Song, Cai-Xia; Qiao, Cui-Xia

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Technology Importation, Institutional Environment and Industrial Upgrading: Evidence from China[1]

*CAI-XIA SONG – CUI-XIA QIAO**

Abstract

Considering the importance of technology for industrial structure upgrading, especially under the impetus of the fourth industrial revolution, the paper examines the impact of technology importation on industrial structure upgrading in 31 Chinese provinces from 2002 to 2020. It also emphasises the moderating role of institutional environment based on two dimensions of industrial upgrading. The findings indicate that technology importation has a positive effect on industrial advancement; however, its impact on industrial rationalisation is not significant. A higher-quality institutional environment can indirectly contribute to the impact of technology importation on industrial upgrading. Finally, the effects of technology importation and institutional environment on industrial upgrading vary with regions, and there are also differences in the moderating effects of different aspects of institutional quality. Therefore, the article suggests that technology should be introduced according to the institutional environment of different regions, and the government should develop personalised industrial upgrading strategies.

Keywords: *technology, institutional environment, industrial upgrading, China*

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* CAI-XIA SONG – CUI-XIA QIAO, corresponding author, School of Economics, Shandong Normal University, 1 College Road, Jinan, 250358 Shandong, China; e-mail: xia_xia008@126.com; cuixiaqiao@163.com

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Introduction

Accelerated industrial upgrading, along with the initiative of international competition, has become a common problem faced by all countries in the world, especially in the complex international environment and the new context of the fourth industrial revolution (Bolek et al., 2021). Industrial structure is now regarded as the core variable in distinguishing between developed and underdeveloped economies, and the upgrading of industrial structure has been the main factor in developing countries' accelerated economic development. Because it is central to high-quality economic development, optimising industrial structure plays an important role in promoting China's rapid economic growth. However, after more than 30 years of rapid economic development, China's economic growth has entered a period known as the 'new normal', which emphasises sustainable development rather than speed. The experience of global economic development has proved that there is a positive relationship between the economy's sustainable development and industrial structure (Friedman, 2002; Maddison, 1980). Among the goals of sustainable development is the upgrading of industrial structure, which is key to the optimisation of economic structure, and technological innovation is an important force for the upgrading of industrial structure.

Technological progress is another important driving force behind economic development and is related to industrial structure (Antonelli and Fassio, 2014; Dosi et al., 2015; Hausmann et al., 2013; Zhang, 2021). Technological progress is an effective way of promoting the transformation of industrial structure and the rise of emerging industries. Technology can promote the upgrading of traditional industries by improving the quality of production factors and labour productivity. Besides, increasingly more industries will emerge through the continuous development of technology, which will integrate with traditional industries to accelerate transformation and upgrading. Furthermore, technological innovation can create differences in the average profit rates of various industries, thereby continuously optimising the traditional industrial structure. The evolution of industrial structure is essentially a process of technological progress.

Technology importation is also an effective means of narrowing the technology gap in late-developing countries (Coe and Helpman, 1995; Xie et al., 2014; You et al., 2020). The fourth industrial revolution has forced the process of industrialisation and the improvement of its quality to rely more on technology, which has naturally become the driver of all countries' economic and social development. Governments focus on accelerating the development of artificial intelligence, big data and other technology-intensive industries that reflect trends in the most recent waves of technological revolution and industrial revolution and rely on the advanced manufacturing industry to drive the technological transformation of

traditional industries. Therefore, the importation of advanced technology from developed countries is now the first choice for developing countries to achieve rapid technological progress. Moreover, technological progress recombines the original factors of production and maximizes labour productivity, thus directly upgrading the industrial structure (Romer, 1990; Chandan, 2019).

Industrial upgrading is an essential step for a country to take to ensure its sustained economic growth, which is influenced by several factors. Among them, the institutional environment is crucial, according to new institutional economics theory. North (1990) pointed out that the institutional environment plays an important role in the upgrading of traditional industries, and industrial upgrading is also essentially a process of institutional change (Acemoglu et al., 2001). The stock of knowledge and technology is an important factor affecting the output of industry, but the actual output is also affected by the institutional environment (Acemoglu et al., 2014). The institutional system has played a unique role in China's rapid economic growth in the past, and it will certainly be a necessary element to influence industrial upgrading in the new era.

Technology importation has several impacts on industrial upgrading within different institutional contexts, and using technological innovation to reconstruct the industrial structure and boost economic growth is also a strategic issue for various countries, especially under the impetus of the fourth industrial revolution (Kumar and Bhatia, 2021; Lin and Wang, 2020). Different levels of institutional qualities are needed for governments to ensure that the importation of technology has fully positive effects on industrial upgrading. These factors hold great theoretical and practical significance for industrial upgrading, not only for China but also for other developing countries. It is on these bases that this study explores the effects of technology importation and institutional environment on industrial upgrading.

Research on the relationship between industrial upgrading and technology is limited because most of the existing literature has mainly focused on the effects of technology importation on technological progress, innovation performance and economic growth. Moreover, the conclusions that have been drawn on whether the importation of technology promotes industrial upgrading have also been inconsistent, which may be the result of incomplete measurements of industrial upgrading indicators. Therefore, the purposes and contributions of this study are as follows. First, the study explores the relationships between industrial upgrading, technology importation and institutional quality when the institutional environment changes in 31 administrative regions in Chinese provinces. Second, the paper emphasises the moderating effect of institutional quality. This study proposes that the institutional environment is a moderating variable that

affects the relationship between technology importation and industrial upgrading, which fills the gap in the existing studies. Finally, the study divides industrial upgrading into two dimensions (rationalisation and advancement of industrial structure) and conducts further heterogeneity analyses on different aspects of institutional quality and different sample subgroups, respectively.

The rest of the study is structured as follows. Section 1 covers the literature review and theoretical background, Section 2 explains the method used and illustrates a description of the data, Section 3 presents the empirical findings and discusses the results and Section 4 summarises the conclusion and offers policy implications.

1. Theoretical Background and Literature

1.1. Technological Innovation and Industrial Upgrading

Scholars have demonstrated the important role of technology in industrial upgrading from different angles. First, the application of new technologies has given birth to new industries, new products and new models. It also expands the production scale of an industry, extends the industrial chain, reduces manufacturing costs and prices, and facilitates the transfer of labour in industrial sectors. Thus, the adjustment and upgrading of the industrial structure will be promoted through the linkage and transmission mechanism between industries (Bulu, 2014; Klepper, 2002; Naimzada and Randon, 2007). In addition, new technologies promote the technological transformation and renewal of traditional industries so that emerging industries can grow alongside traditional industries (Ding and Chen, 2019; Pascali, 2017; Zhao et al., 2021). Finally, the importation of new technologies will stimulate new consumption and investment, leading to changes in the industrial structure by influencing the demand structure (Sultanuzzaman et al., 2019). Tourk and Marsh (2016), Wu and Liu (2021) also analysed the development status and challenges of China's traditional manufacturing industry and pointed out that it should achieve industrial upgrading through technological innovation and the establishment of independent brands.

New features have emerged during the fourth industrial revolution (Hori et al., 2018; Jiang et al., 2020; Tian et al., 2019; Xiao et al., 2018). For example, the application of interdisciplinary integration will promote change in the division and cooperation of industrial sectors and in the development of integrated production. Eventually, the integration of manufacturing and service industries will be promoted, and industrial boundaries will gradually become blurred. Therefore, the following hypothesis is tested:

H1: *Technology importation can promote industrial structure upgrading*.

1.2. The Institutional Mechanism

Existing studies have also shown that the institutional environment is closely related to industrial upgrading. Kuznets' (1980) empirical analysis of this relationship revealed direct and indirect influences of the institutional environment on industrial structure. North (1990) further studied the institutional environment as the main factor in changing the industrial structure and affirmed its role therein.

In addition to technological innovation, the institutional environment is also an important factor in promoting the upgrading of industries. This has prompted some scholars to consider the institutional dimensions of marketisation and government innovation support. The optimisation of the institutional environment promotes market transactions in traditional industries and the rational flow of capital and technology between industries by reducing transaction costs and creating a fair competitive environment, thereby promoting the upgrading of traditional industries (Acemoglu et al., 2012; Costantini and Liberati, 2014; Nelson, 2002; Zhai et al., 2020). Some of the literature that has focused on the factors of industrial structure change has found that China's reform and opening-up policy has had a significant impact (Dekle and Vandenbrouck, 2012; Hermosilla et al., 2018; Uy et al., 2013). At the same time, because the higher-level institutional environment is dominated by the market, regions with high institutional quality can discover market demand in time and carry out technological innovation in a more targeted manner. Therefore, the higher the quality of the institutional environment, the better the industrial upgrading.

Institutions and technology are also regarded as social and material technologies, respectively, from the perspective of evolutionary economics (Intarakumnerd et al., 2015; Nelson, 2009; Pelikan, 2003). It is notable when these two factors are mutually selective forces promoting industrial development (Tambovtsev, 2019) since this implies that differences in the institutional environment will also affect the effects of technological innovation on the promotion of industrial upgrading (Fabio, 2010; Veiseh, 2010). Nunn's (2007) research on countries with advantages in high-end manufacturing found that inducing enterprises to develop intensive knowledge by optimising their institutional quality has had a more lasting effect on industrial upgrading. Sui and Liu (2020) also found that a good institutional environment can foster technological innovation to promote industrial upgrading and improve the efficiency of technological innovation diffusion (González-Blanco et al., 2019; Li and Tang, 2021). Murmann's (2003) analysis of the synergy of technology and systems in the synthetic dye industry in four countries in Europe and North America supported this point. The above findings imply that a good institutional environment can guide economic entities

to carry out technological innovation, improve production efficiency and reach the high end of the smiling curve, thereby promoting the upgrading of industrial structure.

The institutional environment is the basic guarantee for the economic and social development of a region, and good social conditions have a direct impact on the mechanism of industrial structure upgrading by enhancing the efficiency of resource allocation and improving innovation capabilities (Callado-Muñoz et al., 2018; López-Cabarcos et al., 2020; Wang and Feng, 2021; Wawrzyniak and Doryń, 2020). Considering the process of promoting the transformation and upgrading of China's industrial structure is driven by technology, questions have been raised as to the role the institutional environment system plays in industrial upgrading. What impact does the quality of the institutional environment have on upgrading and technology importation? According to the relationship that exists between the institutional environment and industrial upgrading, the following hypotheses are tested:

H2: *Institutional quality can influence the degree of industrial structure upgrading.*

H3: *The marginal impact of technology importation on industrial upgrading can be moderated by the quality of institutions.*

2. Data and Methodology

2.1. The Source of Data and Variables

2.1.1. Upgrading of Industrial Structure

According to related theories, upgrading industrial structure reflects the unification of inter-industry coordination and the reasonable proportional relationship between various departments; that is, it is the process of unifying industrial structure rationalisation and advancement. From a dynamic perspective, the changes in the industrial structure of an economy include two dimensions: the rationalisation of industrial structure (RIS) and the advancement of industrial structure (AIS) (Li and Zou, 2018; Yu et al., 2020).[2] Therefore, this study adopts RIS and AIS as the dimensions with which to measure the upgrading of industrial structure.

[2] <https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&filename=JJYJ201811012&dbname=CJFDLAST2018>;
<https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&filename=JJYJ202008005&dbname=CJFDLAST2020>.

2.1.2. Rationalisation of Industrial Structure (RIS_{it})

RIS represents the quality of aggregation between industries, which can reflect the degree of coordination between industries and the degree of effective utilisation of resources. RIS is mainly measured through four methods: the standard structure method, the structural benefit index, the degree of industrial structure deviation and the Theil index. Due to the differences between various regions' economic foundations and resource endowments in China, the first two methods are not applicable for this research. At the same time, the lack of data on the amount of capital input in various industries has made using the structural effectiveness index for measurement impossible as well (Tian et al., 2019; Wu et al., 2021; Xiao et al., 2018). The Theil index (see Johnston and Theil, 1969),[3] also known as Theil entropy, it is a good indicator to measure the rationality of industrial structure. The Theil index is a statistic primarily used to measure economic inequality and other economic phenomena, It was proposed by a Dutch econometrician Henri Theil. According to the meaning of the Theil index, it is considered that if the economy is in equilibrium, the index is equal to 0, otherwise, the economy deviates from equilibrium and there is irrationality.

According to the theoretical basis of the structural deviation of the Theil index and its economic meaning, it is also a good measure of whether the industrial structure is reasonable or not, and the index is equal to 0, which means the industrial structure is balanced. Unfortunately, in reality, at least in the present study, the Thiel index is not equal to 0, which indicates that the industrial structure has different degrees of irrationalization. A perfectly balanced state does not exist. Therefore, this study adopts the Theil index to reflect the rationality of the industrial structure (Li and Zou, 2018; Yu et al., 2020). The calculation formula is as follows:

$$RIS = \sum_{i=1}^{n} \left(\frac{Y_i}{Y} \right) \ln \left(\frac{Y_i}{L_i} / \frac{Y}{L} \right) = \sum_{i=1}^{n} \left(\frac{Y_i}{Y} \right) \ln \left(\frac{Y_i}{Y} / \frac{L_i}{L} \right) \quad (1)$$

where Y and L represent the output value and the number of employees, respectively, and Y/L represents the productivity level. Based on classical economic theory, when the economy is in a state of final equilibrium, the productivity levels among the various sectors are the same ($Y_i/L_i = Y/L$, $RIS = 0$).[4]

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[3] <https://doi.org/10.2307/2230396>.

[4] Since Y/L denotes productivity, therefore, the economy is in equilibrium when $Yi/Li = Y/L$, and thus the degree of structural deviation equal to 0. Meanwhile, Yi/Y denotes the output structure and Li/L denotes the employment structure, thus, the degree of structural deviation is the response of the coupling of output and employment structures. A non-zero Thiel index indicates that the industrial structure deviates from the equilibrium and there is a certain degree of irrationality.

Otherwise, the industrial structure is unreasonable. At the same time, RIS can also be used to reflect the coupling between output structure and employment structure. Limited by the availability of data, this article uses data from the primary, secondary and tertiary industries in each province examined to calculate the RIS indicators.

2.1.3. Advancement of Industrial Structure (AIS_{it})

AIS is a process of evolution from the primary industry to the secondary industry and then to the tertiary industry. Its notable feature is that the proportion of the primary industry shows a declining trend. According to Clark's law, many documents use the proportion of non-agricultural output value as a measure of industrial structure upgrading.

However, driven by the fourth industrial revolution, AIS is essentially explained by the different performances of production efficiency brought about by technological innovation in different industrial sectors, thus reflecting a 'service-oriented economy'. Its main feature is that the tertiary industry developed faster than the secondary industry. Therefore, this article uses the ratio of the tertiary industry (TI_{it}) to the secondary industry (SI_{it}) to represent the degree of AIS (Matsuyama, 2009). Since it is greater than 1, this indicates that the economic structure is becoming more advanced.

$$AIS = \frac{TI_{it}}{SI_{it}} \tag{2}$$

2.1.4. Technology Importation ($Tech_{it}$)

Foreign direct investment and international trade are the main channels for technology importation. International trade includes two methods: product import and technology patent transfer. However, to maintain a technological monopoly, patents for old or obsolete technologies are transferred. It is difficult for latecomer economies to acquire the key technologies contained in imported products due to information asymmetry. Foreign direct investment has always been an important way to introduce new technologies. In addition to bringing in new capital, foreign direct investment also builds platforms for acquiring advanced technologies abroad (Blomstrom, 1989; Tang et al., 2014). At the same time, it promotes spreading technology and has an impact on the upgrading of the industrial structure. This paper uses the actual amount of foreign direct investment (the annual value of FDI net inflows) introduced as a proxy for the level of technology importation. To eliminate the influence of heteroscedasticity, we take the logarithm of it.

2.1.5. Institutional Environment (Institution$_{it}$)

Based on data integrity and availability, this study selects the marketisation index as a measure of the institutional environment (Wang et al., 2018). This index measures the level of marketisation from five aspects – (a) the relationship between the government and the market, (b) the development of a non-state economy, (c) market intermediary organisations and the legal system environment, (d) factor market development and (e) product market development – providing a stable observational framework that reflects institutional changes in a more comprehensive and representative manner. Therefore, the marketisation index is widely used as a variable for the overall institutional environment and its changes in various provinces in China. The higher the value of the marketisation index, the better the institutional environment.

2.1.6. Control Variables

The upgrading of industrial structure is affected by many factors, and representative factors should be incorporated into the model as control variables. This article uses fixed asset investment divided by GDP (CAP_{it}) to reflect physical capital, total import and export divided by GDP (TRA_{it}) to indicate the degree of market openness, the number of students in ordinary colleges and universities divided by total population (HUM_{it}) to measure human capital (Boarini et al., 2012). The level of economic development is expressed in the logarithmic form of GDP (GDP_{it}).

T a b l e 1

Descriptive Statistics of the Variable Data

Variable	Obs	Mean	Std. Dev.	Min	Max
AIS	589	1.149	0.586	0.518	5.022
RIS	589	1.086	0.360	0.233	2.553
Tech	589	12.01	1.935	0.693	15.09
Institution	589	5.990	2.093	–0.230	11.71
Inst-Law	589	4.997	3.374	–0.700	16.94
Inst-Govmaret	589	6.342	2.389	–6.750	10.65
Inst-Nonstate	589	6.456	2.703	–1.930	13.44
Inst-Product	589	7.600	1.626	0	10.61
Inst-Factor	589	4.683	2.494	–1.210	12.23
TRA	589	0.0420	0.0475	0.00183	0.216
HUM	589	0.0149	0.00725	0.00212	0.0358
CAP	589	0.664	0.295	0.220	1.597
GDP	589	18.09	1.236	13.98	20.72

Source: Authors' estimations by Stata.

This paper uses data from 31 Chinese provinces from 2002 to 2020. Data on the quality of the system are obtained from China's marketisation index, and other indicators are obtained from the China Statistical Yearbook, the China Regional

Economic Statistical Yearbook and the statistical bulletins on the national economic and social development of each province in each year. The descriptive statistics of each variable are shown in Table 1.

2.2. Empirical Model

To understand the interactions among variables, a panel data model was mainly used to study the interrelationships between technology importation, institutional quality and industrial structure upgrading. The use of panel data is preferred because it can expand the scope of the sample, increase the volatility characteristics of the data and make the results of the econometric regression more robust. Accordingly, the following econometric model is established.

$$Y_{it} = \alpha + \beta_1 Tech_{it} + \beta_2 Institution_{it} + \Theta X_{it} + \varphi_i + \varphi_t + \varepsilon_{it} \tag{3}$$

$$Y_{it} = \alpha + \beta_1 Tech_{it} + \beta_2 Institution_{it} + \beta_3 Tech_{it} * Institution_{it} + \\ + \Theta X_{it} + \varphi_i + \varphi_t + \varepsilon_{it} \tag{4}$$

In the above formula, i represents Chinese provinces, and t represents time. Y_{it} represents industrial upgrading, including RIS and AIS. $Tech_{it}$ represents technology importation. X_{it} is the vector representing the control variables, and θ is the coefficient of each control variable. φ_i and φ_t are the period and region fixed effect variables, respectively. Before regression, this paper uses two methods – the Pearson correlation coefficient and the variance inflation factor (VIF) – to check whether there is multicollinearity between the variables to avoid pseudo-regression problems.

2.2.1. Correlation Coefficient Analysis

The correlations between the six explanatory variables are less than 0.6. In addition, the highest correlation coefficient between GDP and technology importation is 0.5094.

2.2.2. vVIF Tests

The largest VIF value between all variables is 5.14, which is much smaller than 10. The results for the VIF tests are shown in Table 2.

T a b l e 2

VIF for Each Explanatory Variable

Variable	Tech	Institution	GDP	HUM	TRA	CAP	Mean
VIF	5.140	4.350	4.100	2.150	2.070	1.710	3.250
1/VIF	0.195	0.230	0.244	0.465	0.483	0.583	0.367

Source: Authors' estimations by Stata.

According to the correlation coefficients and the VIF results, multicollinearity issues do not exist.

Furthermore, to deal with the potential endogeneity problem between technology importation and industrial upgrading, this paper controls for regional fixed effects. Regional fixed effects can effectively address the estimation bias caused by factors related to regional characteristics that may be overlooked. Time-fixed effects are also introduced to ensure the regression results of the impact of technology importation on industrial upgrading are unbiased estimates. This can address the problem of omitted variables that do not vary with region but vary with time. Therefore, all regressions in this paper use fixed-effects models. Finally, to prevent heteroscedasticity and serial correlation, a cluster robust standard error is used that can simultaneously correct heteroscedasticity and autocorrelation.

3. Empirical Outcomes and Discussion

3.1. Benchmark Testing

The results in Table 3 show that technology importation (Tech) has a positive effect on industrial advancement (AIS); however, it does not have a significant effect on industrial rationalisation (RIS). From the perspective of advancement, through the learning and absorption of the introduced technology, developing countries can accelerate their industrialisation process from a primary production to a high value-added manufacturing production process, which can significantly promote industrial structure advancement. From the perspective of rationalisation, economic development leads to a gradual transition in the industrial sector of technology importation, that is, it leads to a shift away from labour-intensive industries towards technology-intensive industries. The productivity levels of low-end and high-end industries are shrinking; therefore, the impact on the rationalisation of industrial structure is uncertain. H1 is partially supported by the results of the benchmark testing because related to RIS and AIS dimensions on industrial structure upgrading.

It is worth noting that institutional quality (Institution) makes a significant contribution to both advanced and rationalised industries. In addition to the structural change in the three industries (i.e. advancement), industrial upgrading increases through the technological content within industries, the reliance on markets and dedicated investments to produce heterogeneous products. Thus, the industrial upgrading of economies tends to be deeper and more subtle. It can be concluded that a good institutional environment can not only influence the structural changes of primary, secondary and tertiary industries but can also be

an important force of coordinated development within industries. The empirical analysis results support H2.

According to the control variables, the degree of market opening (TRA) is not conducive to the AIS but can promote the RIS. Most of China's exports are in low-end industries and most of its imports are in high-end industries, which is conducive to the development of low-end industries but not high-end industries. Therefore, the efficiency of production in middle to low-end industries can be improved, and the industrial structure becomes more reasonable, but it is not conducive to an advanced industrial structure.

The level of regional economic development (GDP), fixed asset investment (CAP) and human capital (HUM) can promote the AIS, but the effect on the RIS is not obvious. On the one hand, the higher the level of economic development, the higher the demand for the development of a service industry within the economy. Although it is conducive to an advanced industrial structure, since it is driven by the market's goal of maximising economic benefits, it does not solve the coordination problem of development among industries and within industries. On the other hand, China's economic development has led to an increasing share of the tertiary industry in the GDP, and the amount of investment in the tertiary industry has also increased. The increase in investment has led to a continuously advanced industrial structure in China, but the impact on the rationalisation of the industrial structure is uncertain due to the phenomenon of duplication in China's investment in multiple regions, which may hinder the improvement of the RIS.

T a b l e 3

Benchmark Testing

VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**
	AIS	**AIS**	**RIS**	**RIS**
Tech	0.0467**	0.0109**	0.0001	0.0026
	(0.0183)	(0.0039)	(0.0119)	(0.0119)
Institution	0.0931***	0.121***	0.0301***	0.0270**
	(0.0273)	(0.0239)	(0.0116)	(0.0117)
TRA		–1.148*		1.252***
		(0.642)		(0.404)
HUM		25.27***		4.345
		(7.455)		(3.435)
CAP		0.438***		0.0578
		(0.0823)		(0.0394)
GDP		0.597***		0.0389
		(0.101)		(0.102)
Constant	3.418***	13.77***	0.212	–0.436
	(0.309)	(1.714)	(0.152)	(1.729)
Observations	589	589	589	589
R-squared	0.877	0.917	0.875	0.877

Note: Cluster robust standard error in parenthesis. *Significance*: * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: Authors' estimations by Stata.

3.2. Test for the Moderating Effect of Institutional Quality

The results of the underlying regressions above show that technology importation has a significant and positive impact on industrial structure upgrading, in which a good institutional quality can also facilitate the process of industrial structure upgrading. In addition to the direct effect derived in the previous section, this paper further verifies that technology importation has an indirect effect on industrial structural upgrading moderated by institutional quality. That is, the marginal effect of technology importation on industrial upgrading changes as the quality of the institution improves.

In order to understand the moderating effect of institutional quality more deeply, the study further extends the basic regression in Equation (3) by adding the interaction term between institutional quality and technology importation ($Tech * Institution_{it}$) to obtain Equation (4) and conduct a regression analysis based on this equation.

T a b l e 4

Test for the Moderating Effect of Institutional Quality

VARIABLES	(1)	(2)	(3)	(4)
	AIS	AIS	RIS	RIS
Tech	0.0882**	0.0461*	–0.0071	–0.0157
	(0.0363)	(0.0238)	(0.0155)	(0.0131)
Institution	0.0882**	0.0291**	0.0295**	0.0290**
	(0.0327)	(0.0083)	(0.0105)	(0.0160)
TechInst	0.0126**	0.0105**	0.0021	0.0039
	(0.0059)	(0.0041)	(0.0027)	(0.0024)
Control variables	No	Yes	No	Yes
Constant	4.046***	14.10***	0.318	–0.313
	(0.514)	(1.693)	(0.212)	(1.733)
Observations	589	589	589	589
R-squared	0.880	0.919	0.875	0.878

Note: Cluster robust standard error in parenthesis. *Significance*: * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: Authors' estimations by Stata.

$$\frac{\partial UIS_{it}}{\partial Tech_{it}} = \beta_1 + \beta_3 Institution_{it} \tag{5}$$

$$\frac{\partial UIS_{it}}{\partial Tech_{it}} = 0.0461 + 0.0105 \tag{6}$$

Table 4 and Equation (6) show that technology importation has a significant effect on industrial structure advancement, but this effect is unstable. The bias effect of technology importation on industrial upgrading increases in keeping with the institutional quality. Specifically, the effect of technology importation

on industrial upgrading increases by 0.0105 units for each unit increase in institutional quality. Therefore, good institutional quality can indirectly contribute to the transformative upgrading effect of technology importation on industry. This verifies H3: the promotion effect of technology importation on industrial upgrading may be affected by institutional quality.

3.3. Heterogeneity Analysis

The above empirical results verify the overall interaction between technology importation, institutional quality and industrial upgrading. However, the direct effect of technology importation and the indirect moderating effect of institutional quality on industrial advancement and rationalisation are inconsistent for all regressions. To make this study robust, a more detailed heterogeneity analysis is required. This analysis includes regressions for each of the five dimensions: (a) the relationship between the government and the market, (b) the development of a non-state economy, (c) market intermediary organisations and the legal system environment, (d) factor market development and (e) product market development. Together, these dimensions constitute the overall score to analyse the variability of the moderating effect of institutional quality from different aspects. The analysis also divides the total Chinese sample into three regions (east, central and west) to analyse whether the impact of technology importation on industrial upgrading and the moderating effect of institutional environment vary by region.

Table 5 demonstrates the heterogeneous effects of each of the five sub-indicators of institutional quality on industry advancement and rationalisation. For the advancement of industrial structure, only the degree of factor market development is not influential. The opposite is found in the case of industrial structure rationalisation, as only the degree of factor market development has a significant and positive effect.

Table 6 reports the impact of technology importation on industrial upgrading and the moderating effect of institutional quality for each of the three major economic regions of China. The regression results for the economically developed eastern coastal region show that technology importation has a significant and positive effect on both industrial advancement and rationalisation, and institutional quality also plays a positive role in promoting them

However, in the central region, neither technology importation nor institutional quality has a significant effect on the advancement and rationalisation of the industrial structure. It is worth noting that in the western region, both technology importation and institutional quality have a significant positive effect on industrial structure rationalisation.

T a b l e 5

Test for Heterogeneity of 5 Sub-indicators of the Institution

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	AIS	AIS	AIS	AIS	AIS	RIS	RIS	RIS	RIS	RIS
Tech	0.0618*** (0.0227)	0.0048** (0.0027)	0.0574** (0.0233)	0.0171** (0.0087)	0.122*** (0.0414)	0.0002 (0.0141)	0.0081 (0.0204)	0.0085 (0.0137)	0.0205* (0.0115)	0.0065 (0.0144)
InstLaw	0.113* (0.0603)					–0.0172 (0.0318)				
Tech*Law	0.0111** (0.0044)					0.0013 (0.0023)				
InstGovmarket		0.137*** (0.0422)					0.0202 (0.0329)			
Tech*Govmarket		0.0057* (0.0033)					–0.0009 (0.0027)			
InstNonstate			0.183*** (0.0397)					–0.0299 (0.0228)		
Tech*Nonstate			0.0097*** (0.0029)					0.0027 (0.0016)		
InstProduct				0.0020 (0.0391)					0.0329** (0.0182)	
Tech*Product				–0.0057 (0.0035)					0.0042*** (0.0016)	
InstFactor					0.282*** (0.0775)					–0.0101 (0.0306)
Tech*Factor					0.0248*** (0.0063)					0.00250 (0.0023)
Constant	3.932*** (0.331)	3.076*** (0.313)	4.417*** (0.280)	3.674*** (0.324)	4.583*** (0.491)	0.409** (0.187)	0.254 (0.254)	0.487*** (0.166)	0.572*** (0.126)	0.308* (0.176)
Observations	589	589	589	589	589	589	589	589	589	589
R-squared	0.885	0.878	0.883	0.877	0.891	0.873	0.874	0.874	0.875	0.878

Note: Cluster robust standard error in parenthesis. *Significance*: * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: Authors' estimations by Stata.

There are huge differences across China's regions, reflecting their natural conditions and economic locations. For example, the eastern region's economic geography is more suitable for the development of industries related to technology importation. Moreover, the industrial base and productivity level of the eastern region are relatively higher, enabling it to master the production of technologies to which it is introduced.

The differences between the regional economic-geographic gradients and original technology bases are the basic factors creating China's unbalanced technology importation and industrial structure. In addition, the effects of these factors under the market mechanism may attract more technology importation into the eastern region. Despite its relatively low technology level by comparison, the western region is still able to achieve technological improvement within the industry if technology is introduced at this stage. This is also the reason for the significant RIS coefficient in the western region.

T a b l e 6

Test for Heterogeneity of Samples Grouped By Region

VARIABLES	(1)		(2)		(3)	
	Eastern Region		Central Region		Western Region	
	AIS	RIS	AIS	RIS	AIS	RIS
Tech	0.598***	0.159***	0.0658	0.0414	0.0082	0.0227*
	(0.190)	(0.0511)	(0.0548)	(0.0713)	(0.0194)	(0.0137)
Institution	0.886***	0.333***	0.0886	0.185	–0.0227	0.0784*
	(0.337)	(0.0855)	(0.131)	(0.161)	(0.0506)	(0.0465)
TechInst	0.0570**	0.0206***	–0.0003	0.0216*	0.0060	0.0095**
	(0.0230)	(0.0060)	(0.0092)	(0.0120)	(0.0042)	(0.0038)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	–13.38**	2.894	18.87***	–12.47***	12.38***	13.77***
	(5.409)	(1.942)	(1.623)	(1.644)	(3.268)	(4.209)
Observations	209	209	152	152	228	228
R-squared	0.963	0.905	0.912	0.836	0.849	0.707

Note: Cluster robust standard error in parenthesis. *Significance*: * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: Authors' estimations by Stata.

3.4. Endogeneity and Robustness Testing

3.4.1. Endogeneity Testing

The previous analysis included a series of control variables that affected industrial upgrading and controlled for fixed effects, which mitigated the endogeneity problem to some extent. However, if there is a two-way causal relationship between the dependent and independent variables, the regression results may also be biased and inconsistent. While technology importation affects industrial transformation, the increase in technology level reflected in industrial upgrading

may also present new requirements for technology importation. Therefore, a two-way causality between them might exist. It is particularly important to deal with the endogeneity issue. In this paper, the one-period lags of technology importation indicators are used as instrumental variables instead of the original variables for two stage least square (2SLS) estimation. Meanwhile, considering the dynamic endogeneity issue, we also applied the generalized method of moment (GMM) estimators for robustness testing. The regression results are shown in Table 7. Compared with the original regression, the significance and sign of the core explanatory variables do not change. This implies that the original regression results are robust.

T a b l e 7

Endogeneity Testing

VARIABLES	2SLS		GMM	
	(1)	(2)	(3)	(4)
	AIS	RIS	AIS	RIS
Tech	0.267***	0.0122	0.546***	0.114
	(0.0511)	(0.0167)	(0.066)	(0.197)
Institution	0.526***	0.126***	0.924**	0.097**
	(0.0984)	(0.0270)	(0.243)	(0.034)
TechInst	0.0453***	0.0139	0.0872***	0.007
	(0.0087)	(0.0122)	(0.0128)	(0.019)
Control variables	Yes	Yes	Yes	Yes
Constant	6.396***	0.758***	7.407***	1.052***
	(0.627)	(0.188)	(0.216)	(0.027)
Observations	558	558	558	558
R-squared	0.315	0.595	0.406	0.544

Note: Cluster robust standard error in parenthesis. *Significance*: * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: Authors' estimations by Stata.

3.4.2. Robustness Testing

To test the accuracy and rigor of the regression model, the regression results need to be tested for robustness. To achieve this, the main variables are replaced and the model is regressed again. Specifically, the paper uses the turnover of the technology market as a proxy variable for technology importation and the level of market development (private and individual employment/total employment) as a proxy variable for institutional quality. The article also considers the potential problems of the limitedness of the dependent variable, and to ensure robustness, we additionally use Truncated regression and Tobit regression for robustness testing, as well as robust standard deviation to overcome the possible existence of heteroskedasticity that may adversely affect the overall validity of the model.

The results in Table 8 show that the coefficients of the main explanatory variables are significantly positive once the indicators are replaced, which is generally consistent with the results shown in Table 2. This result further confirms the robustness of the results of the previous analysis. As for the other control variables, the regression results in the table are also consistent with the results of the previous regression analysis, thus illustrating the robustness of the regression results.

Table 8

Robustness Testing

VARIABLES	Replace Tech		Replace Inst		Truncated Regression		Tobit Regression	
	AIS	RIS	AIS	RIS	AIS	RIS	AIS	RIS
Tech	0.0673*** (0.0177)	0.0292* (0.0108)	0.0401** (0.0161)	0.0057 (0.0129)	0.303*** (0.111)	0.0389 (0.0874)	0.0859*** (0.0249)	0.0178 (0.0212)
Institution	0.0278* (0.0162)	0.0527** (0.0234)	4.992*** (1.114)	0.509* (0.406)	0.0559*** (0.0117)	0.124** (0.0544)	0.0581*** (0.0116)	0.0314* (0.0163)
TechInst	0.0100*** (0.0037)	0.0053 (0.0055)	0.383*** (0.0786)	0.0538 (0.0429)	0.0378*** (0.0091)	0.884 (0.654)	1.393*** (0.301)	0.458 (0.946)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	13.45*** (1.628)	–0.543 (1.665)	12.14*** (1.609)	–0.210 (1.894)	10.29*** (2.354)	1.556*** (0.157)	3.625*** (0.432)	1.605*** (0.202)
Observations	589	589	589	589	576	589	589	589
R-squared	0.922	0.880	0.918	0.877				
Sigma					1.110*** （0.184）	1.556*** （0.157）		

Note: Cluster robust standard error in parenthesis. *Significance*: * p < 0.1, ** p < 0.05, *** p < 0.01.

Source: Authors' estimations by Stata.

4. Conclusions and Policy Implications

This study examined the relationships between technology importation, institutional environment and industrial upgrading in China using panel data. The main conclusions are as follows. First, technology importation has a positive effect on industrial advancement; however, it does not have a significant effect on industrial rationalisation. Meanwhile, institutional quality makes a significant contribution to both advanced and rationalised industries. Second, good institutional quality can indirectly contribute to the transformative upgrading effect of technology importation on industry. Finally, the effects of technology importation and institutional environment on industrial upgrading in the eastern region were higher than in the central and western regions. In addition, there were differences in the moderating effects of different aspects of institutional quality on industrial upgrading, which implies that the institutional environment should be improved in a more targeted manner to achieve regional industrial development.

This research has important policy implications. Although the introduction of technology can promote an advanced industrial structure, it does not play a positive

role in the rationalisation of industrial structure. Moreover, both rationalisation and advancement are important aspects of industrial upgrading. China's economy has entered a new normal; therefore, the foreign direct investment policy of exchanging markets for technology should not be adopted, and the market access standard should be appropriately improved to increase the introduction of high-quality technology. Although China has made great progress in science and technology, mainly through the introduction and absorption of technology, it is important to strengthen the introduction of technology further to reach new heights. However, industrial structure upgrading is both a prerequisite and the foundation for this process of introducing technology.

China should spare no effort in its attempts to improve the quality of innovation and also continue to speed up the process of developing a market-oriented framework to promote the role of technology importation in industrial structure advancement and rationalisation with a high level of institutional quality. Specifically, the government should manage the relationship between it and the market, improve the market's ability to regulate itself and create a good market environment for enterprise innovation to occur. Besides, it is essential to strengthen the power of individual, private and foreign-funded enterprises and other non-state economies by encouraging enterprises to participate fully in market competition with the market economy mechanism and by stimulating enterprises to import technology. At the same time, marketing intermediaries should be encouraged and a legal system developed to provide appropriate organisational and legal protections. Finally, in order to upgrade the industrial structure, more attention should be paid to the central and western regions to balance China's regional development. It is particularly necessary to improve the market economy institutional environments in these less developed regions. Removing the country's administrative divisions and eliminating the geographical divisions between regional product and factor markets could lead to a free flow of factors and a reduction in transaction costs. These conclusions and policy recommendations are not only applicable to China – they also have implications for other developing countries that are upgrading their industrial structure.

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