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The Role of Research and Development in Fostering Innovation and Economic Growth in Developing Economies

研究与开发在促进发展中经济体创新与经济增长中的作用

Ayouska Faikhaz, Zolkan Barthea *

Faculty of Economics, University of Miskolc, Miskolc-Egyetemvaros 3515, Hungary

*****Correspondence: Zolkan Barthea; zolkan.barthea@uni-miskolc.hu

Abstract. This study investigates the mechanisms through which research and development (R&D) influences economic growth in developing countries. Using nine indicators drawn from three main categories in the World Economic Forum database, the analysis covers 32 lower-middle-income countries for the year 2019. Grounded in an R&D ecosystem framework, the study incorporates key components institutions, human capital, capital markets, R&D, and innovation that jointly shape economic development. Structural equation modeling (SEM) is employed to construct and test a path model capturing the interrelationships among these components. The results show that R&D activities and capital market institutions significantly enhance innovation performance; however, neither R&D nor innovation exhibits a direct or significant effect on economic growth. Consistent with a Schumpeterian institutional perspective, the findings suggest that innovation-driven growth mechanisms may be constrained in middle-income economies. The absence of a significant link between innovation and growth implies that, although R&D and capital markets foster entrepreneurial innovation, their contribution is insufficient to translate into sustained economic expansion. Overall, the results provide additional empirical support for the existence of a middle-income trap in developing economies.

Keywords: Ecosystem approach, lower-middle-income economies, research and development, structural equation modeling

摘要：本研究旨在揭示研究与开发（R&D）影响发展中国家经济增长的作用机制。研究基于世界经济论坛数据库，选取来自三大类的九项指标，覆盖2019年32个中低收入国家。理论框架以研发生态系统为基础，涵盖制度环境、人力资本、资本市场、研发活动与创新等关键要素，这些要素共同塑造国家经济发展。研究采用结构方程模型（SEM）构建并检验路径模型，以分析各要素之间的相互关系。结果表明，研发活动与资本市场制度对创新绩效具有显著的正向影响，但研发与创新均未对经济增长产生直接且显著的作用。该结论与熊彼特制度视角一致，表明在中等收入经济体中，创新驱动型增长机制可能受到结构性约束。创新绩效与经济增长之间缺乏显著关联，说明尽管研发和资本市场通过创业活动促进了创新，但其作用尚不足以转化为持续的经济增长。总体而言，本研究为发展中经济体存在“中等收入陷阱”提供了进一步的经验证据。

关键词： 生态系统方法,中低收入经济体,研究与开发,结构方程模型

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1. Introduction

New Growth Theory (NGT) broadly encompasses a set of endogenous growth frameworks developed by various scholars. As noted by Capolupo (2009), variations in economic growth can be explained by internal technological mechanisms, including learning-by-doing (Romer, 1986), human capital spillovers (Lucas, 1988), threshold externalities (Azariadis & Drazen, 1990), production externalities (Barro, 1990), and quality improvements driven by invention (Grossman & Helpman, 1991). Central to NGT is the proposition that sustained long-run growth is fundamentally driven by knowledge creation (Ge & Liu, 2022). When positive externalities are present to offset diminishing marginal returns to capital, economies may achieve persistent growth. Such externalities typically arise from activities such as public infrastructure development, knowledge diffusion, and research and development (R&D). In essence, because the returns to accumulative factors remain constant, economic growth becomes a self-reinforcing process that proceeds at a stable rate (Diebolt & Perrin, 2019).

For developing economies, NGT and the extensive debate it has generated offers several important insights. First, it demonstrates that per capita income levels in developing countries may either converge toward or diverge from those in advanced economies, depending largely on domestic conditions and policy choices. In this regard, NGT challenges the perception that neoclassical growth theory lacks relevance for long-term policy formulation (Lee, 2020). Empirical studies inspired by NGT have documented substantial cross-country productivity differences, thereby encouraging developing economies to prioritize productivity enhancement rather than focusing solely on capital accumulation (Rizwanul, 2004). Moreover, NGT places strong emphasis on the role of institutions in economic development. The increasing availability of data on institutional quality has enabled quantitative assessments of how institutional frameworks influence growth trajectories in emerging economies. Importantly, NGT clarifies the interdependence between human capital development and the diffusion of institutional and technological innovations, while also underscoring the persistent challenge developing economies face in building adequate human capital stocks (Prasetyo, 2020).

Building on this perspective, the present study aims to identify the channels through which R&D of which human capital constitutes a critical input affects economic outcomes in developing countries. Existing research indicates that the growth effects of R&D are conditioned by broader economic factors, particularly institutional quality (Doloreux & Turkina, 2023; Chen & Song, 2024). Institutions are central to economic stability, as they govern and coordinate activities across different sectors. Accordingly, this study primarily examines whether R&D performance translates into economic growth within developing economies. As argued by Aghion and Bircan (2017), institutional arrangements may constrain growth beyond certain stages of development, implying that R&D and innovation do not automatically generate growth in middle-income contexts. Using structural equation modeling, this study empirically tests the interrelationships among institutions, R&D, innovation, and economic growth within a sample of lower-middle-income countries. In doing so, it contributes to the literature by elucidating both the potential and the limitations of R&D and innovation as engines of economic growth in developing economies.

2. Materials and Methods

Research and development (R&D) are commonly defined as a systematic and creative process aimed at expanding the stock of knowledge including insights related to society, culture, and human behavior and applying existing knowledge to generate new applications (OECD, 2015). This study examines the interrelationships between R&D, innovation, economic growth, and institutional factors associated with human capital formation and capital market development. Accordingly, each of these linkages is reviewed separately to clarify their theoretical and empirical foundations.

R&D Expenditure and Economic Growth

Moving beyond the exogenous technological progress assumed in the classical growth frameworks of Solow (1956) and Mukerji and Johansen (1963), Romer's (1989) endogenous growth model illustrates how technological change can sustain long-term economic growth. Romer argues that technological knowledge is non-rival and cumulative, and that increased investment in research enhances the rate of technological advancement. As prior discoveries raise researchers' productivity, the R&D sector exhibits increasing returns to scale. Moreover, research activities generate positive externalities by creating new forms of capital and improving future research productivity benefits that are not fully captured by market prices. These externalities are largely associated with the diffusion of information (Diebolt & Perrin, 2016).

A substantial body of empirical literature supports the growth-enhancing role of R&D. Coe et al. (2009) emphasize that R&D investment is a key determinant of economic growth. Using U.S. data, Aghion et al. (2011) show that R&D expenditure as a share of GDP significantly influences growth performance. Lichtenberg (2001), analyzing data from 74 countries over the period 1964–1989, finds that while both public and private R&D spending contribute to growth, private-sector R&D is relatively more productive. Coe et al. (1997) further demonstrate that R&D conducted in advanced economies generates spillover benefits for developing countries through trade in high-technology goods and capital equipment, thereby improving productivity and output in recipient economies. However, Ke (2024), focusing on Malaysia, Thailand, Indonesia, and the Philippines, argues that these countries face a "middle-technology trap," characterized by limited international technology spillovers. Similarly, Lichtenberg and Pottelsberghe de la Potterie (1998) question the magnitude of external spillovers and stress the importance of strengthening domestic R&D efforts to achieve sustained long-term growth.

Human Capital

Lucas (1988) highlights the role of individual decisions regarding education and skill accumulation in shaping both personal productivity and aggregate economic growth. In his framework, human capital functions as both a complement and an alternative to technological progress. In the overlapping-generations model of Azariadis and Drazen (1990), human capital serves as the primary engine of growth due to its cumulative nature and increasing social returns. Individuals allocate early life stages to education and training, which later translates into higher-quality labor. Moreover, intergenerational spillovers arise when accumulated human capital is partially transmitted to future generations, further reinforcing growth dynamics (Altinok & Diebolt, 2024).

Empirical studies by Barro (1992) and Barro et al. (1995) show that economies with higher initial levels of human capital tend to converge more rapidly toward advanced income levels. The link between human capital and technology adoption was first suggested by Nelson and Phelps (1966) and later reaffirmed by Färnstrand Damsgaard and Krusell (2010). Benhabib and Spiegel (2005) identify two channels through which human capital contributes to total factor productivity (TFP): innovation and the diffusion or adaptation of existing technologies. However, measuring R&D spillovers remains challenging, as traditional definitions such as those in Griliches (1998) and Romer (1986) focus primarily on formal R&D activities within firms and institutions. Learning processes that occur outside formal R&D settings also enhance human capital and factor quality, although these effects are often not captured in TFP residuals.

Krueger (1968) demonstrates that differences in human capital explain a substantial share of cross-country income disparities, particularly between the United States and developing economies. More recent growth accounting exercises, such as those by Jorgenson et al. (2016), confirm the significant contribution of human capital accumulation to growth even within a neoclassical framework (Mincer, 2022). Nevertheless, Devassia et al. (2024) find mixed effects: while general education promotes growth, higher tertiary enrollment may exert a negative impact in certain contexts.

Capital Markets

Capital markets play a critical role in economic development by channeling savings into long-term investments and supporting entrepreneurial activity. According to Will (2019), capital markets constitute the institutional mechanism through which financial resources are allocated to productive uses. A well-functioning financial system facilitates capital accumulation, attracts foreign investment, and enhances growth potential, whereas weak financial institutions constrain investment and reduce competitiveness. Underdeveloped capital markets also deter foreign capital inflows due to high transaction costs and illiquidity. Empirical evidence from Shaw (1973) and Degong et al. (2021) supports a positive relationship between financial liberalization and economic growth.

Institutions

Institutions are widely recognized as fundamental determinants of economic performance. Cross-country analyses reveal strong correlations between growth outcomes and institutional indicators such as property rights protection, legal systems, and civil liberties (Knack & Keefer, 1995; Son, 2016; Cvetanović et al., 2019). North (1991) defines institutions as the formal and informal rules that structure human interaction, shaping incentives across political, social, and economic domains. Acemoglu and Robinson (2005) argue that although strong institutions particularly secure property rights can facilitate structural transformation, their growth effects depend on effective implementation within existing economic structures. Moreover, Acemoglu et al. (2001) suggest that institutional quality exerts stronger long-term than short-term effects on growth. Empirical findings by Méon and Sekkat (2004) confirm that countries with superior institutions tend to exhibit higher productivity levels.

However, institutional rigidities may also hinder innovation in developing economies, contributing to a middle-income trap (Aghion & Bircan, 2017). Entrenched political and economic elites can restrict structural change and weaken incentives for R&D and innovation (Mickiewicz, 2023). Such constraints may also limit public investment in institutional capacity and human capital development (Doner & Schneider, 2016), helping to explain the difficulty of formulating a consistent growth theory for middle-income countries (Kharas & Gill, 2020).

Innovation

Innovation the application of new knowledge to economic activities is a key driver of long-term growth (Smith et al., 2012). Empirical evidence shows that firm-level innovation, particularly improvements in processes, systems, products, and services, enhances competitiveness and aggregate economic performance (Smith & Estibals, 2011). Innovation requires substantial financial and organizational investment, including both tangible and intangible assets, which ultimately support productivity and income growth (Smith et al., 2012). Durham (2004), analyzing patent and R&D data for OECD and non-OECD countries, finds a positive association between innovation output and per-capita income, although only larger OECD economies effectively translate R&D spending into innovation outcomes. In a rapidly changing global environment, effective innovation strategies must emphasize not only the creation of new technologies but also their adaptation and diffusion across economic and social activities (Brunswicker & Schecter, 2019).

Theoretical Framework and Hypothesis Development

The ecosystem perspective emphasizes the interdependence of diverse stakeholders involved in value creation, ranging from firms and their customers and suppliers (Moore, 1993; Iansiti & Levien, 2004) to universities, research institutions, public agencies, and supporting organizations (Van der Borgh et al., 2012; Clarysse et al., 2014; Thomas & Autio, 2014; Li & Garnsey, 2014). Building on this literature, the present study conceptualizes R&D as exerting an indirect influence on economic growth through its interactions with institutions, human capital, capital markets, and innovation capacity. These interdependencies are collectively referred to as the "R&D ecosystem."

Within this ecosystem, three institutional pillars are identified:

1) R&D Institutions (RDI), encompassing public and private organizations engaged in scientific research, technological development, and innovation;
2) Financial Institutions (FI), which facilitate savings mobilization, investment, and capital allocation; and
3) Labor Institutions (LI), which shape workforce quality through education, training, and labor-market policies.

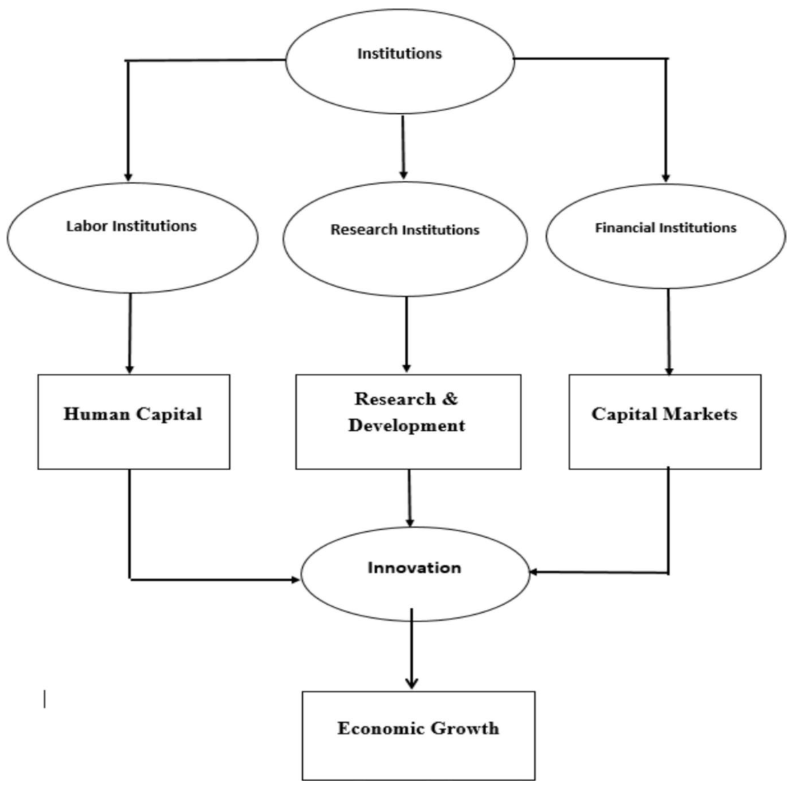


Figure 1. The R&D ecosystem (theoretical framework).

Figure 1 illustrates the proposed R&D ecosystem framework. Based on this theoretical structure, the following hypotheses are formulated:

H1. *Institutions related to R&D performance have a significant effect on innovation.*

H2. *Institutions related to capital market development have a significant effect on innovation.*

H3. *Institutions related to human capital formation have a significant effect on innovation.*

H4. *Innovation has a significant effect on economic growth.*

The dataset employed in this study originates from the World Economic Forum (WEF) databases and official reports published on the organization's website, with all observations drawn exclusively from the year 2019. The analysis deliberately focuses on pre-pandemic economic conditions in order to capture structural and strategic characteristics of countries prior to the disruptions caused by the COVID-19 crisis in early 2020. Accordingly, only 2019 data are utilized to ensure temporal consistency and avoid pandemic-related distortions. The WEF database covers 141 countries worldwide. From this population, the study selects countries classified as lower-middle-income economies according to the World Bank Atlas classification. This selection aligns with the study's objective of examining the role of research and development (R&D) in developing economies. Moreover, countries within this income group tend to share broadly comparable economic, political, and legal environments, enhancing the internal consistency of the sample. The final sample consists of 32 lower-middle-income countries, as reported in Table 2.

The study constructs six core variables: economic growth, research and development (R&D), institutions, human capital, capital markets, and innovation. Economic growth serves as the dependent variable and is measured as the average annual GDP growth rate over a ten-year period (2009–2018), expressed in purchasing power parity (PPP) terms and measured in billions of U.S. dollars. Among the six constructs, three aggregated variables economic growth, institutions, and innovation are directly adopted from the WEF database. The remaining three constructs R&D, capital markets, and human capital are derived as component variables using factor analysis based on underlying indicators provided by the WEF. The WEF applies an aggregation procedure in compiling indicators for the Global Competitiveness Index (GCI). Indicator values are first calculated at the most disaggregated level and subsequently aggregated into higher-level composite indices. Each aggregated construct is computed as the arithmetic mean of its constituent indicators. Prior to aggregation, raw indicator values are normalized into progress scores ranging from 0 to 100, where higher values indicate closer proximity to the ideal benchmark (see Table 1).

The constructs representing R&D, capital markets, and human capital are each operationalized using three indicators and are denoted in the empirical model as RDI, FI, and LI, respectively. All indicators are sourced from the World Economic Forum (Schwab, 2019). Descriptive statistics for these variables across the 32 sampled countries are presented in Table 2. Specifically, R&D (RDI) is measured using scientific publications, research institution prominence, and R&D expenditure. Capital market development (FI) is captured through domestic credit to the private sector, financing of small and medium-sized enterprises, and venture capital availability. Human capital (LI) is proxied by mean years of schooling, quality of vocational training, and digital skills among the active population.

To examine the effect of R&D on economic growth and the moderating role of institutional factors, this study employs structural equation modeling (SEM). SEM is a multivariate analytical technique that simultaneously estimates relationships among multiple independent variables and a dependent variable through the specification of both a measurement model and a structural path model. One of the principal advantages of SEM lies in its capacity to evaluate complex causal relationships while accounting for measurement error. Additionally, SEM facilitates the assessment of construct validity by incorporating multiple observed indicators for each latent construct an advantage not available in conventional linear regression approaches (Weston & Gore, 2006). Confirmatory factor analysis (CFA) is used within the SEM framework to estimate latent variables and corresponding factor loadings.

Table 1. The dependent variable (GDP growth) and the aggregated variables of the research

Major Indicator	Abbreviation (used in Fig. 2)	Definition	Scale	Periodicity
GDP growth	GDP	10-year average annual GDP growth (%, real terms)	Weighted average	Annual, 2009–2018
Institutions	Ins	Regulate the setting in which the economy and society organize themselves by formal and informal checks and balances	Score: 0–100 (0 = worst, 100 = frontier)	Annual, 2019
Innovation	Inn	The conversion of new ideas into products and services	Score: 0–100	Annual, 2019

Source: Schwab (2019)

Table 2 Descriptive statistics of the variables for the 32 selected lower-middle-income countries

Variable	N	Minimum	Maximum	Mean	Mode	Median	Std. deviation
GDP Average annual GDP growth 2011–20	32	0.10	6.90	41.188	2.20	3.90	165.499
Ins Institutions	32	36.40	60.00	474.938	41.90	47.85	613.588
Inn Innovation	32	18.80	50.90	317.375	30.70	30.85	589.323
ScP Scientific publications	32	47.10	92.70	699.250	47.10	69.95	940.391
RIP Research institutions prominence	32	0.00	98.40	59.625	0.00	0.55	1.744.269
RDE R&D expenditure	32	0.50	84.00	128.844	11.10	10.85	1.478.707
DCPS Domestic credit to private sector	32	2.90	100.00	423.656	15.80	41.40	2.361.560
FSME Financing of SMEs	32	21.30	61.00	419.406	21.30	43.50	947.958
VCA Venture capital availability	32	11.80	52.70	290.750	19.60	27.85	977.776

Variable	N	Minimum	Maximum	Mean	Mode	Median	Std. deviation
MYS Mean years of schooling	32	18.90	77.20	472.313	46.00	46.00	1.429.467
QVT Quality of vocational training	32	25.60	62.40	453.469	50.10	44.30	838.562
DSAP Digital skills among active population	32	24.10	67.70	482.562	48.30	48.05	880.967
Countries included	Angola, Bangladesh, Bolivia, Cambodia, Cameroon, Cape Verde, Côte d'Ivoire, Egypt, El Salvador, Eswatini, Ghana, Honduras, India, Indonesia, Kenya, Kyrgyz Republic, Lao PDR, Mauritania, Moldova, Mongolia, Morocco, Nicaragua, Nigeria, North Macedonia, Pakistan, Philippines, Senegal, Tunisia, Ukraine, Vietnam, Zambia, Zimbabwe.						

3. Result

After data collection and model specification, the next step involves analyzing the empirical results derived from the measurement and structural tests. This section presents the statistical procedures employed to evaluate both the measurement model and the structural model.

As an initial step, confirmatory factor analysis (CFA) was conducted to validate the latent constructs and examine the relationships between observed and latent variables. Figure 2 illustrates the correlation coefficients among the indicators and the aggregated constructs used in the factor analysis. The chi-square statistic is 935.701 with a p-value below 0.001, indicating that the null hypothesis can be rejected and confirming significant relationships among the variables. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy is 0.859, which is considered satisfactory. In addition, all Cronbach's alpha values exceed the recommended threshold of 0.7 (Table 3), indicating acceptable internal consistency reliability (Samuels, 2015). Following the validation of the measurement model through CFA, a structural path diagram is developed to illustrate the hypothesized relationships among constructs and to assess overall model fit, thereby confirming their effects on the proposed outcomes.

The path diagram generated using SPSS Amos Graphics incorporates several essential features of the structural equation modeling framework. First, it distinguishes between observed (manifest) variables and unobserved (latent) constructs. Second, it represents both directional (causal) relationships among latent variables through single-headed arrows and bidirectional (correlational) relationships among residual terms (e1, e2, …, e15). These residual correlations capture additional shared variance not explained by the specified structural paths.

The theoretical framework posits that selected institutional and structural factors influence innovation, which in turn affects economic growth. Specifically, Hypothesis 1 predicts a positive relationship between R&D performance (RDI) and innovation. Hypotheses 2 and 3 propose that capital market institutions (FI) and labor market institutions (LI), respectively, exert positive effects on innovation. Finally, Hypothesis 4 assumes a positive association between innovation (Inn) and economic growth (GDP).

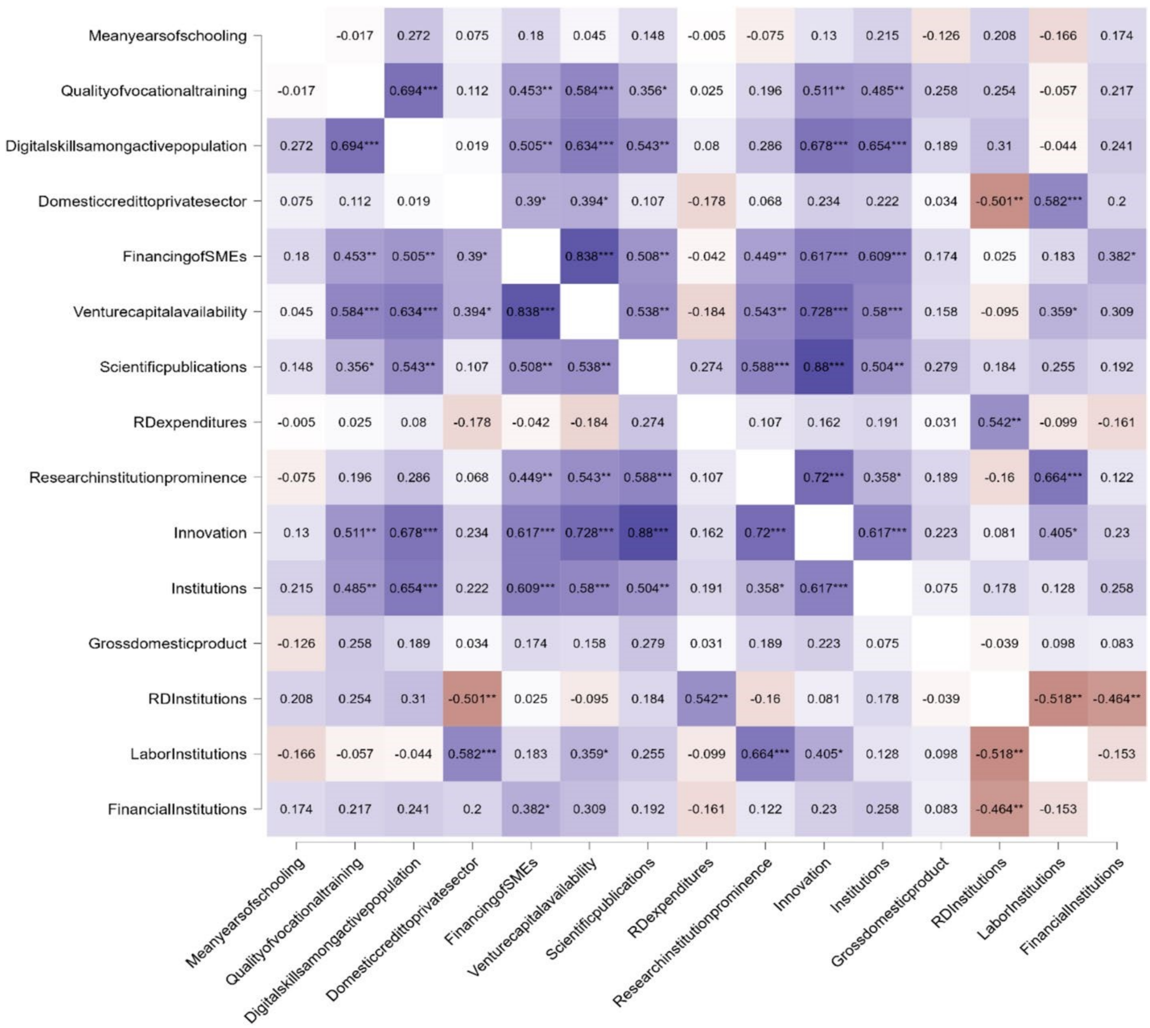


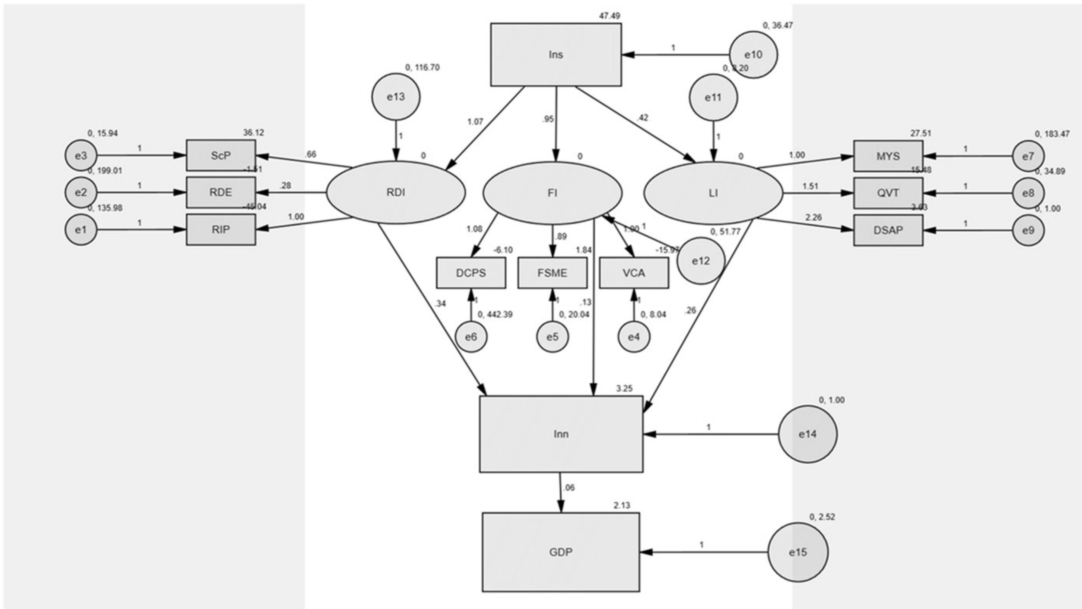
Figure 2. The correlation map of the investigated variables.

Table 3. Reliability analysis of the confirmatory factor analysis.

Factor	Coefficient ω	Coefficient α
RDI R&D construct	0.789	0.752
FI Capital market construct	0.789	0.771
LI Labor market construct	0.771	0.765
Total	0.845	0.879

To test these hypotheses empirically, structural equation modeling (SEM) was employed, as illustrated in the path diagram (Fig. 3). Latent constructs for RDI, FI, and LI were developed using factor analysis. The SEM framework enables the estimation of both direct and indirect effects of these institutional factors on innovation and, subsequently, on economic growth. The presence of statistically significant positive relationships among the constructs provides empirical support for the proposed theoretical model.

Table 4 reports the unstandardized regression coefficients along with the corresponding test statistics. The unstandardized coefficients indicate the expected change in the dependent or mediating variable associated with a one-unit change in the predictor variable. The *p*-values reported in the *P* column represent the probability of observing the estimated effect under the null hypothesis of no relationship, thereby indicating the statistical significance of each structural path.



Legend

Ins: *Institutions (see Table 1)*
RDI: *Research & Development construct built from the three indicators below (see Component variables section)*
ScP: *Scientific publications*
RDE: *R&D expenditure*
RIP: *Research institution prominence*
FI: *Capital market construct built from the three indicators below (see Component variables section)*
DCPS: *Domestic credit to private sector*
FSME: *Financing of SMEs*
VCA: *Venture capital availability*
LI: *Human capital construct built from the three indicators below (see Component variables section)*
MYS: *Mean years of schooling*
QVT: *Quality of vocational training*
DSAP: *Digital skills among active population*
Inn: *Innovation (see Table 1)*
GDP: *Average annual GDP growth 2011-20 (see Table 1)*

Figure 3. SEM Path Diagram

Table 4. Regression weights. *Source* Author's own calculations

Regression pairs			Estimate	S.E	C.R	*P*
RDI (R&D)	←	Institutions	1.074	0.384	2.795	0.005
FI (CM Capital market)	←	Institutions	0.949	0.229	4.146	***
LI (HC Human capital)	←	Institutions	0.415	0.281	1.480	0.139
Innovation	←	RDI	0.344	0.062	5.535	***
Innovation	←	FI	0.128	0.047	2.698	0.007
Innovation	←	LI	0.262	0.200	1.312	0.190

Regression pairs			Estimate	S.E	C.R	*P*
Research institution prominence	←	RDI	1.000			
RD expenditure	←	RDI	0.282	0.211	1.338	0.181
Scientific publications	←	RDI	0.663	0.127	5.210	***
Venture capital availability	←	FI	1.000			
Financing of SMEs	←	FI	0.890	0.134	6.622	***
Domestic credit to private sector	←	FI	1.076	.437	2.464	0.014
Mean years of schooling	←	LI	1.000			
Quality of vocational training	←	LI	1.515	1.014	1.494	0.135
Digital skills among active population	←	LI	2.263	1.457	1.553	0.120
GDP growth	←	Innovation	0.063	0.053	1.192	0.233

Regression weight represents the expected change in dependent variable because of an increase in independent variable of one of its standardized units with all other independent variables unchanged (Siegel and Wagner 2022)

A *p*-value exceeding 0.05 indicates the absence of a statistically significant relationship between variables in the model (Dahiru, 2011). The results show that institutional development, as measured by the World Economic Forum, exerts a significant influence on both R&D (RDI) and financial institutions (FI). Specifically, a one-unit increase in the institutional indicator leads to an approximate increase of 1.074 units in RDI and 0.949 units in FI, highlighting the central role of institutional quality in shaping innovation-related inputs.

The regression coefficient of 0.344 confirms a positive and statistically significant relationship between R&D and innovation. A one-unit increase in RDI is associated with an increase of approximately 0.344 units in innovation, holding other factors constant. The high critical ratio (5.535) allows rejection of the null hypothesis, indicating that R&D significantly enhances innovation performance. This suggests that middle-income countries with higher R&D spending and stronger scientific output tend to achieve higher innovation levels. Moreover, the strong positive association between R&D activity and research institution prominence underscores the importance of well-established research infrastructure.

Financial institutions also display a positive and significant effect on innovation. A one-unit increase in FI corresponds to an increase of about 0.128 units in innovation, with significance at conventional levels ($p = 0.007$). This result reflects the critical role of venture capital availability, SME financing, and domestic credit provision in fostering innovative activity. In contrast, although labor institutions (LI) show a positive association with innovation (0.262), and innovation is positively linked to economic growth (0.063), neither relationship is statistically significant ($p = 0.19$ and $p = 0.233$, respectively).

Model fit statistics indicate that the SEM specification provides an adequate representation of the data. The Chi-square ratio (CMIN/DF = 1.215) suggests a good fit, while incremental fit indices (IFI = 0.946, TLI = 0.926, CFI = 0.942) exceed commonly accepted thresholds. Although NFI (0.756) and RFI (0.690) are relatively modest, overall parsimony measures (PRatio = 0.788, PNFI = 0.595, PCFI = 0.742) support the robustness of the model. Additional indices, including RMSEA (0.08), FMIN (2), and ECVI (4.48), fall within acceptable ranges, indicating reasonable approximation and predictive adequacy. The Hoelter index further confirms that the sample size is sufficient to sustain model validity.

SEM analysis generally requires relatively large samples; however, sample adequacy depends on model complexity and data characteristics (Westland, 2010). Given an indicator-to-latent-variable ratio of four, a minimum sample size of approximately 100 is recommended. Although two variables research institution prominence and R&D expenditure deviate from normality, most indicators satisfy normality assumptions based on the Shapiro–Wilk test. This strengthens confidence in the reliability and stability of the estimated SEM results despite the modest sample size.

Table 5. SEM analysis, model fit summary

Measure	Estimate	Threshold	Interpretation
CMIN	63.165	–	–
DF	52	–	–
CMIN/DF	1.215	2	Excellent
NFI	0.756	Closer to 1	Good
RFI	0.690	1 = Perfect fit Closer to 1 = Good fit	Good
IFI	0.946	1 = Perfect fit Closer to 1 = Good fit	Good
TLI	0.926	1 = Perfect fit Closer to 1 = Good fit	Good
CFI	0.942	1 = Perfect fit ≥ 0.95 = Excellent fit ≥ .90 = Acceptable fit	Good
PRatio	0.788	No cutoff value	–
PNFI	0.595	0.5 and above	Excellent
PCFI	0.742	0.6 and above	Excellent
NCP	0–35.39	–	–
FMIN	2	No cutoff value	–
RMSEA	0.08	0.05 or 0.08	Excellent
AIC	139.16	–	–
BCC	194.05	–	–
ECVI	4.48	No cutoff value	–
MCVI	6.26	No cutoff value	–
Hoelter 0.5	35	–	–
Hoelter 0.1	39	–	–

4. Discussion

Structural equation modeling (SEM) was employed to evaluate the proposed theoretical framework, and the results indicate an overall good model fit. The SEM path diagram reveals a statistically significant positive relationship between institutions and both R&D and capital markets, while the association with human capital, although positive, is not statistically significant. Adopting an ecosystem perspective, this study conceptualizes economic growth as an indirect outcome of interactions among institutional factors related to R&D, human capital, and capital markets, operating through innovation. The findings show that R&D and capital markets exert significant positive effects on innovation, whereas the effects of human capital on innovation and innovation on economic growth are not statistically significant. Accordingly, hypotheses H1 and H2 are supported, while H3 and H4 are rejected.

The empirical results strongly support the first hypothesis, confirming a positive and significant relationship between R&D and innovation. Specifically, a one-unit increase in R&D performance is associated with an approximate 0.34-unit increase in innovation, corroborating earlier evidence that emphasizes the central role of R&D investment in driving innovative activity (Coe et al., 1997; Lichtenberg, 2001; Aghion et al., 2011). Similarly, the second hypothesis is supported, as capital markets are found to have a statistically significant and positive impact on innovation. A one-unit increase in financial institutions corresponds to a 0.12-unit rise in innovation, with a p-value of 0.007. This suggests that transparent and well-functioning financial systems enhance investor confidence, facilitate capital allocation, and promote entrepreneurship, thereby stimulating innovation (Shaw, 1973; Degong et al., 2021; Lerner, 1999). Entrepreneurs, as agents of innovation, play a pivotal role in translating financial resources into new products, services, and business models, reinforcing the dynamic link between capital markets and technological progress (Schumpeter, 2017; Gompers et al., 2005).

In contrast, the third hypothesis concerning the relationship between human capital and innovation is not supported. This finding suggests that endogenous growth models emphasizing human capital as a primary engine of innovation (Lucas, 1988; Azariadis & Drazen, 1990) may have limited applicability in lower-middle-income developing countries. While some studies argue that higher education and skill accumulation enhance innovative capacity (Acemoglu, 2002), others highlight potential drawbacks, such as conformity and reduced risk-taking (Naylor & Florida, 2003). Empirical evidence further indicates that human capital does not always translate into higher innovation outcomes (Jones & Williams, 1998; Bessen & Hunt, 2007). Thus, the impact of human capital on innovation appears to be context-dependent and mediated by institutional and organizational conditions.

Finally, the absence of a significant relationship between innovation and economic growth provides further support for the middle-income trap hypothesis (Kharas & Gill, 2020). This finding aligns with recent empirical evidence (Hannum, 2024) and the World Bank's 3i development framework, which posits that growth initially driven by investment may stagnate if technological infusion is insufficient, delaying the transition to innovation-led growth (World Bank, 2024). The results suggest that lower-middle-income countries may prioritize R&D institutions prematurely, without adequately strengthening absorptive and infusion capacities, thereby limiting the growth impact of innovation. In this context, human capital development and institutional upgrading emerge as critical prerequisites for escaping the middle-income trap (Doner & Schneider, 2016; Mickiewicz, 2023; Song et al., 2023; Cm et al., 2024). Overall, the findings highlight the complexity of the innovation–growth nexus in developing economies and underscore the pivotal role of institutional quality in shaping long-term development trajectories.

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

5. Conclusions and Implications

This study demonstrates that weak institutional quality constrains investment in capital markets and education, thereby undermining firm performance and reinforcing a self-perpetuating cycle of underdevelopment. Insufficient institutional support leads to underinvestment in human capital, which in turn limits the availability of skilled labor, weakens R&D capacity, and suppresses innovation outcomes. Using an R&D ecosystem framework and SEM analysis on lower-middle-income countries in 2019, the findings confirm that capital market institutions and R&D features exert a significant positive effect on innovation, while the relationship between innovation and economic growth remains statistically insignificant. This pattern provides empirical support for the middle-income trap hypothesis, suggesting that innovation activity alone is insufficient to generate sustained growth in the absence of robust institutional foundations and effective absorptive capacity.

The results highlight the need for policymakers in developing economies to prioritize institutional strengthening as a prerequisite for innovation-led growth. In particular, improving financial system depth, legal certainty, governance quality, and labor market flexibility is essential to enhance investment in R&D, education, and innovation ecosystems. Addressing structural rigidities in labor markets such as underemployment and hidden unemployment can further support the translation of innovation into productivity gains. While disparities in R&D capacity between developed and developing countries are well documented, this study shows that institutional weaknesses extend beyond R&D to broader economic structures, limiting the growth impact of innovation. Although the study is constrained by a relatively small sample size and reliance on pre-pandemic data, these choices allow for a focused examination of structural dynamics in lower-middle-income economies under stable global conditions. Overall, the findings underscore that escaping the middle-income trap requires coordinated institutional reforms that integrate capital markets, human capital development, and R&D within a coherent and well-functioning economic ecosystem.

References

Acemoglu, D., & Robinson, J. A. (2005). *Economic origins of dictatorship and democracy*. Cambridge University Press. https://doi.org/10.1017/CBO9780511510809

Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *American Economic Review, 91*(5), 1369–1401. https://doi.org/10.1257/aer.91.5.1369

Aghion, P., & Bircan, C. (2017). *The middle-income trap from a Schumpeterian perspective* (ADB Economics Working Paper Series No. 521). Asian Development Bank. https://doi.org/10.2139/ssrn.3187838

Aghion, P., Howitt, P., & Prantl, S. (2011). Revisiting the relationship between competition, patenting, and innovation. In *Advances in economics and econometrics: Tenth World Congress (Vol. I): Economic theory* (pp. 449–455). Cambridge University Press. https://doi.org/10.1017/CBO9781139060011.016

Altinok, N., & Diebolt, C. (2024). Cliometrics of learning-adjusted years of schooling: Evidence from a new dataset. *Cliometrica, 18*(3), 691–764. https://doi.org/10.1007/s11698-023-00276-x

Azariadis, C., & Drazen, A. (1990). Threshold externalities in economic development. *The Quarterly Journal of Economics, 105*(2), 501–526. https://doi.org/10.2307/2937797

Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy, 98*(5), S103–S125.

Barro, R. J. (1992). A tale of two cities: Factor accumulation and technical change in Hong Kong and Singapore: Comment. *NBER Macroeconomics Annual, 7*, 56–60. https://doi.org/10.2307/3584995

Barro, R. J., Mankiw, N. G., & Sala-i-Martin, X. X. (1995). Capital mobility in neoclassical model of growth. *American Economic Review, 90*(3), 687–694.

Benhabib, J., & Spiegel, M. M. (2005). Human capital and technology diffusion. In *Handbook of economic growth* (pp. 935–966). Elsevier. https://doi.org/10.1016/S1574-0684(05)01013-0

Bessen, J., & Hunt, R. M. (2007). An empirical look at software patents. *Journal of Economics & Management Strategy, 16*(1), 157–189. https://doi.org/10.1111/j.1530-9134.2007.00136.x

Brunswicker, S., & Schecter, A. (2019). Coherence or flexibility? The paradox of change for developers' digital innovation trajectory on open platforms. *Research Policy, 48*(8), 1–16. https://doi.org/10.1016/j.respol.2019.03.016

Capolupo, R. (2009). The new growth theories and their empirics after twenty years. *Economics, 3*(1), 1–72. https://doi.org/10.5018/economics-ejournal.ja.2009-1

Chen, W., & Song, H. (2024). National innovation system: Measurement of overall effectiveness and analysis of influencing factors. *Technology in Society, 77*, 102514. https://doi.org/10.1016/j.techsoc.2024.102514

Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research Policy, 43*(7), 1164–1176. https://doi.org/10.1016/j.respol.2014.04.014

Cm, J., Hoang, N. T., & Yarram, S. R. (2024). The transition from middle-income trap: Role of innovation and economic globalisation. *Applied Economics, 56*(1), 1–21. https://doi.org/10.1080/00036846.2023.2267821

Coe, D. T., Helpman, E., & Hoffmaister, A. W. (1997). North-south R&D spillovers. *The Economic Journal, 107*(440), 134–149. https://doi.org/10.1111/1468-0297.00146

Coe, D. T., Helpman, E., & Hoffmaister, A. W. (2009). International R&D spillovers and institutions. *European Economic Review, 53*(7), 723–741. https://doi.org/10.1016/j.euroecorev.2009.02.005

Cvetanović, S., Mitrović, U., & Jurakić, M. (2019). Institutions as the driver of economic growth in classic, neoclassic endogenous theory. *Economic Themes, 57*(1), 111–125. https://doi.org/10.2478/ethemes-2019-0007

Dahiru, T. (2011). P-value, a true test of statistical significance? A cautionary note. *Annals of Ibadan Postgraduate Medicine, 6*(1), 21–26. https://doi.org/10.4314/aipm.v6i1.64038

Degong, M., Ullah, R., Ullah, F., & Mehmood, S. (2021). Financial liberalization, economic growth, and capital flight: The case of Pakistan economy. In M. Shahbaz, A. Soliman, & S. Ullah (Eds.), *Economic growth and financial development: Effects of capital flight in emerging economies* (pp. 115–134). Springer. https://doi.org/10.1007/978-3-030-79003-5_7

Devassia, B. P., Karma, E., & Muço, K. (2024). Role of human capital as a driver for sustainable development (SDG) in Western Balkan countries. *Journal of Lifestyle and SDGs Review, 4*(2), 02051. https://doi.org/10.47172/2965-730X.SDGsReview.v4.n02.pe02051

Diebolt, C., & Perrin, F. (2016). Growth theories. In *Handbook of cliometrics* (pp. 177–195). Springer. https://doi.org/10.1007/978-3-642-40406-1_3

Diebolt, C., & Perrin, F. (2019). Cliometrics of growth. In C. Diebolt & M. Haupert (Eds.), *Handbook of cliometrics* (pp. 403–421). Springer. https://doi.org/10.1007/978-3-030-00181-0_3

Doloreux, D., & Turkina, E. (2023). Intermediaries in regional innovation systems: An historical event-based analysis applied to AI industry in Montreal. *Technology in Society, 72*, 102192. https://doi.org/10.1016/j.techsoc.2022.102192

Doner, R. F., & Schneider, B. R. (2016). The middle-income trap: More politics than economics. *World Politics, 68*(4), 608–644.

Durham, J. B. (2004). Absorptive capacity and the effects of foreign direct investment and equity foreign portfolio investment on economic growth. *European Economic Review, 48*(2), 285–306. https://doi.org/10.1016/S0014-2921(02)00264-7

Färnstrand Damsgaard, E., & Krusell, P. L. (2010). *The world distribution of productivity: Country TFP choice in a Nelson-Phelps economy* (NBER Working Paper No. 16375). National Bureau of Economic Research. https://doi.org/10.2139/ssrn.1693765

Ge, S., & Liu, X. (2022). The role of knowledge creation, absorption and acquisition in determining national competitive advantage. *Technovation, 112*, 102396. https://doi.org/10.1016/j.technovation.2021.102396

Gompers, P. A., Kovner, A., Lerner, J., & Scharfstein, D. S. (2005). *Venture capital investment cycles: The impact of public markets* (NBER Working Paper No. 11385). National Bureau of Economic Research. http://www.nber.org/papers/w11385

Griliches, Z. (1998). Introduction to R&D and productivity: The econometric evidence. In *R&D and productivity: The econometric evidence* (pp. 1–14). University of Chicago Press.

Grossman, G. M., & Helpman, E. (1991). Quality ladders and product cycles. *The Quarterly Journal of Economics, 106*(2), 557–586. https://doi.org/10.2307/2937947

Hannum, C. M. (2024). The middle income trap: Look closer and you'll find it, but maybe not where you expected. *Applied Economics Letters, 31*(3), 182–186.

Iansiti, M., & Levien, R. (2004). Strategy as ecology. *Harvard Business Review, 82*(2), 68–78.

Jones, C. I., & Williams, J. C. (1998). Measuring the social return to R&D. *The Quarterly Journal of Economics, 113*(4), 1119–1135. https://doi.org/10.1162/003355398555856

Jorgenson, D. W., Fukao, K., & Timmer, M. P. (2016). *The world economy: Growth or stagnation?* Cambridge University Press. https://doi.org/10.1017/9781316534502

Ke, Y. (2024). ASEAN Four's middle income trap dilemma: Evidence of the middle technology trap. *Asian Review of Political Economy, 3*(14), 1–29. https://doi.org/10.1007/s44216-024-00033-5

Kharas, H., & Gill, I. S. (2019). *Growth strategies to avoid the middle-income trap*. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3526261

Knack, S., & Keefer, P. (1995). Institutions and economic performance: Cross-country tests using alternative institutional measures. *Economics & Politics, 7*(3), 207–227. https://doi.org/10.1111/j.1468-0343.1995.tb00111.x

Krueger, A. O. (1968). Factor endowments and per capita income differences among countries. *The Economic Journal, 78*(311), 641–659. https://doi.org/10.2307/2229388

Lee, Y. S. (2020). New general theory of economic development: Innovative growth and distribution. *Review of Development Economics, 24*(2), 402–423. https://doi.org/10.1111/rode.12654

Lerner, J. (1999). The government as venture capitalist: The long-run impact of the SBIR program. *The Journal of Business, 72*(3), 285–318. https://doi.org/10.1086/209616

Li, J. F., & Garnsey, E. (2014). Policy-driven ecosystems for new vaccine development. *Technovation, 34*(12), 762–772. https://doi.org/10.1016/j.technovation.2014.07.002

Lichtenberg, F. R. (2001). Probing the link between gross profitability and R&D spending. *Health Affairs, 20*(5), 221–222. https://doi.org/10.1377/hlthaff.20.5.221

Lichtenberg, F. R., & Pottelsberghe de la Potterie, B. (1998). International R&D spillovers: A comment. *European Economic Review, 42*(8), 1483–1491. https://doi.org/10.1016/S0014-2921(97)00089-5

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics, 22*(1), 3–42. https://doi.org/10.1016/0304-3932(88)90168-7

Méon, P.-G., & Sekkat, K. (2004). Does the quality of institutions limit the MENA's integration in the world economy? *The World Economy, 27*(9), 1475–1498. https://doi.org/10.1111/j.0378-5920.2004.00661.x

Mickiewicz, T. (2023). Middle-income trap and the evolving role of institutions along the development path. In J. Ricz & T. Gerőcs (Eds.), *The political economy of emerging markets and alternative development paths* (pp. 37–60). Palgrave Macmillan. https://doi.org/10.1007/978-3-031-20702-0_3

Mincer, J. (1993). Human capital, technology, and the wage structure: What do time series show? In J. Mincer (Ed.), *Studies in human capital: Collected essays of Jacob Mincer* (Vol. 1, pp. 366–406). Edward Elgar Publishing. https://doi.org/10.4337/9781782541554.00022

Moore, J. F. (1993). Predators and prey: A new ecology of competition. *Harvard Business Review, 71*(3), 75–86.
Mukerji, V., & Johansen, L. (1963). A multisectoral study of economic growth. *Econometrica, 31*(4), 770–771. https://doi.org/10.2307/1909181
Naylor, T. D., & Florida, R. (2003). The rise of the creative class: And how it's transforming work, leisure, community and everyday life. *Canadian Public Policy / Analyse de Politiques, 29*(3), 378–379. https://doi.org/10.2307/3552294
Nelson, R. R., & Phelps, E. S. (1966). Investment in humans, technological diffusion, and economic growth. *American Economic Review, 56*(1/2), 69–75.
North, D. C. (1991). Institutions. *Journal of Economic Perspectives, 5*(1), 97–112. https://doi.org/10.1257/jep.5.1.97
OECD. (2015). *Frascati manual 2015: Guidelines for collecting and reporting data on research and experimental development*. OECD Publishing. https://doi.org/10.1787/9789264239012-en
Prasetyo, P. E. (2020). Human capital as the main determinant of regional economic growth. *International Journal of Advanced Science and Technology, 29*(3), 6261–6267.
Rizwanul, I. (2004). *The nexus of economic growth, employment and poverty reduction: An empirical analysis* (Issues in Employment and Poverty Discussion Paper No. 14). International Labour Office.
Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy, 94*(5), 1002–1037.
Romer, P. M. (1989). Human capital and growth: Theory and evidence: A comment. *Carnegie-Rochester Conference Series on Public Policy, 32*, 287–291. https://doi.org/10.1016/0167-2231(90)90029-K
Samuels, P. (2015). *Statistical methods: Scale reliability analysis with small samples*. Birmingham City University, Centre for Academic Success.
Schumpeter, J. A. (2017). *Theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle*. Taylor & Francis. https://doi.org/10.4324/9781315135564
Schwab, K. (2019). *The global competitiveness report 2019*. World Economic Forum.
Shaw, E. S. (1973). *Financial deepening in economic development*. Oxford University Press.
Siegel, A. F., & Wagner, M. R. (2022). Multiple regression. In *Practical business statistics* (pp. 371–431). Academic Press. https://doi.org/10.1016/B978-0-12-820025-4.00012-9
Smith, K., & Estibals, A. (2011). *Innovation and research strategy for growth* (BIS Economics Paper No. 15). UK Department for Business, Innovation & Skills.
Smith, A., Arond, E., Fressoli, M., Hernán, T., & Abrol, D. (2012). *Supporting grassroots innovation: Facts and figures*. SciDev.Net.
Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513
Son, H. (2016). Trust, economic growth and importance of the institution. *International Journal of Economic Sciences, 5*(4), 32–50. https://doi.org/10.20472/ES.2016.5.4.003
Song, H., Buts, C., & Jegers, M. (2023). The middle-income trap and competition policy: An institutional analysis. *Asian Journal of Law and Economics, 14*(2), 135–161. https://doi.org/10.1515/ajle-2022-0102
Thomas, L. D. W., & Autio, E. (2014). The fifth facet: The ecosystem as an organizational field. *Academy of Management Proceedings, 2014*(1), 10306. https://doi.org/10.5465/ambpp.2014.10306abstract
Van der Borgh, M., Cloodt, M., & Romme, A. G. L. (2012). Value creation by knowledge-based ecosystems: Evidence from a field study. *R&D Management, 42*(2), 150–169. https://doi.org/10.1111/j.1467-9310.2011.00673.x
Westland, C. J. (2010). Lower bounds on sample size in structural equation modeling. *Electronic Commerce Research and Applications, 9*(6), 476–487. https://doi.org/10.1016/j.elerap.2010.07.003

Weston, R., & Gore, P. A., Jr. (2006). A brief guide to structural equation modeling. *The Counseling Psychologist*, *34*(5), 719–751. https://doi.org/10.1177/0011000006286345

Will, K. (2019). Capital markets definition. *Investopedia*.

World Bank. (2024). *World development report 2024: The middle-income trap*. World Bank. https://doi.org/10.1596/978-1-4648-2078-6