Asian Economic and Financial Review
ISSN(e): 2222-6737
ISSN(p): 2305-2147
DOI: 10.55493/5002.v15i8.5505
Vol. 15, No. 8, 1210-1227.

URL: www.aessweb.com

Threshold effects of institutional quality on economic growth in China's leading provinces

Yanyan Fu[1]
Pei-Tha Gan[2+]
Awadh Ahmed Mohammed Gamal[3]

[1,2,3]*Department of Economics, Faculty of Management and Economics, Universiti Pendidikan Sultan Idris (Sultan Idris Education University), 35900 Tanjong Malim, Perak, Malaysia.*
[1]*Email: p20211002214@siswa.upsi.edu.my*
[2]*Email: gan.pt@fpe.upsi.edu.my*
[3]*Email: awadh.gamal@fpe.upsi.edu.my*

(+ Corresponding author)

ABSTRACT

This study investigates how institutional quality influences the linkage between economic growth and factor inputs specifically physical capital, labor, human capital, and R&D within China's leading provinces. Drawing on annual panel data from 1996 to 2022 for Guangdong, Jiangsu, Shandong, Zhejiang, Henan, and Sichuan, a panel threshold modeling approach is employed to identify non-linear effects of institutional quality on the relationship between factor inputs and growth. A robustness check is conducted to validate the findings. The empirical results suggest that economic growth benefits from factor inputs only when institutional quality surpasses a critical threshold. This study provides empirical evidence that institutional quality mediates the effectiveness of factor inputs in driving economic growth. While physical capital, labor, and human capital remain influential across different institutional settings, R&D contributes significantly only above a certain institutional threshold. Policymakers should prioritize strengthening institutional frameworks to optimize the productivity of investments in physical capital, labor, human capital, and R&D.

Article History
Received: 3 April 2025
Revised: 26 June 2025
Accepted: 15 July 2025
Published: 28 July 2025

Keywords
Economic growth
Factor inputs
Physical capital
Labor
Human capital
R&D
Panel threshold model
Threshold effects.

JEL Classification:
O43; O47.

Contribution/ Originality: This study pioneers the identification of threshold effects of institutional quality in shaping the impact of factor inputs on economic growth, demonstrating that factor inputs spur growth only when institutional quality exceeds critical levels. Using panel threshold models provides targeted policy insights for optimizing growth strategies in China's leading provinces.

1. INTRODUCTION

"Economic growth" refers to the continuous expansion of the productive capacity of an economy. The pioneering work by Solow (1957) established the foundational framework for analyzing economic growth, emphasizing the essential contributions of capital formation, labor force growth, and technological advancement. Since then, scholars have employed various methodologies to explore the forces behind economic growth. While significant attention has been given to analyzing how factor inputs contribute to growth under different circumstances, these studies often yield limited practical insights due to theoretical gaps and research design flaws. Even analyses of cross-country growth patterns and convergence hypotheses have failed to produce actionable or policy-relevant conclusions for China's specific economic landscape (Glawe & Wagner, 2023; Saggu & Anukoonwattaka, 2015). Since the initiation of investment programs and market reforms in 1978, government policies have been instrumental in advancing infrastructure development, manufacturing output, and R&D. While these policies have led to substantial economic growth, several challenges have emerged (Brandt, Litwack, Mileva, & Wang, 2020). In response to the changing economic landscape, China's government has launched substantial endeavors to eliminate institutional barriers, aiming to stabilize economic growth in the medium to long-term (Gill & Kharas, 2015; Zhang & Rodríguez-Pose, 2024). These initiatives have focused on reforms, such as lowering trade and investment barriers, bolstering the rule of law, thereby increasing productivity and spurring technological innovation (Brandt et al., 2020; Morrison, 2019; World Bank, 2022). China's institutional reforms aim to increase economic efficiency, yet their effectiveness remains uncertain. This study investigates how institutional quality functions as a catalyst in strengthening the contribution of key factor inputs namely physical capital, labor, human capital, and R&D to sustain economic growth. The findings offer meaningful implications for policymakers steering China's ongoing economic transformation.

The pivotal role of institutional quality in fostering economic growth has been well recognized in theoretical perspective. Endogenous growth models position institutional quality as a fundamental determinant of long-term economic performance (North, 1990), a view further reinforced by the empirical analyses of Acemoglu, Johnson, and Robinson (2004) and Daron Acemoglu and Robinson (2008). Nevertheless, while the theoretical consensus is clear, empirical investigations into how institutional quality mediates the impact of factor inputs on economic growth—particularly in the context of China remain limited. China's remarkable growth trajectory has been largely fueled by the accumulation of capital, the expansion of the labor force, and continuous technological progress. Yet, the productivity of these inputs may critically depend on the quality of institutional frameworks. Considering China's regional disparities and its ongoing structural and institutional reforms, exploring the threshold effects of institutional quality is essential for designing effective policies that promote sustainable economic growth. Empirical research has shed light on the influence of institutional quality in shaping the relationship between physical capital and economic growth. For example, Ogbaro (2019) and Ogbaro and Oladeji (2021) find that physical capital consistently promotes economic growth, regardless of whether institutional quality falls below or exceeds the identified threshold, suggesting that capital accumulation remains a key driver of growth across varying institutional contexts. In contrast, evidence from Hall, Sobel, and Crowley (2010) and Hussen (2023) indicate that the growth-enhancing effect of physical capital is significantly amplified under strong institutional conditions, while weak institutions tend to undermine its effectiveness, often leading to negative growth outcomes due to rent-seeking and inefficient resource allocation. Similarly, Zergawu, Walle, and Giménez-Gómez (2020) report a positive linkage between physical capital and economic growth in high-institutional-quality environments, though this effect diminishes when institutional quality deteriorates. Collectively, these studies underscore the critical role of institutional quality in unlocking the full growth potential of physical capital investments.

Institutional quality plays a pivotal role in the labor-growth nexus. Rodríguez-Pose and Ganau (2022) emphasize that institutional quality significantly shapes how labor contributes to productivity shifts. Similarly, Kpognon and Bah (2019) argue that better institutional conditions enhance labor productivity, thereby fostering overall economic performance. This view is further supported by Kpognon, Atangana Ondoa, Bah, and Asare-Nuamah (2022), who contend that improvements in institutional frameworks are instrumental in stimulating labor-driven productivity growth. However, Sanga, Ahouakan, and Adje (2022) present an opposite perspective, suggesting that institutional quality may hinder labor productivity through bureaucratic inefficiencies. These findings illustrate that the link between institutional quality and labor productivity may vary across different institutional settings. Turning to the human capital-growth relationship, Adams‐Kane and Lim (2016) highlight that institutional quality enhances the positive contribution of human capital to economic growth by improving the enabling environment for skills development and utilization. Similarly, Raifu, Nnadozie, and Opeloyeru (2021) and Cooray and Nam (2025) demonstrate that strong institutional foundations are vital for translating human capital accumulation into growth outcomes. Nevertheless, Apergis, Mustafa, and Khan (2022) argue that the contribution of human capital to growth remains limited until a certain institutional threshold is reached. Furthermore, Bethencourt and Perera-Tallo (2020) suggest that variations in institutional quality may lead to misleading negative correlations between human capital and GDP, underscoring the importance of accounting for institutional quality context. This implies that institutional quality acts as a critical enabler or barrier in realizing the growth potential of both labor and human capital, depending on whether institutional quality is conducive to leveraging human capital effectively.

Institutional quality plays a central role in shaping the effectiveness of R&D in promoting economic growth. Bekana (2021) finds that higher institutional quality not only has a direct positive effect on economic performance but also reinforces the growth-enhancing impact of R&D efforts. Further, Alam, Uddin, and Yazdifar (2019) demonstrate that robust institutional quality fosters R&D by encouraging technological investments. Building on this argument, Saidi, Hakimi, and Rachdi (2024) and Duyen and Tinh (2024) argue that the influence of R&D on growth is conditional upon the marginal effects of institutional quality. Supporting this position. To support this view, Law, Sarmidi, and Goh (2020) highlight that strong institutions significantly enhance the capacity of R&D to contribute to economic development. These findings underscore that institutional quality is a crucial determinant in translating R&D investments into sustained economic gains.

This study is motivated by the important role of institutional quality in mediating the influence of factor inputs on growth within China's leading provinces, which provides a valuable reassessment of these dynamics for achieving sustainable and balanced growth. Although China's economic reform has achieved remarkable success, recent years have seen growth deceleration (International Monetary Fund, 2023; World Bank, 2024), prompting policymakers to address institutional barriers (Gill & Kharas, 2015; Zhang & Rodríguez-Pose, 2024). As China transitions into a "new normal" economy characterized by slower but more balanced growth (Garnaut, Song, & Fang, 2018) it becomes increasingly important to explore whether institutional quality exhibits threshold effects in mediating the relationship between factor inputs and economic growth particularly in leading provinces such as Guangdong, Jiangsu, Shandong, Zhejiang, Henan, and Sichuan. These provinces contribute substantially to China's GDP and global economic standing. Insights from this study will help bridge a significant gap in the literature by providing new empirical evidence, enabling policymakers to design region-specific strategies, optimize resource allocation, and enhance economic resilience. While institutional quality has been widely emphasized in theoretical literature (Acemoglu et al., 2004; Acemoglu & Robinson, 2008; North, 1990), its specific role within the context of China's economic development remains under-explored in empirical research. Despite not having fully functional institutional frameworks, China has achieved remarkable growth, a phenomenon termed the "China Paradox" (Glawe & Wagner, 2023; Uddin, Ali, & Masih, 2021). World Bank (2024) emphasizes the urgency to address this paradox by investigating the mechanisms through which institutional quality influences the efficient utilization of factor inputs in economically critical areas.

This study aims to investigate how institutional quality mediates the impact of factor inputs and economic growth. In doing so, it identifies threshold effects and provides empirical evidence to inform policies that enhance economic resilience in China's leading provinces. The effectiveness of factor inputs in promoting growth depends on the quality of institutions, with significant positive effects emerging only when institutional quality surpasses a critical threshold. The analysis is based on annual panel data from 1996 to 2022 for six leading provinces: Guangdong, Jiangsu, Shandong, Zhejiang, Henan, and Sichuan.

This study contributes to literature in three key aspects. First, this investigation provide novel empirical evidence that institutional quality serves as a critical threshold for factor inputs to effectively promote economic growth in China's leading provinces. Second, unlike prior studies focusing on linear relationships (Brandt et al., 2020; Glawe & Wagner, 2023) we employ Hansen (1999) panel threshold model to reveal the nonlinear nature of this relationship, with robustness check through Kremer, Bick, and Nautz (2013) dynamic approach. These methods effectively capture rich dynamics in the relationship between factor inputs and economic growth. Third, this study offers practical policy insights for China's leading provinces, suggesting that investments in physical capital, human capital, and R&D yield optimal returns only when accompanied by institutional improvements. The anticipated results are expected to provide theoretically consistent and policy-relevant insights by identifying the institutional conditions that enhance the effectiveness of factor inputs in driving economic growth. In addition, these findings complement existing growth theories while providing valuable guidance for growth strategies.

2. METHODOLOGY

The empirical model is a modified version of Romer (1990) endogenous growth model. Among other researchers, this model was used by Omar (2019) and Sulaiman, Bala, Tijani, Waziri, and Maji (2015). Building on their pioneering contributions, economists have increasingly examined how factor inputs, specifically physical capital, labor, human capital, and R&D, empirically affect economic growth through the following linear equation:

$$\ln y_t = \alpha \ln k_t + \beta \ln L_t + \delta \ln H_t + \varepsilon \ln r_t \qquad (1)$$

Here, y denotes real output, while k, L, H, and r represent physical capital, labor, human capital, and R&D respectively. The coefficients α, β, δ, and ε correspond to the output elasticity of k, L H, and r respectively. Theoretically, all factor inputs positively influence the economic growth, and thus the coefficients are expected to have positive signs, i.e., $\varepsilon > 0, \alpha > 0, \beta > 0$, and $\delta > 0$.

To examine the hypothesis outlined in the previous section, this study employs the panel threshold model developed by Hansen (1999), which is designed to detect nonlinearities in the relationship between institutional quality and factor inputs in the context of economic growth. This approach is particularly well-suited for identifying threshold effects, where the influence of factor inputs may differ across varying levels of institutional quality. A notable advantage of this method lies in its ability to endogenously determine the number of threshold values based on the characteristics of the sample data. In other words, Hansen (1999) panel threshold regression model permits an endogenous sample split (Ndiweni & Bonga-Bonga, 2021). The general specification of threshold regression models takes the following forms:

$$\ln y_{it} = \mu + \alpha_L \ln k_{it} I(IQ_{it} < \gamma) + \alpha_H \ln k_{it} I(IQ_{it} \geq \gamma) + \beta \ln L_{it} + \delta \ln H_{it} + \varepsilon \ln r_{it} + e_{it} \qquad (2)$$

$$\ln y_{it} = \mu + \beta_L \ln L_{it} I(IQ_{it} < \gamma) + \beta_H \ln L_{it} I(IQ_{it} \geq \gamma) + \alpha \ln k_{it} + \delta \ln H_{it} + \varepsilon \ln r_{it} + e_{it} \qquad (3)$$

$$\ln y_{it} = \mu + \delta_L \ln H_{it} I(IQ_{it} < \gamma) + \delta_H \ln H_{it} I(IQ_{it} \geq \gamma) + \alpha \ln k_{it} + \beta \ln L_{it} + \varepsilon \ln r_{it} + e_{it} \qquad (4)$$

$$\ln y_{it} = \mu + \varepsilon_L \ln r_{it} I(IQ_{it} < \gamma) + \varepsilon_H \ln r_{it} I(IQ_{it} \geq \gamma) + \alpha \ln k_{it} + \beta \ln L_{it} + \delta \ln H_{it} + e_{it} \qquad (5)$$

In this framework, institutional quality (IQ) acts as the threshold variable, dividing the sample into distinct regimes depending on whether its value exceeds or falls below an estimated threshold parameter γ. The indicator function $I(\bullet)$ equals 1 when the specified condition is met and 0 otherwise. This formulation permits the marginal effects of k, L, H, and r to fluctuate across regimes, depending on whether the institutional quality level is below or above the estimated threshold level γ in each regime. In doing so, it captures potential nonlinear and regime-specific impacts on the relationship between factor inputs and economic outcomes. Equation 2 through 5 employ institutional quality as threshold variables. The estimation procedure classifies observations into a low-IQ regime (i.e., weak institutional quality) and a high-IQ regime (i.e., strong institutional quality), depending on whether the institutional quality measure falls below or above the threshold level. The impacts of k, L, H, and r on y are captured by the parameters α_L and α_H, β_L and β_H, δ_L and δ_H, ε_L and ε_H, which correspond to the low and high regimes, respectively. Under the hypotheses $\alpha_L=\alpha_H$, $\beta_L=\beta_H$, $\delta_L=\delta_H$, and $\varepsilon_L=\varepsilon_H$, the model simplifies to a linear form and reduces to Equation 1. Following Li, Tanna, and Nissah (2023) and Wang, Shao, Wang, and Wu (2021), the initial step in employing the Hansen (1999) threshold model involves testing for the existence of threshold effects within the specified relationship. The threshold value is identified by minimizing the residual sum of squares, allowing for the endogenous determination of regime splits.

$$\hat{\gamma} = \operatorname{argmin} S_1(\gamma) \qquad (6)$$

Hansen (1999) suggested a method involving a grid search to identify potential threshold values. This approach calculates the sum of the squared residuals for each candidate threshold value to determine the one that minimizes the overall sum.

This approach is equivalent to determining whether the coefficients are identical across regimes when testing for a threshold effect. The null hypothesis H_0: $\beta_1 = \beta_2$ (linear model) is tested against the alternative hypothesis H_1: $\beta_1 \neq \beta_2$ (single-threshold model). The test statistic follows F-distribution:

$$F_1 = \frac{S_0 - S_1(\hat{\gamma})}{\hat{\sigma}^2} \qquad (7)$$

The F_1 statistic follows a nonstandard distribution, as threshold values are uncertain under the null hypothesis. To address this issue, Hansen (1999) introduced a bootstrap procedure to generate asymptotically valid critical values, thereby enabling formal inference on the presence of threshold effects.

The next step involves calculating the confidence intervals for the threshold values. In line with the Hansen (1999) method, $\hat{\gamma}$ serves as a consistent estimator for γ, and the confidence interval is obtained through the likelihood ratio (LR) statistic. The LR statistic can be calculated as

$$LR_1(\gamma) = \frac{S_1(\gamma) - S_1(\hat{\gamma})}{\hat{\sigma}^2} \qquad (8)$$

The LR statistic exhibits a nonstandard asymptotic distribution under the H_0. However, Hansen (1999) provides a formula to construct the rejection region LR_1.Specifically, when $LR_1(\gamma) > c(\alpha) = -2\log(1-\sqrt{1-\alpha})$, the null hypothesis H_0: $\gamma = \gamma_0$ is rejected at the significance level α, suggesting the presence of a threshold point in the data.

3. DATA DESCRIPTION

This study focuses on six economically advanced provinces in China: Guangdong, Jiangsu, Shandong, Zhejiang, Henan, and Sichuan. Annual data from 1996 to 2022 are obtained from authoritative sources, including the China Statistical Yearbook, the World Bank, the International Country Risk Guide (ICRG), and the Worldwide Governance Indicators (WGI). This sample period captures significant changes in economic transition, technological advancements, and institutional reforms. It provides a robust basis for examining how institutional quality mediates the relationship between factor inputs and economic growth, accounting for both short-term fluctuations and long-term structural changes. This period also reflects the dynamic shifts in key macroeconomic indicators relevant to this study, such as economic growth, physical capital, labor, human capital, R&D, and institutional quality. The selected variables are consistent with endogenous growth theory while addressing China's unique institutional context. Detailed measurements of all variables are presented in Table 1.

Table 1. Detailed measurements for all variables.

Variable	Proxy indicator	Description
Dependent variable		
Real output (y)	Real gross domestic product	$y =$ Nominal GDP / Consumer price index
Independent variable		
Physical capital (k)	Real fixed asset investment	$k_t = k_{t-1}(1-\delta) + i_t$ $k_0 = i_0/(g+\delta)$ k_t is capital stock, i_t is real fixed asset investment in year t, g is growth rate, δ is 9.6% (Arya, Banerjee, & Cavoli, 2019; Bailliu, Kruger, Toktamyssov, & Welbourn, 2019; Zhang, 2008)
Labor (L)	Working age population	L=Numbers of working age population
Human capital (H)	Average years of schooling	$H=\frac{0\times L_0+6\times L_6+9\times L_9+12\times L_{12}+16\times L_{16}}{\text{total population}}$ 0 for illiterate, 6 for primary, 9 for junior secondary, 12 for senior secondary, and 16 for tertiary education. L_i is persons with schooling years (Zhang & Zhuang, 2011)
R&D (r)	Real R&D expenditure	$r_t = e_{t-i} + (1-\delta)r_{t-1}$ $r_0 = e_0/(g+\delta)$ r_t is the capital stock, e is real R&D expenditure, g is the growth rate, δ is 15% (Goto & Suzuki, 1989; Griliches & Lichtenberg, 1984; Hu, Jefferson, & Jinchang, 2005)
Threshold variable		
Institutional quality (IQ_{ICRG})	ICRG	IQ_{ICRG} =corruption+law and order + bureaucratic quality (Aluko & Ibrahim, 2020; Law, Azman-Saini, & Ibrahim, 2013)
Institutional quality (IQ_{WGI})	WGI	IQ_{WGI} = (control of corruption + rule of law + government effectiveness) / 3 (Aluko & Ibrahim, 2020; Law et al., 2013)

In line with the specification mentioned above, all variables, i.e., y, k, L, H, and r, are expressed in log form except for IQ_{ICRG} and IQ_{WGI}.

The descriptive statistics for the study variables show in Table 2, while Table 3 provides the correlation matrix. The correlation analysis confirms strong positive relationships between y and k, L, H, and r. Additionally, both institutional quality variables exhibit positive and significant correlations with factor inputs as well as economic growth, suggesting their mediating role in enhancing economic productivity.

Table 2. Descriptive statistics, 1996–2022.

Variable	Unit of measurement	Mean	Std. dev.	Min.	Max.
y	CNY 1996 constant price	25076.742	19215.604	2871.650	83221.039
k	CNY 1996 constant price	77094.629	73277.700	4299.038	275458.202
L	10000 persons	4827.403	972.914	2612.540	7072.000
H	Number of years	8.388	0.897	6.421	10.204
r	CNY 1996 constant price	2595.568	3151.774	26.252	14316.631
IQ_{ICRG}	Scaled from 0 to 10	8.054	0.683	7.000	9.500
IQ_{WGI}	Scaled from–2.5 to 2.5	0.791	0.230	0.526	1.435

Table 3. Correlation matrix.

Variable	y	k	L	H	r	IQ_{ICRG}	IQ_{WGI}
y	1.000						
k	0.761***	1.000					
L	0.362***	0.283***	1.000				
H	0.701***	0.874***	0.312***	1.000			
r	0.758***	0.756***	0.328***	0.761***	1.000		
IQ_{ICRG}	0.576***	0.625***	0.181**	0.685***	0.613***	1.000	
IQ_{WGI}	0.677***	0.767***	0.188**	0.663***	0.704***	0.521***	1.000

Note: ***, ** signify statistical significance at 1% and 5% levels, respectively.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. Panel Cross-Sectional Dependence (CSD) Test and Panel Unit Root Test

Ignoring CSD may introduce significant estimation bias and distort the results.

Table 4. CSD test results.

Variable	LM	Scaled LM	CD	Bias adjusted LM
y	328.4*** (0.000)	18.01*** (0.000)	20.070*** (0.000)	162.0*** (0.000)
k	261.5*** (0.000)	15.86*** (0.000)	20.077*** (0.000)	127.3*** (0.000)
L	142.9*** (0.000)	10.33*** (0.000)	8.014*** (0.000)	65.73*** (0.000)
H	271.4*** (0.000)	16.43*** (0.000)	19.424*** (0.000)	132.4*** (0.000)
r	299.1*** (0.000)	17.23*** (0.000)	20.044*** (0.000)	146.8*** (0.000)
IQ_{ICRG}	405.0*** (0.000)	20.12*** (0.000)	20.125*** (0.000)	201.8*** (0.000)
IQ_{WGI}	405.0*** (0.000)	20.12*** (0.000)	20.125*** (0.000)	201.8*** (0.000)

Note: ***, **, and * signify statistical significance at 1%, 5%, and 10% levels, respectively.

To overcome this issue, this study therefore applies four diagnostic tests: (i) the Lagrange Multiplier (LM) test by Breusch and Pagan (1980), (ii) the scaled LM test proposed by Pesaran (2004), (iii) Pesaran (2004) cross-sectional dependence (CD) test, and (iv) the bias-adjusted LM test developed by Pesaran, Ullah, and Yamagata (2008). As demonstrated in Table 4, those tests provide robust evidence of CSD among the variables included in the panel datasets.

To obtain robust estimates in the presence of CSD, this study employs panel unit root procedures, namely the cross-sectional augmented Dickey-Fuller (CADF) test and the cross-sectional augmented IPS (CIPS) test based on second-generation methods. The variables exhibit mixed orders of integration, specifically I(0) and I(1), as shown in Table 5.

Table 5. Panel unit root test results.

Variables	Tests		
		CIPS	CADF
y_t	Level	−2.016	−2.016
	First difference	−3.623***	−3.623***
	Decision	$I(1)$	$I(1)$
k_t	Level	−3.296***	−3.230***
	First difference	−2.899***	−3.065***
	Decision	$I(0)$	$I(0)$
L_t	Level	−1.878	−1.259
	First difference	−2.946***	−2.419**
	Decision	$I(1)$	$I(1)$
H_t	Level	−3.399***	−2.482**
	First difference	−5.007***	−4.258***
	Decision	$I(0)$	$I(0)$
r_t	Level	−1.852	−1.903
	First difference	−3.757***	−3.423***
	Decision	$I(1)$	$I(1)$
IQ_{ICRG}	Level	−2.610***	−2.100***
	First difference	−2.101***	−2.221***
	Decision	$I(0)$	$I(0)$
IQ_{WGI}	Level	−2.120***	−2.210***
	First difference	−2.106***	−2.330***
	Decision	$I(0)$	$I(0)$

Note: ***, ** signify statistical significance at 1%, 5% levels, respectively.

4.2. Hansen (1999) Panel Threshold Regression

This study uses Hansen's (1999) panel threshold regression framework, as specified in Equation 2 through Equation 5, to examine whether institutional quality introduces threshold effects in the relationship between factor inputs and economic growth. The estimation results, reported in Table 6, indicate that when $\boldsymbol{k}$, $\boldsymbol{L}$, $\boldsymbol{H}$, and $\boldsymbol{r}$ are regime-dependent variables, taking IQ_{ICRG} and IQ_{WGI} as threshold variables, the F-statistics and their corresponding bootstrap p-values are calculated, with critical values at the 1, 5, and 10 per cent significance levels derived through a bootstrap procedure based on 300 replications, a grid search of 400 points, and a trimming percentage of 5. Table 7 presents the estimated threshold values along with their 95% confidence intervals. The bootstrap results support the rejection of the null hypothesis of no threshold effect, thereby confirming the existence of a single threshold.

Table 6. Significance of the threshold effect.

Regime-dependent variable	Threshold variable	*F*-statistic	*P*-value	Critical values		
				10%	5%	1%
k_t	IQ_{ICRG}	19.70***	0.000	5.913	7.222	11.589
	IQ_{WGI}	40.94**	0.010	24.373	29.026	40.624
L_t	IQ_{ICRG}	17.84***	0.000	8.114	9.996	12.800
	IQ_{WGI}	39.90**	0.023	26.571	31.515	44.211
H_t	IQ_{ICRG}	20.54***	0.000	5.935	7.594	11.789
	IQ_{WGI}	40.74***	0.006	22.277	27.586	37.933
r_t	IQ_{ICRG}	21.78***	0.000	4.813	5.490	8.445
	IQ_{WGI}	41.76**	0.010	21.755	28.835	38.245

Note:
***, ** signify statistical significance at 1%, 5% levels, respectively. H_0: no threshold effect, H_1: single threshold effect.

As presented in Table 7, the estimation results identify two distinct regimes across model 2a and 2b, in which physical capital (k) serves as a regime-dependent variable. Empirical evidence consistently supports the evidence of a single threshold, regardless of whether institutional quality is measured by IQ_{ICRG} or IQ_{WGI}. Versions "a" and "b" correspond to institutional quality datasets from IQ_{ICRG} and IQ_{WGI}, respectively. In Model 2a, the threshold estimate of 7.833, with a corresponding 95% confidence interval [7.500, 8.083], divides the low-*IQ* regime (below 7.833) from the high-*IQ* regime (above 7.833). Model 2b yields a threshold estimate value of 0.716, with a 95% confidence interval [0.705, 0.870]. Similarly, Model 3a and 3b, 4a and 4b, and 5a and 5b also confirm a single threshold across different specifications, confirming the robustness of the threshold effect alternative under both IQ_{ICRG} and IQ_{WGI}.

Table 7. Single threshold estimates of institutional quality.

Regime-dependent variable	Threshold model	Threshold variable	Threshold value	95% confidence interval
k_t	2a	IQ_{ICRG}	7.833	[7.500, 8.083]
	2b	IQ_{WGI}	0.716	[0.705, 0.870]
L_t	3a	IQ_{ICRG}	7.833	[7.500, 8.083]
	3b	IQ_{WGI}	0.716	[0.705, 0.870]
H_t	4a	IQ_{ICRG}	7.833	[7.500, 8.083]
	4b	IQ_{WGI}	0.716	[0.705, 0.870]
r_t	5a	IQ_{ICRG}	7.833	[7.500, 8.083]
	5b	IQ_{WGI}	0.716	[0.705, 0.870]

Note: The second column corresponds to Model Equation 2 to Equation 5 in the model specification section; versions "a" and "b" correspond to institutional quality datasets from IQ_{ICRG} and IQ_{WGI}, respectively.

After establishing the institutional quality threshold, the next question focuses on how institutional quality influences the relationship between factor inputs and growth. Table 8 presents the threshold regression results from Equation 2, where physical capital serves as a regime-dependent variable. Considering that the data favors a threshold model, this study concentrates on the specifications of the threshold model. Turning first to Model 2a, where institutional quality is measured by IQ_{ICRG}, physical capital exhibits significant positive effects in both regimes, increasing from 0.558 below the threshold to 0.565 above it. Similarly, in Model 2b, using IQ_{WGI} as the threshold variable, physical capital yields significant positive effects in both threshold regimes, the corresponding coefficients are 0.626 and 0.633 in the low and high regimes. These results suggest that institutional quality consistently enhances the growth effectiveness of physical capital, with the magnitude of enhancement exhibiting a nonlinear pattern contingent upon threshold attainment. This evidence aligns with prior studies by Ogbaro (2019), Ogbaro and Oladeji (2021), and Zergawu et al. (2020), confirming that institutional quality operates as both an enabling condition and a productivity multiplier for physical capital investments.

Table 8. Regression results. Dependent variable: Economic growth; Regime-dependent variable: Physical capital.

Threshold model 2a **Institutional quality=IQ_{ICRG}**		**Threshold model 2b** **Institutional quality=IQ_{WGI}**	
L_t	0.864*** (0.096)	L_t	0.988*** (0.091)
H_t	0.076*** (0.018)	H_t	0.027* (0.016)
r_t	0.047 (0.030)	r_t	0.026 (0.028)
Regime 1 $IQ_{ICRG}< 7.833$	0.558*** (0.034)	Regime 1 $IQ_{WGI}< 0.716$	0.626*** (0.034)
Regime 2 $IQ_{ICRG}\geq 7.833$	0.565*** (0.034)	Regime 2 $IQ_{WGI}\geq 0.716$	0.633*** (0.035)
_cons	−4.487*** (0.912)	_cons	−5.763*** (0.882)
No. observations	162	No. observations	162
N	6	N	6

Note: *** and * signify statistical significance at 1% and 10% levels, respectively. ( ) denotes the standard errors.

Table 9 reports the empirical results from Equation 3, with labor serving as a regime-dependent variable. The results indicate a nonlinear association between labor input and economic growth performance. Specifically, the estimated institutional quality threshold, below or above which labor significantly promotes economic growth, aligns precisely with that identified for physical capital. This result suggests that improvements in institutional quality foster labor productivity growth, leading to the creation of productive jobs. An expanded working-age population can serve as a driving force for productivity improvements by increasing labor force participation rates. As a result, this group also accumulates savings at a higher rate, facilitating further investment-driven economic growth. These findings corroborate the institutional productivity mechanisms identified by Kpognon et al. (2022) and Rodríguez-Pose and Ganau (2022) while extending their work by specifying the precise threshold levels at which institutional quality begins generating labor market dividends.

Table 9. Regression results. Dependent variable: Economic growth; Regime-dependent variable: Labor.

Threshold model 3a **Institutional quality=IQ_{ICRG}**		**Threshold model 3b** **Institutional quality=IQ_{WGI}**	
k_t	0.557*** (0.034)	k_t	0.641*** (0.035)
H_t	0.078*** (0.019)	H_t	0.026** (0.016)
r_t	0.048 (0.030)	r_t	0.023 (0.028)
Regime 1 $IQ_{ICRG}< 7.833$	0.856*** (0.097)	Regime 1 $IQ_{WGI}< 0.716$	0.985*** (0.091)
Regime 2 $IQ_{ICRG}\geq 7.833$	0.865*** (0.097)	Regime 2 $IQ_{WGI}\geq 0.716$	1.002*** (0.092)
_cons	−4.432*** (0.917)	_cons	−5.878*** (0.889)
No. observations	162	No. observations	162
N	6	N	6

Note: ***, ** signify statistical significance at 1%, 5% levels, respectively. ( ) denotes the standard errors.

Table 10 reports the threshold regression estimates from Equation 4, where human capital serves as a regime-dependent variable. The results indicate that the effect of human capital on economic growth varies across institutional quality regimes. In Model 4a, with institutional quality measured by IQ_{ICRG}, the coefficient on human capital is positive in both low- and high-regime contexts, with a greater magnitude observed in the high-regime group. Model 4b, which uses IQ_{WGI} as the threshold variable, also shows that human capital positively affects growth in both regimes, with estimated coefficients of 0.014 and 0.029 below and above the threshold, respectively. These findings suggest that human capital significantly enhances economic growth when institutional quality surpasses the identified threshold, whereas its effect is comparatively weaker in lower-quality institutional settings. This outcome aligns with the findings of Adams-Kane and Lim (2016) and Apergis et al. (2022), providing a precise institutional quality effect in which human capital investments yield greater growth dividends in stronger institutional settings.

Table 10. Regression results. Dependent variable: Economic growth; Regime-dependent variable: Human capital.

Threshold model 4a **Institutional quality=IQ_{ICRG}**		**Threshold model 4b** **Institutional quality=IQ_{WGI}**	
k_t	0.560*** (0.034)	k_t	0.636*** (0.035)
L_t	0.867*** (0.096)	L_t	0.999*** (0.092)
r_t	0.045 (0.030)	r_t	0.026 (0.028)
Regime 1 $IQ_{ICRG}< 7.833$	0.074*** (0.018)	Regime 1 $IQ_{WGI}< 0.716$	0.014** (0.016)
Regime 2 $IQ_{ICRG}\geq 7.833$	0.084*** (0.019)	Regime 2 $IQ_{WGI}\geq 0.716$	0.029** (0.016)
_cons	−4.512*** (0.910)	_cons	−5.843*** (0.885)
No. observations	162	No. observations	162
N	6	N	6

Note: ***, ** signify statistical significance at 1%, 5% levels, respectively. ( ) denotes the standard errors.

Table 11 reports the empirical results of Equation 5, with R&D as a regime-dependent variable. This highlights that the response of economic growth to R&D varies depending on the levels of institutional quality.

Table 11. Regression results. Dependent variable: Economic growth; Regime-dependent variable: R&D.

Threshold model 5a **Institutional quality=IQ_{ICRG}**		**Threshold model 5b** **Institutional quality=IQ_{WGI}**	
k_t	0.579*** (0.034)	k_t	0.635*** (0.034)
L_t	0.908*** (0.095)	L_t	1.007*** (0.091)
H_t	0.045*** (0.017)	H_t	0.028* (0.016)
Regime 1 $IQ_{ICRG}< 7.833$	0.043 (0.030)	Regime 1 $IQ_{WGI}< 0.716$	0.010 (0.029)
Regime 2 $IQ_{ICRG}\geq 7.833$	0.054** (0.029)	Regime 2 $IQ_{WGI}\geq 0.716$	0.026** (0.028)
_cons	−4.803*** (0.911)	_cons	−5.902*** (0.884)
No. observations	162	No. observations	162
N	6	N	6

Note: ***, **, and * signify statistical significance at 1%, 5%, and 10% levels, respectively. ( ) denotes the standard errors.

Turning to Model 5a, the coefficient of R&D is insignificant when IQ_{ICRG} falls below the threshold level. However, R&D significantly enhance growth once IQ_{ICRG} exceeds the estimated threshold. In Model 5b, the findings are similar to those in Model 5a, suggesting that R&D has the potential to benefit from economic growth. These benefits may not be realized in contexts with weak institutional quality. This result aligns with previous empirical studies, confirming that strong institutional quality is a necessary condition for R&D to positively affect long-term growth. Better institutional quality creates a reliable environment that can optimize the positive effects of innovation (Bekana, 2021; Law et al., 2020). Based on the findings above, economic growth responds differently to factor inputs depending on the levels of institutional quality. All estimated coefficients for $\boldsymbol{k}$, $\boldsymbol{L}$, $\boldsymbol{H}$, and $\boldsymbol{r}$ align with theoretical expectations. Notably, the growth effects exhibit greater magnitude for physical capital and labor compared to human capital and R&D. This pattern is consistent with previous empirical studies, including Guo, Hu, Zhao, and Li (2023); Li, Loyalka, Rozelle, and Wu (2017); Yang (2020) and Yang (2023). Strong institutional quality has played a critical role in enhancing productivity growth in China's leading provinces, functioning through both direct and indirect mechanisms. The productivity-enhancing effects of $\boldsymbol{k}$, $\boldsymbol{H}$, and $\boldsymbol{r}$ are shown to be highly contingent on the quality of institutional frameworks (Hall et al., 2010; Law et al., 2020; Raifu et al., 2021). Additionally, good institutional quality can significantly contribute to growth in labor by strengthening human capital and fostering innovation capacity (Kpognon et al., 2022; Rodríguez-Pose & Ganau, 2022). In contrast, poor institutional quality may hamper productivity growth and become a major obstacle to converting local talent and innovation into sustained economic performance (Apergis et al., 2022; Bekana, 2021).

4.3. Robustness Check

To assess the robustness of the results, this study applies the Kremer et al. (2013) dynamic panel threshold regression model (see Appendix). This method addresses endogeneity by using the lagged value of real GDP as an instrument, while institutional quality remains the threshold variable. The estimated threshold values derived from IQ_{ICRG} and IQ_{WGI} are 8.083 and 0.653, respectively. Table 12a through Table 12d support the findings of Hansen's (1999) threshold regression. The results again confirm that the factor inputs-growth nexus is contingent on institutional quality. In other words, the defined threshold value in the preceding section indicates the influence of institutional quality that triggers factor inputs in stimulating long-run economic growth. Most notably, physical capital, labor, and human capital contribute significantly across all institutional settings, while R&D-driven growth becomes effective only once institutional quality surpasses the threshold level. All the estimated coefficients for $\boldsymbol{k}$, $\boldsymbol{L}$, $\boldsymbol{H}$, and $\boldsymbol{r}$ align with theoretical expectations across all regressions.

Table 12a. Robustness check. Regime-dependent variable $\mathbf{k}$

Threshold model 2a **Institutional quality=IQ_{ICRG}**		**Threshold model 2b** **Institutional quality=IQ_{WGI}**	
Lagged dependent variable	0.899*** (0.023)	Lagged dependent variable	0.993*** (0.024)
L_t	0.096*** (0.030)	L_t	0.092*** (0.030)
H_t	0.242*** (0.062)	H_t	0.220*** (0.056)
r_t	0.038** (0.013)	r_t	0.021 (0.013)
Regime 1 IQ_{ICRG}< 8.083	0.563*** (0.080)	Regime 1 IQ_{WGI}< 0.653	0.548*** (0.069)
Regime 2 IQ_{ICRG}≥8.083	0.661*** (0.065)	Regime 2 IQ_{WGI}≥0.653	0.729*** (0.066)
_cons	1.024*** (0.291)	_cons	0.818*** (0.290)
No. observations	162	No. observations	162
N	6	N	6

Note: ***, ** signify statistical significance at 1%, 5%, levels, respectively. ( ) denotes the standard errors.

Table 12b. Robustness check. Regime-dependent variable.

Threshold model 3a Institutional quality=IQ_{ICRG}		Threshold model 3b Institutional quality=IQ_{WGI}	
Lagged dependent variable	0.831*** (0.045)	Lagged dependent variable	0.687*** (0.053)
k_t	0.110*** (0.030)	k_t	0.113*** (0.033)
H_t	0.385*** (0.112)	H_t	0.728*** (0.123)
r_t	0.040** (0.017)	r_t	0.031 (0.024)
Regime 1 $IQ_{ICRG} < 8.083$	0.099** (0.047)	Regime 1 $IQ_{WGI} < 0.653$	0.103** (0.046)
Regime 2 $IQ_{ICRG} \geq 8.083$	0.106** (0.047)	Regime 2 $IQ_{WGI} \geq 0.653$	0.111** (0.046)
_cons	−0.830* (0.422)	_cons	−0.211 (0.454)
No. observations	162	No. observations	162
N	6	N	6

Note: ***, **, and * signify statistical significance at 1%, 5%, and 10% levels, respectively. ( ) denotes the standard errors.

Table 12c. Robustness check. Regime-dependent variable H

Threshold model 4a Institutional quality=IQ_{ICRG}		Threshold model 4b Institutional quality=IQ_{WGI}	
Lagged dependent variable	0.895*** (0.049)	Lagged dependent variable	0.777*** (0.055)
k_t	0.039 (0.033)	k_t	0.142*** (0.040)
L_t	0.051 (0.062)	L_t	0.210*** (0.069)
r_t	0.006 (0.059)	r_t	0.005 (0.016)
Regime 1 $IQ_{ICRG} < 8.083$	0.162** (0.651)	Regime 1 $IQ_{WGI} < 0.653$	0.105* (0.060)
Regime 2 $IQ_{ICRG} \geq 8.083$	0.183*** (0.066)	Regime 2 $IQ_{WGI} \geq 0.653$	0.135** (0.060)
_cons	−0.152 (0.508)	_cons	−1.273** (0.536)
No. observations	162	No. observations	162
N	6	N	6

Note: ***, **, and * signify statistical significance at 1%, 5%, and 10% levels, respectively. ( ) denotes the standard errors.

Table 12d. Robustness check. Regime-dependent variable r

Threshold model 5a Institutional quality=IQ_{ICRG}		Threshold model 5b Institutional quality=IQ_{WGI}	
Lagged dependent variable	0.863*** (0.047)	Lagged dependent variable	0.782*** (0.054)
k_t	0.097*** (0.034)	k_t	0.160*** (0.039)
L_t	0.143** (0.063)	L_t	0.261*** (0.069)
H_t	0.211*** (0.068)	H_t	0.008 (0.063)
Regime 1 $IQ_{ICRG} < 8.083$	0.019 (0.012)	Regime 1 $IQ_{WGI} < 0.653$	0.016 (0.012)
Regime 2 $IQ_{ICRG} \geq 8.083$	0.027** (0.012)	Regime 2 $IQ_{WGI} \geq 0.653$	0.023** (0.012)
_cons	−1.123** (0.496)	_cons	−1.618*** (0.527)
No. observations	162	No. observations	162
N	6	N	6

Note: ***, ** signify statistical significance at 1%, 5%, levels, respectively. ( ) denotes the standard errors.

The empirical findings yield important policy implications for formulating effective growth strategies in China. The results indicate that economic growth benefits from factor inputs only when institutional quality surpasses a critical threshold. Policymakers should prioritize the strengthening of institutional frameworks to maximize the productivity of investments in factor inputs. In doing so, institutional reforms that reduce constraints on political institutions can create a more favorable environment for economic growth, enhance the effectiveness of economic institutions, and improve investment efficiency. In other words, the transmission channels connecting optimal factor inputs to economic growth improve resource allocation efficiency, which in turn strengthens output growth under conditions of strong institutional quality. Additionally, the results also indicate that R&D contributes significantly only above a certain institutional threshold. To fully leverage the growth potential of innovation, policymakers should improve the institutional mechanisms to reap the benefits of R&D in driving economic growth. Enhancing institutional quality can boost the effectiveness of innovation and the transformation of R&D investments into tangible economic outcomes.

Furthermore, considering the empirical evidence that institutional quality significantly mediates the impact of factor inputs on economic growth in China, this study recommends several targeted policy suggestions. Central governments should prioritize enhancing the overall institutional framework, which includes strengthening property rights protection, improving judicial efficiency, and reducing bureaucratic red tape. These reforms would create a more conducive environment for business operations and innovation. To increase the productivity of physical capital, policies should focus on reducing administrative intervention in investment allocation and promoting market-oriented reforms. Such measures can address persistent issues of overcapacity and misallocation, thereby enhancing economic efficiency. To complement these efforts, labor market reforms are essential. Relaxing "hukou" restrictions in urban centers and expanding social service coverage can enhance labor mobility and productivity. These reforms are particularly crucial as China's demographic structure evolves, with an aging population and a shrinking workforce. Moreover, the transition to an innovation-driven growth model requires parallel developments in human capital and R&D. Targeted investments in tertiary education and vocational training programs, coupled with incentives for skilled professionals, can address regional disparities in workforce quality. Strengthening intellectual property rights protection and fostering collaboration among the government, universities, and industry can shift the innovation paradigm from quantity to quality. In addition, fine-tuning fiscal and tax policies to reward high-value innovation, rather than mere R&D expenditure, can further enhance innovation efficiency. By prioritizing these measures, policymakers can unlock the full potential of factor inputs, fostering sustainable growth and reducing regional disparities.

5. CONCLUSION

This study employs panel data covering China's leading provinces from 1996 to 2022 examine whether institutional quality exhibits threshold effects in mediating the relationship between economic growth and factor inputs. To capture potential nonlinear dynamics, the analysis adopts the Hansen (1999) approach. To ensure the robustness of the results, this study also uses the Kremer et al. (2013) threshold model as a complementary approach. The consistency between models reinforces the validity of the findings, which are sensible and corroborate the findings mentioned above. In particular, the empirical findings demonstrate a significant threshold effect, where institutional quality critically shapes the dynamics between factor inputs and growth. This study provides empirical evidence that institutional quality mediates the effectiveness of factor inputs in driving economic growth. While physical capital, labor, and human capital remain influential across different institutional settings, R&D contributes significantly only above a certain institutional threshold. These findings offer valuable implications for policymakers aiming to strengthen economic resilience and long-term development through institutional reform.

However, this study is subject to several limitations that should be addressed. First, the analysis concentrates on six provincial economies and four independent variables physical capital, labor, human capital, and R&D. Future research should focus on identifying the determinants of institutional quality. This insight will empower governments to implement targeted improvements in institutional frameworks effectively. Understanding these determinants can also guide policymakers toward fostering more robust and adaptable institutions. In addition, the methodology used in this study can also be replicated in other regional scenarios. Second, the study is constrained by the time dimension and the limitations associated with data collection from secondary sources, particularly in terms of data availability. The findings will be more meaningful if more data become available in future research. Third, the findings may not be applicable across regions other than China, as factor inputs are influenced by region-specific industrial structures or government policies. Finally, this study adopts a macro-level perspective on institutional quality. Overall, the issue provides significant avenues for future research, including the investigation of regional disparities, the development of robust indicators for institutional performance, and the use of microdata tailored to evaluate specific policies of interest in both developed and developing regions of China. This is a potentially interesting and critical issue left for future research.

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by the corresponding author.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Acemoglu, D., Johnson, S., & Robinson, J. A. (2004). *Institutions as the fundamental cause of long-run growth (NBER Working Paper No. 10481). National Bureau of Economic Research.* Retrieved from

Acemoglu, D., & Robinson, J. (2008). *The role of institutions in growth and development* (Vol. 10): World Bank Washington, DC.

Adams-Kane, J., & Lim, J. J. (2016). Institutional quality mediates the effect of human capital on economic performance. *Review of Development Economics, 20*(2), 426-442. https://doi.org/10.1111/rode.12236

Alam, A., Uddin, M., & Yazdifar, H. (2019). Institutional determinants of R&D investment: Evidence from emerging markets. *Technological Forecasting and Social Change, 138*, 34-44. https://doi.org/10.1016/j.techfore.2018.08.007

Aluko, O. A., & Ibrahim, M. (2020). Institutions and the financial development–economic growth nexus in Sub-Saharan Africa. *Economic Notes, 49*(3), e12163. https://doi.org/10.1111/ecno.12163

Apergis, N., Mustafa, G., & Khan, M. (2022). Governance thresholds and the human capital–growth nexus. *Journal of Economic Studies, 49*(7), 1181-1196. https://doi.org/10.1108/jes-03-2021-0150

Arya, V., Banerjee, R., & Cavoli, T. (2019). Capital flows to Asia and Latin America: Does institutional quality matter? *The World Economy, 42*(7), 2039-2069. https://doi.org/10.1111/twec.12783

Bailliu, J., Kruger, M., Toktamyssov, A., & Welbourn, W. (2019). How fast can China grow? The Middle Kingdom's prospects to 2030. *Pacific Economic Review, 24*(2), 373-399. https://doi.org/10.1111/1468-0106.12240

Bekana, D. M. (2021). Innovation and economic growth in sub-Saharan Africa: Why institutions matter? An empirical study aross 37 countries. *Arthaniti: Journal of Economic Theory and Practice, 20*(2), 161-200. https://doi.org/10.1177/0976747920915114

Bethencourt, C., & Perera-Tallo, F. (2020). *Human capital, economic growth, and public expenditure.* (ADBI Working Paper No. 1066) ADBI Working Paper Series.

Brandt, L., Litwack, J., Mileva, E. A., & Wang, L. (2020). *China's productivity slowdown and future growth potential.* (Policy Research Working Paper No. 9298). World Bank.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies*, *47*(1), 239-253. https://doi.org/10.2307/2297111

Caner, M., & Hansen, B. E. (2004). Instrumental variable estimation of a threshold model. *Econometric Theory*, *20*(5), 813-843. https://doi.org/10.1017/s0266466604205011

Cooray, A., & Nam, Y.-S. (2025). Public social spending, government effectiveness, and economic growth: an empirical investigation. *Applied Economics*, *57*(1), 52-66. https://doi.org/10.1080/00036846.2024.2302933

Duyen, M. T. T., & Tinh, T. P. D. (2024). The interrelationships between economic growth and innovation: International evidence. *Journal of Applied Economics*, *27*(1), 2332975. https://doi.org/10.1080/15140326.2024.2332975

Garnaut, R., Song, L., & Fang, C. (2018). *China's 40 years of reform and development: 1978-2018*: ANU Press. https://doi.org/10.22459/cyrd.07.2018.

Gill, I. S., & Kharas, H. (2015). *The middle-income trap turns ten (Policy Research Working Paper No. 7403).* World Bank. https://doi.org/10.1596/1813-9450-7403

Glawe, L., & Wagner, H. (2023). The "double trap" in China—Multiple equilibria in institutions and income and their causal relationship. *Open Economies Review*, *34*(3), 703-757. https://doi.org/10.1007/s11079-022-09693-3

Goto, A., & Suzuki, K. (1989). R & D capital, rate of return on R & D investment and spillover of R & D in Japanese manufacturing industries. *The Review of Economics and Statistics*, *71*(4), 555-564. https://doi.org/10.2307/1928096

Griliches, Z., & Lichtenberg, F. (1984). Interindustry technology flows and productivity growth: A reexamination. *The review of economics and statistics*, *66*(2), 324-329. https://doi.org/10.2307/1925836

Guo, P., Hu, X., Zhao, S., & Li, M. (2023). The growth impact of infrastructure capital investment: the role of regional innovation capacity—evidence from China. *Economic Research-Ekonomska istraživanja*, *36*(2), 1-21. https://doi.org/10.1080/1331677x.2022.2142632

Hall, J. C., Sobel, R. S., & Crowley, G. R. (2010). Institutions, capital, and growth. *Southern Economic Journal*, *77*(2), 385-405. https://doi.org/10.4284/sej.2010.77.2.385

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of Econometrics*, *93*(2), 345-368. https://doi.org/10.1016/s0304-4076(99)00025-1

Hu, A. G., Jefferson, G. H., & Jinchang, Q. (2005). R&D and technology transfer: Firm-level evidence from Chinese industry. *Review of Economics and Statistics*, *87*(4), 780-786. https://doi.org/10.1162/003465305775098143

Hussen, M. S. (2023). Institutional quality and economic growth in Sub-Saharan Africa: A panel data approach. *Journal of Economics and Development*, *25*(4), 332-348. https://doi.org/10.1108/JED-11-2022-0231

International Monetary Fund. (2023). *People's Republic of China: 2022 Article IV consultation Press release; Staff report; and statement by the Executive Director for the People's Republic of China (IMF Staff Country Report No. 23/67). International Monetary Fund.* Retrieved from https://doi.org/10.5089/9798400201356.002

Kpognon, K., & Bah, M. (2019). *Does institutional quality contribute to increasing labor productivity in Sub-Saharan Africa? An empirical analysis. (MPRA Paper No. 93993). University Library of Munich, Germany.* Retrieved from https://mpra.ub.uni-muenchen.de/id/eprint/98674

Kpognon, K. D., Atangana Ondoa, H., Bah, M., & Asare-Nuamah, P. (2022). Fostering labour productivity growth for productive and decent job creation in Sub-Saharan African countries: The role of institutional quality. *Journal of the Knowledge Economy*, *13*(3), 1962-1992. https://doi.org/10.1007/s13132-021-00794-x

Kremer, S., Bick, A., & Nautz, D. (2013). Inflation and growth: new evidence from a dynamic panel threshold analysis. *Empirical Economics*, *44*, 861-878. https://doi.org/10.1007/s00181-012-0553-9

Lahet, D., & Prat, S. (2023). Local-currency debt and currency internationalization dynamics: A nonlinear framework. *Review of World Economics*, *159*(1), 215-254. https://doi.org/10.1007/s10290-022-00463-4

Law, S. H., Azman-Saini, W., & Ibrahim, M. H. (2013). Institutional quality thresholds and the finance–growth nexus. *Journal of Banking & Finance, 37*(12), 5373-5381. https://doi.org/10.1016/j.jbankfin.2013.03.011

Law, S. H., Sarmidi, T., & Goh, L. T. (2020). Impact of innovation on economic growth: Evidence from Malaysia. *Malaysian Journal of Economic Studies, 57*(1), 113-132. https://doi.org/10.22452/mjes.vol57no1.6

Li, C., Tanna, S., & Nissah, B. (2023). The effect of institutions on the foreign direct investment-growth nexus: What matters most? *The World Economy, 46*(7), 1999-2031. https://doi.org/10.1111/twec.13349

Li, H., Loyalka, P., Rozelle, S., & Wu, B. (2017). Human capital and China's future growth. *Journal of Economic Perspectives, 31*(1), 25-48. https://doi.org/10.1257/jep.31.1.25

Morrison, W. M. (2019). China's economic rise: History, trends, challenges, and implications for the United States. *Current Politics and Economics of Northern and Western Asia, 28*(2/3), 189-242.

Ndiweni, Z. L., & Bonga-Bonga, L. (2021). *Capital inflows and economic growth nexus in Sub-Saharan Africa: Evidence on the role of institutions (MPRA Paper No. 103335). University Library of Munich, Germany*. Retrieved from https://mpra.ub.uni-muenchen.de/107392/

North, D. C. (1990). *Institutions, institutional change and economic performance*: Cambridge University Press. https://doi.org/10.1017/CBO9780511808678.

Ogbaro, E. O. (2019). Threshold effects of institutional quality in the infrastructure-growth nexus. *Journal of Quantitative Methods, 3*(2), 45-61. https://doi.org/10.29145/2019/jqm/030203

Ogbaro, E. O., & Oladeji, S. I. (2021). Infrastructure-growth link and the threshold effects of sub-indices of institutions. *Asian Journal of Business Environment, 11*(1), 17-25. https://accesson.kr/ajbe/v.11/1/17/36729

Omar, N. S. (2019). Innovation and economic performance in MENA region. *Review of Economics and Political Science, 4*(2), 158-175. https://doi.org/10.1108/reps-12-2018-0042

Pesaran, M. H. (2004). General diagnostic tests for cross-section dependence in panels. *Cambridge Working Papers in Economics, 1240*(1), 1-39. https://doi.org/10.17863/CAM.5113

Pesaran, M. H., Ullah, A., & Yamagata, T. (2008). A bias-adjusted LM test of error cross-section independence. *The Econometrics Journal, 11*(1), 105-127. https://doi.org/10.1111/j.1368-423x.2007.00227.x

Raifu, I. A., Nnadozie, O. O., & Opeloyeru, O. S. (2021). The role of institutional quality in the human capital-economic growth nexus in Nigeria: evidence from aggregate and gender perspective. *Journal of Economic Development, 46*(4), 157-188.

Rodríguez-Pose, A., & Ganau, R. (2022). Institutions and the productivity challenge for European regions. *Journal of Economic Geography, 22*(1), 1-25. https://doi.org/10.1093/jeg/lbab003

Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy, 98*(5, Part 2), S71-S102.

Saggu, A., & Anukoonwattaka, W. (2015). China's 'new normal': Challenges ahead for Asia-Pacific trade. *United Nations ESCAP Trade Insights*, 7(11), 1-11.

Saidi, H., Hakimi, A., & Rachdi, H. (2024). On the technology-growth relationship: Does institutional quality matter? A panel simultaneous equation framework. *Journal of the Knowledge Economy, 15*(1), 3439-3465. https://doi.org/10.1007/s13132-023-01228-6

Sanga, D., Ahouakan, E. W. V., & Adje, N. g. A. F. (2022). Institutional quality and labour productivity. *Journal of Economic Integration, 37*(3), 540-557. https://doi.org/10.11130/jei.2022.37.3.540

Solow, R. M. (1957). Technical change and the aggregate production function. *The review of Economics and Statistics, 39*(3), 312-320. https://doi.org/10.2307/1926047

Sulaiman, C., Bala, U., Tijani, B. A., Waziri, S. I., & Maji, I. K. (2015). Human capital, technology, and economic growth: Evidence from Nigeria. *Sage Open, 5*(4), 2158244015615166. https://doi.org/10.1177/2158244015615166

Uddin, M. A., Ali, M. H., & Masih, M. (2021). Institutions, human capital and economic growth in developing countries. *Studies in Economics and Finance, 38*(2), 361-383. https://doi.org/10.1108/sef-10-2019-0407

Wang, P., Shao, Z., Wang, J., & Wu, Q. (2021). The impact of land finance on urban land use efficiency: A panel threshold model for Chinese provinces. *Growth and Change, 52*(1), 310-331. https://doi.org/10.1111/grow.12464

World Bank. (2022). *Global economic prospects*. Washington, DC: World Bank.

World Bank. (2024). *China economic update: Which way forward? Navigating China's post-pandemic growth path*. Washington, DC: World Bank.

Yang, J. (2023). Factor price distortion among regions in China and its influence on China's economic growth. *Plos One*, *18*(4), e0284191. https://doi.org/10.1371/journal.pone.0284191

Yang, Y. (2020). China's economic growth in retrospect. *China 2049: Economic Challenges of a Rising Global Power*, 3-28.

Zergawu, Y. Z., Walle, Y. M., & Giménez-Gómez, J.-M. (2020). The joint impact of infrastructure and institutions on economic growth. *Journal of Institutional Economics*, *16*(4), 481-502. https://doi.org/10.1017/s1744137420000016

Zhang, C., & Zhuang, L. (2011). The composition of human capital and economic growth: Evidence from China using dynamic panel data analysis. *China Economic Review*, *22*(1), 165-171. https://doi.org/10.1016/j.chieco.2010.11.001

Zhang, J. (2008). Estimation of China's provincial capital stock (1952–2004) with applications. *Journal of Chinese Economic and Business Studies*, *6*(2), 177-196. https://doi.org/10.1080/14765280802028302

Zhang, M., & Rodríguez-Pose, A. (2024). Government reform and innovation performance in China. *Papers in Regional Science*, *103*(3), 100023. https://doi.org/10.1016/j.pirs.2024.100023

APPENDIX

To further assess the robustness of the threshold effects of institutional quality in the nonlinear relationship between factor inputs and economic growth, this study adopts the dynamic panel threshold regression model proposed by Kremer et al. (2013). This model extends the original panel threshold framework introduced by Hansen (1999) and later enhanced by Caner and Hansen (2004), offering a structure capable of handling dynamic panel data with endogenous explanatory variables and exogenous threshold variables. In line with Lahet and Prat (2023), the empirical specification employed in this study follows the dynamic panel threshold approach as outlined below:

$$y_{i,t} = \mu_i + \lambda y_{i,t-1} + \beta_{Li} f_{i,t} I(q_{i,t} \leq \gamma) + \beta_{Hi} f_{i,t} I(q_{i,t} > \gamma) + \alpha_i x_{i,t} + \varepsilon_{i,t}$$

In this model, $y_{i,t-1}$ denotes the lagged value of $y_{i,t}$; the term μ_i captures region-specific fixed effects, reflecting unobserved heterogeneity across regions. γ represents the estimated threshold level. The variables $x_{i,t}$,$f_{i,t}$ and $q_{i,t}$ denote regime-independent, regime-dependent and threshold variables, respectively. In particular, the latter allowed us to switch between different regimes based on specific conditions. $I(\cdot)$ is the indicator function, a value of 1 is valid and 0 otherwise. This approach ensures that the impact of factor inputs, k, L, H, and r on economic growth is captured by β_L or β_H, depending on whether the region falls within a low or high level of institutional quality.