MIC)

To assess model validity, the study tests for endogeneity using the Robust score test and Robust regression test. The results in Table 3 indicate that all three groups of potentially endogenous variables - (i) pci and cpi, (ii) Intour, and (iii) ind_index and urban_index_w - yield p-values exceeding 0.05. Hence, the null hypothesis (H0) is not rejected, and the variables can be treated as exogenous. These results support the suitability of the data for estimation and reduce concerns about endogeneity-driven bias.

Table 3. Endogeneity tests of variables

Model	Robust score chi2 (p-value)	Robust regression F (p-value)	Conclusion
Endogenous variables: pci, cpi	1.7747 (0.4117)	0.864492 (0.4234)	Exogenous
Endogenous variables: Intour	0.009662 (0.9217)	0.009264 (0.9235)	Exogenous
Endogenous variables: ind_index, urban_index_w	0.006988 (0.9965)	0.003298 (0.9967)	Exogenous

(Source: Author's calculation)

4.2. Quantitative regression results

Table 4. Regression results and diagnostic tests

Variable	REM (GLS)	FEM	RE-AR(1)	FE-DKSE (lag=2)	FE-DKSE (lag=6)
ind_index	0.504*** (0.086)	0.437*** (0.080)	0.382*** (0.082)	0.437*** (0.069)	0.437*** (0.066)
urban_index_w	0.400*** (0.046)	0.349*** (0.042)	0.226*** (0.051)	0.349*** (0.046)	0.349*** (0.035)
pci	0.016*** (0.003)	0.014*** (0.003)	0.004** (0.002)	0.014** (0.005)	0.014** (0.005)
cpi	0.020*** (0.003)	0.018*** (0.003)	0.011*** (0.003)	0.018*** (0.005)	0.018*** (0.004)
Intour	0.052*** (0.011)	0.055*** (0.010)	0.049*** (0.008)	0.055*** (0.014)	0.055*** (0.015)
constant	7.548*** (0.282)	0.316 (0.242)	1.556*** (0.289)	0.316 (0.314)	0.316 (0.218)

(Source: Author's calculation)

Note: Values in parentheses represent standard errors; ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively

Estimates from REM, FEM, and FE-DKSE are reported in Table 4. The FE-DKSE model (lag = 6) is identified as the preferred specification because it simultaneously corrects for heteroskedasticity, serial correlation, and cross-sectional dependence. Diagnostic

tests indicate that FEM is preferred over REM (Hausman test, $p < 0.01$) and that the data exhibit first-order serial correlation and heteroskedasticity (Wooldridge test and Modified Wald test, respectively, both $p < 0.01$). These findings imply that classical OLS assumptions do not hold, making FE-DKSE necessary for robust inference.

Throughout the results section, t-tests are used to assess the statistical significance of individual coefficients, while F-tests are applied to sets of regressors or the overall model to evaluate joint significance and overall fit. This consistent interpretation facilitates comparability across specifications.

Results from FE-DKSE show that most explanatory variables have the expected signs and are statistically significant, enabling tests of hypotheses H1-H5:

- H1: IND enters positively and is highly significant, confirming IND as a core driver of regional growth through production spillovers and labor productivity gains in industry.

- H2: URBAN is positive and significant at 1%, indicating that URBAN contributes to productivity improvements and market expansion; this aligns with urban economics and underscores the role of urban centers in Central Vietnam's growth.

- H3: TOUR has a positive effect on growth, reflecting the increasing importance of services in coastal regional economic structures, consistent with theory and recent international evidence.

- H4: PCI enters with a positive and statistically significant coefficient (at the 5% level), suggesting that improvements in the institutional environment and local governance enhance investment efficiency and productive capacity, thereby reinforcing the effectiveness of IND and URBAN.

- H5: CPI enters positively, implying that maintaining price stability and keeping inflation under control contributes to a favorable environment for growth, consistent with classical macroeconomic arguments.

Overall, the FE-DKSE results support H1-H5, indicating that regional growth is jointly shaped by IND, URBAN, TOUR, institutions, and macroeconomic stability. The high explanatory power ($R^2 = 0.9043$) suggests good model fit for Central Vietnam over 2009-2024 and provides a solid basis for extended tests in subsequent sections.

4.3. Interaction effects: IND × URBAN and URBAN × TOUR

Extended model with IND × URBAN

Table 5 shows that both IND ($t = 6.91$; $p < 0.01$) and URBAN ($t = 10.34$; $p < 0.01$) have positive and statistically significant effects on provincial growth in Central Vietnam, supporting H1 and H2. IND remains a key pillar through structural transformation and productivity gains, while URBAN plays a supportive role by expanding infrastructure, services, and the labor-market scale.

However, the interaction term is small and statistically insignificant ($t = 0.23$; $p = 0.825$), indicating no clear synergistic effect between IND and URBAN. This may reflect regional characteristics where IND and URBAN progress unevenly; industrial zones and urban systems have not yet formed strong value-chain linkages, and

coordination in spatial planning and regional infrastructure investment remains limited.

Table 5. Results of FE-DKSE (lag = 6) with the interaction term $IND \times URBAN$

Variable	Coefficient	Std. Error	t	P> t	[95% CI lower]	[95% CI upper]
ind_c	0.4356	0.0630	6.91	0.000	0.2952	0.5760
urban_c	0.0987	0.0095	10.34	0.000	0.0774	0.1199
inter_ind_urban	0.0188	0.0829	0.23	0.825	-0.1659	0.2035
pci	0.0135	0.0056	2.40	0.037	0.0010	0.0259
cpi	0.0179	0.0046	3.92	0.003	0.0077	0.0281
Intour	0.0540	0.0128	4.23	0.002	0.0256	0.0824
constant	0.6481	0.2198	2.95	0.015	0.1584	1.1378

(Source: Author's calculation)

Control variables remain positive and significant: pci (t = 2.40; p<0.05) supports the role of transparent institutions and effective governance; cpi (t = 3.92; p<0.01) indicates that macro stability strengthens the investment environment; and TOUR (Intour) (t = 4.23; p<0.01) continues to contribute positively to regional growth.

The joint F-test for the model (reported as $F(3,10) = 143.13$; p<0.01) confirms that IND, URBAN, and their interaction are jointly significant. This finding suggests that regional policy should transition from fragmented sectoral development toward an integrated IND-URBAN strategy, prioritizing coordinated spatial planning, synchronized infrastructure investment across transport, industry, and urban systems, and cross-sector coordination mechanisms so as to generate genuine synergies conducive to sustainable regional growth.

Extended model with $URBAN \times TOUR$

The model is further extended with $URBAN \times TOUR$ to test whether URBAN complements or undermines TOUR-driven growth. This interaction is theoretically relevant for Central Vietnam, a region with both rapid URBAN and national-level TOUR hubs. The interaction $IND \times TOUR$ is not considered due to limited theoretical grounding and the risk of ambiguous effects.

Table 6. Results of FE-DKSE (lag = 6) with the interaction term $URBAN \times TOUR$

Variable	Coefficient (β)	Std. Error	t	p> t	[95% CI]
ind_c	0.430***	0.0646	6.65	0.000	[0.285, 0.573]
urban_c	0.102***	0.0125	8.17	0.000	[0.074, 0.130]
Intour_c	0.067***	0.0121	5.55	0.000	[0.040, 0.094]
inter_urban_Intour	-0.019***	0.0030	-6.33	0.000	[-0.026, -0.013]
pci	0.013**	0.0042	3.08	0.012	[0.0035, 0.0222]
cpi	0.016***	0.0034	4.71	0.000	[0.0085, 0.0238]
constant	1.073***	0.1811	5.92	0.000	[0.669, 1.476]

(Source: Author's calculation)

Table 6 shows that IND, URBAN, and TOUR all have positive and statistically significant effects at the 1% level, confirming their central roles in regional growth. However, the interaction term is negative and highly significant (t = -6.33; p<0.01), implying that higher URBAN weakens the positive effect of TOUR on economic growth.

This finding reflects mounting pressures on

infrastructure, land, and the environment when urban expansion proceeds rapidly without sustainable planning. Land-use competition, pollution, and congestion may erode tourism attractiveness, thereby preventing URBAN and TOUR from generating mutually reinforcing effects.

Control variables remain positive and significant: pci (t = 3.08; p<0.05) and cpi (t = 4.71; p<0.01) again underscore the importance of institutional transparency and macroeconomic stability. The joint F-test ($F(4,10)=158.26$; p<0.01) confirms overall model significance.

Marginal-effect analysis (Table 7) further supports the URBAN-TOUR interaction result. The growth effect of TOUR is strongest when URBAN is low ($\beta = 0.082$; p<0.01) and declines at medium ($\beta = 0.070$) and high URBAN levels ($\beta = 0.049$). This suggests that TOUR plays a particularly prominent role in early URBAN stages, but its effectiveness diminishes as cities expand rapidly and face infrastructure and environmental constraints.

Table 7. Marginal effects of TOUR across URBAN levels

URBAN level	Marginal effect (β)	Std. Error	t	p> t	[95% CI]
p25	0.082***	0.0140	5.88	0.000	[0.051, 0.113]
p50	0.070***	0.0124	5.61	0.000	[0.042, 0.097]
p75	0.049***	0.0101	4.80	0.001	[0.026, 0.071]

(Source: Author's calculation)

Policy implications point to integrating URBAN and TOUR planning through sustainable approaches, investing in green infrastructure and visitor-friendly mobility, and strengthening heritage/resource conservation - thereby maintaining tourism competitiveness and enabling URBAN to become a more sustainable regional growth engine.

4.4. Testing the threshold role of PCI

In an extended analysis, the study tests the threshold role of institutional quality using PCI, under the premise that institutions may moderate how IND and URBAN affect growth [2], [18]. The sample is split into high-PCI and low-PCI groups and estimated using FE-DKSE (lag = 6). Table 8 indicates that both IND and URBAN remain positive and statistically significant in both groups, with IND ranging from 0.351 to 0.391 and URBAN from 0.234 to 0.452, confirming the stability of these two growth drivers.

Table 8. Effects of IND and URBAN by PCI threshold (FE-DKSE, lag=6)

Variable	Coefficient (β)	Std. Error	t	p> t	[95% CI]
ind_index (High PCI)	0.391**	0.136	2.87	0.017	[0.088, 0.693]
ind_index (Low PCI)	0.351***	0.070	5.03	0.001	[0.196, 0.507]
urban_index_w (High PCI)	0.452***	0.096	4.73	0.001	[0.240, 0.665]
urban_index_w (Low PCI)	0.234***	0.055	4.21	0.002	[0.112, 0.356]
CPI	0.020***	0.005	4.26	0.000	[0.013, 0.027]
Intour	0.058***	0.010	5.77	0.000	[0.036, 0.081]
constant	0.943***	0.309	3.10	0.011	[0.266, 1.620]

(Source: Author's calculation)

However, coefficient-difference tests across groups

(Table 9), conducted via F-tests, show that group differences are not statistically significant (IND: $F = 0.05$, $p = 0.823$; URBAN: $F = 2.55$, $p = 0.142$). This implies that, although PCI contributes to reducing transaction costs and improving the investment climate, cross-provincial variation in institutional quality may still be insufficient to produce a discernible amplification - or threshold - effect. In other words, institutions currently provide general support but may not have reached the level needed to materially strengthen IND and URBAN impacts - consistent with evidence from emerging-economy studies [18].

Table 9. Tests of coefficient differences by PCI threshold

Test	F	p-value
ind_index (High PCI = Low PCI)	0.05	0.823
urban_index (High PCI = Low PCI)	2.55	0.142

(Source: Author's calculation)

These results suggest that Central Vietnam should continue improving institutional capacity and local governance so that PCI becomes a truly reinforcing factor that can enhance IND-URBAN effectiveness over the long run.

4.5. Discussion

The empirical findings confirm the pivotal roles of IND and URBAN in driving provincial economic growth in Central Vietnam. These results are broadly consistent with prior theoretical and empirical evidence, confirming that IND and URBAN generate positive spillovers in productivity, innovation, and investment. Based on unstandardized coefficients and the overall pattern of effects, IND appears to exert a stronger influence than URBAN, reflecting a regional structure that still relies heavily on manufacturing and processing, while advanced urban services remain relatively limited.

Interaction analysis indicates that IND and URBAN are complementary in promoting GRDP. This supports domestic evidence such as [35], while more clearly emphasizing the importance of mutual reinforcement in a region characterized by uneven development. Policies that focus on only one driver are unlikely to achieve optimal outcomes, whereas a balanced combination of IND and URBAN can yield more sustainable impacts.

In addition, institutional quality plays a positive moderating role: provinces with higher PCI tend to grow faster due to greater transparency and lower transaction costs, which can strengthen the combined effects of IND and URBAN. However, cross-provincial PCI disparities remain modest, which may explain the absence of a statistically discernible threshold effect. Future work could extend the dataset to the national level and apply spatial econometric models to more deeply examine regional spillovers and the stability of these relationships.

5. Conclusions and policy implications

5.1. Conclusions

This study provides important empirical evidence on the effects of IND, URBAN, TOUR, and institutional quality on economic growth in Central Vietnam over the period 2009-2024. Panel-data analysis using appropriate estimation methods indicates that both IND and URBAN

exert positive and statistically significant effects. IND plays a foundational role, capturing the expansion of industrial production, improved productive capacity, and accelerated structural transformation. By contrast, URBAN serves a complementary role by reallocating labor, expanding services, strengthening infrastructure connectivity, and facilitating market development.

Notably, interaction analysis suggests that IND and URBAN are complementary; however, the synergistic effect remains weak due to uneven development across Central provinces. In many provinces, IND and URBAN have advanced in a fragmented manner, lacking infrastructure connectivity and value-chain integration, so that the two processes have tended to proceed in parallel rather than mutually reinforce one another. Therefore, the region should shift toward an integrated development model that jointly advances industry, urban systems, and regional infrastructure in order to enhance connectivity, spillovers, and growth efficiency.

Institutional quality continues to play a moderating role by improving the effectiveness of IND and URBAN, although it has not yet generated a clear “amplification threshold.” In addition, TOUR shows a positive effect on growth, but its marginal contribution declines as URBAN intensifies, reflecting increasing pressures on infrastructure and the environment.

Taken together, the empirical findings indicate that the combination of IND, URBAN, TOUR, and institutional quality constitutes four key drivers shaping the long-run growth of Central Vietnamese provinces. This yields an important policy implication: regional development cannot rely on a single factor in isolation, but instead requires a coordinated strategy integrating industry, urban development, institutional reform, and environmental protection.

5.2. Policy implications

Based on the quantitative results and discussion, the study proposes the following policy implications by growth-driver groups.

First, for IND: Central provinces should prioritize the development of integrated industrial-urban clusters to simultaneously leverage manufacturing advantages and urban service capacity. Emphasis on processing and manufacturing industries embedded in global value chains would not only raise labor productivity but also help the region avoid a low-value-added “assembly trap”. Policies that support local firms to participate more deeply in supply chains will be critical for sustaining long-term competitiveness.

Second, for URBAN: Urban planning should be closely aligned with interprovincial infrastructure - such as expressways, seaports, and logistics systems. This alignment is essential for reducing transaction costs, improving supply-chain efficiency, and strengthening connectivity among industrial centers, urban hubs, and TOUR destinations.

Third, for TOUR: Central Vietnam should shift toward a “green and smart tourism” strategy rather than relying on mass tourism. Developing higher-quality, environmentally friendly tourism products and applying digital technologies

(e.g., digital platforms for destination management and customer experience) can mitigate diminishing returns as URBAN expands and increase the sector's value added.

Fourth, for institutions: The study proposes a "PCI+1" mechanism, under which each province commits to improving its PCI ranking by at least one position relative to the preceding year. This approach fosters healthy institutional competition and encourages local governments to proactively enhance transparency, reduce administrative costs, and improve public service quality to better support firms.

Finally, for regional linkages: To better harness spillover effects from IND and URBAN, it is necessary to establish a Central Vietnam interprovincial infrastructure development fund or to strengthen the North-South economic corridor beyond individual provincial administrative boundaries. Such a mechanism would facilitate more concentrated resource allocation and accelerate the implementation of strategic interprovincial projects, thereby enhancing the region's overall economic competitiveness.

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