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Research article

Does structural deceleration happen in China? Evidence from the effect of industrial structure on economic growth quality

Tinghui Li and Xue Li*

School of Economics and Statistics, Guangzhou University, Guangzhou 510006, China

* **Correspondence:** Email: 2111964051@e.gzhu.edu.cn; Tel: +8619860073754.

Abstract: China's economy has experienced high-speed development, followed by structural deceleration according to law of development. Does it happen in China? This is the problem focused on in this paper. We explore the appearance for structural deceleration in China through the relation between industrial structure and economic growth quality. The green total factor productivity is selected as the measurement assessing the economic growth quality. We use the Global Malmquist-Luenberger index to measure economic growth quality of China for 30 Chinese provinces over the period of 1998 to 2015. First, the panel regression model is used to show a positive effect of industrial structure on economic growth quality with full sample as well as subsample in the east of China. Negative effects of industrial structure are shown in the middle and west of China. Then the structural deceleration is captured by panel quantile regression model. We claim that structural deceleration indeed happens in China through a decreased contribution of industrial structure to the economic growth quality at different quantiles. However, industrial structure in the east of China still plays a positive role in accelerating the economic growth quality, while its negative effect is anabatic in the middle of China. Finally, we investigate the influencing mechanism of industrial structure on economic growth quality represented by the moderating effects of human capital, innovation capacity and economic development level. All of them show positive moderating effects. The human capital and innovation capacity show heterogeneous at different levels of economic growth quality, contrary to economic development level. Some policy implications are derived according to the results achieved in this the paper.

Keywords: industrial structure; economic growth quality; structural deceleration; moderating effect; panel quantile regression model

JEL Codes: C23, D24, O12

1. Introduction

The relationship between industrial structure and economic growth has been a hotspot in economy for a long time, which generates some remarkable achievement known as Political Arithmetic from William Petty, Classification for three industries by Fisher, "Petty-Clark" law proposed by Clark, national income growth theory from Kuznets and so on. Ding and Knight (2009) explored the remarkable economic growth puzzle of China after the reform and opening-up policy and revealed some indirect determinants including the degree of openness, institutional change and sectoral change, based on a cross-province dataset. However, according to development experience in common industrialized countries, the so-called structural deceleration will turn out as the economic structure develops to some high stage. Structural deceleration, namely economic growth rate is decline with economic structure change. Since industrialization advances toward urbanization, labor was allocated once again and move from industrial sector with high productivity growth rate to service sector with low growth rate, leading to economic growth rate slowed down. This is so-called structural deceleration. There are several origins results in structural deceleration. The first one is represented by the declining efficiency of resource allocation. The structure of resource allocation evolves following the industrial structure. Second, the efficiency of factor supply declines, which is captured by the declining investment yield rate and increasing labour cost. Third, technological innovation capacity needs to be improved. Forth, constraints on environmental resources are going stronger. When we consider environmental constraints, the negative factor of constraints on environmental resources should be added endogenously into the economic growth function of China.

In most existing literatures, the GDP plays the key role in measuring the economic growth. Meanwhile, they neglect the environmental consumption accompanied with the economic growth. In fact, economic growth quality involves two important problems. First, we should coordinate the contradiction among economy, society and environment in the process of economic development, where the economy and environment address the most prominent contradiction. This contradiction between the economy and environment should be coordinated through environmental regulation. However, the environmental regulation results in a larger production cost for the enterprises and then lower production efficiency potentially. This goes against the economic growth. Another problem is the promotion for total factor productivity, who deducts undesirable outputs. The economic growth quality is promoted followed by the promotion of production efficiency. In addition, both the economic development and resource nature of China show heterogeneous characteristic. Accordingly, it should be considered whether the structural deceleration stage has been attained by each district in China.

The primary problem is the measurement for economic growth quality. Green total factor productivity (GTFP) is widely accepted to assess the economic growth quality, which not only takes environment factor but also natural resource consumption, such as energy, into consideration (Feng et al., 2018). A great deal of existing literatures concern about the relationship between industrial structure and GTFP. They focus on the improvement of economic growth quality through the way how industrial structure affects GTFP. First, industrial structure mostly improves GTFP by promoting the development of clean and pollution free industries (Cheng et al., 2018), especially the tertiary industries (Zhang et al., 2014; Tripathy, 2019). Second, different technical inputs and equipment updates demonstrate technical improvement reduces pollutant discharge and then promotes the GTFP (Ambec et al., 2013; Li and Wu, 2017). Furthermore, industrial structure can affect GTFP through optimization and upgrading for industrial structure. Optimization and upgrade of industrial structure improve allocation efficiency as well as competitiveness of professional departments (Zhou et al., 2013; Adom et al., 2012), which then promote the GTFP. These ways result in a great popularity for the impacts of industrial structure on the economic growth quality.

The change of industrial structure is essentially the process of reallocating micro production factors, which will change the structure of resource allocation and the usage efficiency of factor, therefor affecting economic growth quality. As a perpetual theme of economic growth quality, industrial structure has a close relation with economic growth quality, and the reasonable industrial structure has a profound impact on economic growth quality. However, there is dissent with regard to the channels through which industrial structure fosters the economic growth quality. Theoretical models identify multiple channels through which reasonable industrial structure should enhance the economic growth quality, measured by the GTFP, such as human capital, innovation and economic development level. First, the human capital affects the relationship between industrial structure and GTFP through improving not only labor allocation efficiency, but also advanced technology and so on. Second, innovation promotes the technological progress (Corradini et al., 2014; Hashmi and Alam, 2019; Li et al., 2018; Li et al., 2019; Kanamura, 2019), which is beneficial to reduce the pollutant discharge and drive industrial restructuring. This results in the enhancement of GTFP and then the economic growth quality. Third, economic development level promotes the evolution of industrial structure and further affects the economic growth quality (Kwakwa et al., 2018).

Besides the measurement for economic growth quality, in this paper, we devote to exploring the problems on structural deceleration in China through the relation between industrial structure and economic growth quality. First, we concern on whether the structural deceleration happens in China. This conjecture may hold after a high-speed economic growth of China since 1978, when the reform and opening-up policy issued. Second, if structural deceleration happened in China, then we consider the difference of structural deceleration in different districts of China, involving the east, the middle and the west. Economic development of China shows remarkably imbalanced in different districts. It is known that the east addresses a better economic development then the west and the middle. This imbalance motivates us to focus on the heterogeneity of structural deceleration in the east, the middle and the west of China. Third, we investigate the intervening variables playing the intermediate roles between industrial structure and economic growth quality, which may illustrate the influencing mechanism.

Hence, the highlight of the current paper is the structural deceleration and its heterogeneity dominated by districts in China, addressed by the relationship between industrial structure and economic growth quality.

The paper is organized as follows. In Section 2, we study the impact of industrial structure on economic growth quality, followed by the test for structural deceleration in Section 3. In Section 4, we investigate the influencing mechanism of industrial structure on economic growth quality through moderating effect. In Section 5, we conclude the paper with policy implications. See Figure 1 for the logic organization of the paper.

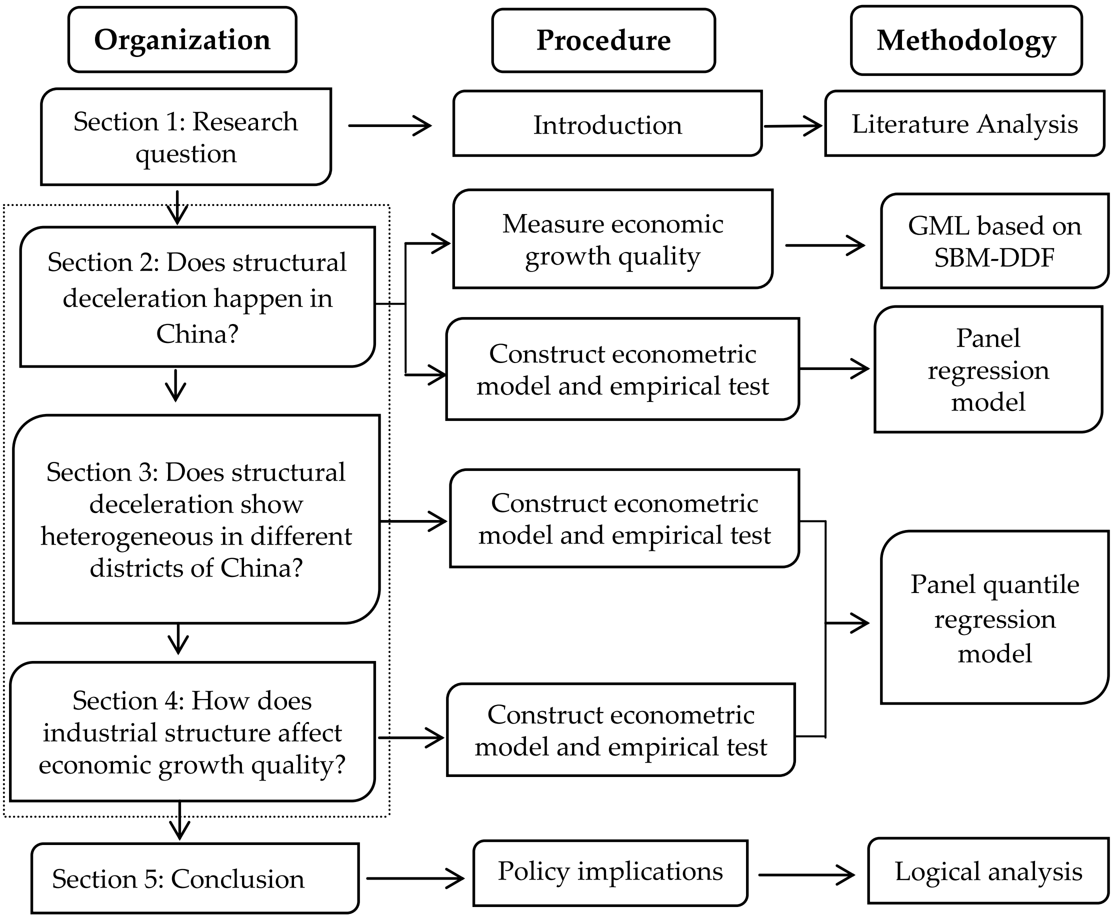

Figure 1. The logical organization of this paper.

2. The impact of industrial structure on economic growth quality

Our goal in this section is to test the structural deceleration of China through analyzing the impact of industrial structure on economic growth quality. We should set up appropriate model to measure relevant variables in the model.

2.1. Panel regression model

The relation between the industrial structure and economic growth quality has been the subject of considerable debate. First, industrial structure exerts positive effect on economic growth quality. Compared with the secondary industry, the tertiary sector is much less relying on resources and creates fewer pollutants. Therefore, a higher ratio of the service sector may lead to lower pressure on environment, which can, in turn, lead to a better economic growth quality. Second, human capital is an important driving force of change of industrial structure and therefore increases economic growth quality indirectly by accelerating technological change. In addition, innovation can promote the improvement of production technology, and reduce the input of raw materials and energy consumption of unit product (Cheng et al., 2019). Moreover, as the economic development level rises, the industrial structure will also be varied, thus improve economic growth quality. At the same time, we attempt to better investigate the impact of industrial structure on economic growth quality from the perspective of province and time. The panel data framework makes it possible to allow for differences of time in the form of unobservable individual “province effects”.

In this paper, we introduce a panel date model that captures variation of economic growth quality both over time and across provinces. There are three kinds of panel data regression models-the fixed effects model, the random effects model, and the mixed effects model. Firstly, we identify if either mixed or fixed effects are preferred for the regression specification with F-test. The null hypothesis of the F-test which accept mixed effects model is rejected at 1% level. Then, the fixed effects model is used to the regression specification instead of the random effects model through Hausman test (Hausman, 1978). Finally, we applied a fixed effects model to analyze the impact of industrial structure on economic growth quality. To assess the extent to which industrial structure affects economic growth quality, we estimate the following regression specification:

$$egq_{it} = \beta_0 + \beta_1 \ln indu_{it} + \beta_2 \ln hc_{it} + \beta_3 \ln inno_{it} + \beta_4 perGDP_{it} + \mu_i + \gamma_t + \varepsilon_{it}, \quad (1)$$

where i and t represent province and time respectively; egq_{it} is a dependent variable refers to economic growth quality, which is measured by GTFP; $\ln indu_{it}$ is an independent variable denotes industrial structure; $\ln hc_{it}$, $\ln inno_{it}$, $perGDP_{it}$ are control variables denote human capital, innovation capacity and the level of economic development respectively. The specification also includes province-fixed effects, μ_i, and year-fixed effects, γ_t, ε_{it} is a stochastic disturbance term.

2.2. Variable and Data

2.2.1. Measurement of economic growth quality

This section measures economic growth quality of China’s 30 provinces (excluding Tibet) from 1998 to 2015. The Global Malmquist–Luenberger index developed by Oh (2010) and SBM-based global directional distance function could be regarded as an effective tool to measure GTFP and then the economic growth quality. A province i is represented as DMU_i. Under a panel of $i = 1,...,I$ provinces and $t = 1,...,T$ time periods, the production technology for each province obtains m kinds of desired output (y, $y \in R^{m_+}$) and n kinds of undesired output (b, $b \in R^{n_+}$) by using p inputs (x, $x \in R^{p_+}$). In order to emphasis consistency and comparability of the production frontier, Oh (2010) constructed the global production possibility set $P^G(x)$. Thus, we construct the global production possibility set $P^G(x)$ as follows:

$$P^G(x) = \left\{ \begin{array}{l} \left(y^t, b^t\right): \sum_{t=1}^{T} \sum_{i=1}^{I} z_i^t y_{im}^t \geq y_{im}^t, \forall m; \sum_{t=1}^{T} \sum_{i=1}^{I} z_i^t b_{in}^t = b_{in}^t, \forall n; \\ \sum_{t=1}^{T} \sum_{i=1}^{I} z_i^t x_{ip}^t \leq x_{ip}^t, \forall p; \sum_{t=1}^{T} \sum_{i=1}^{I} Z_i^t = 1, z_i^t \geq 0, \forall i; \end{array} \right\}, \quad (2)$$

where z_i^t represents the weight of each cross-section.

Taking the influence of input and output slack variables on efficiency into consideration, we apply the global SBM directional function considering undesired output according the research of Fukuyama and Weber (2009) as well as Liu and Xin (2019). The global SBM directional function is constructed:

$$\vec{S}^G\left(x^{t,i'}, y^{t,i'}, b^{t,i'}, g^x, g^y, g^b\right) = \max_{s^x, s^y, s^b} \frac{\frac{1}{p}\sum_{p=1}^{P}\frac{S_p^x}{g_p^x} + \frac{1}{M+N}\left(\sum_{m=1}^{M}\frac{S_m^y}{g_m^y} + \sum_{n=1}^{N}\frac{S_n^b}{g_n^b}\right)}{2}$$

$$s.t.\ \sum_{t=1}^{T}\sum_{i=1}^{I} z_i^t x_{ip}^t + s_p^x = x_{i'p}^t, \forall p; \sum_{t=1}^{T}\sum_{i=1}^{I} z_i^t y_{im}^t - s_m^y = y_{i'm}^t, \forall m; \quad , \tag{3}$$

$$\sum_{t=1}^{T}\sum_{i=1}^{I} z_i^t b_{in}^t + s_n^b = b_{i'p}^t, \forall n; \sum_{i=1}^{I} z_i^t = 1, z_i^t \geq 0, \forall i; s_m^y \geq 0, \forall m; s_n^b \geq 0, \forall n$$

where (g^x, g^y, g^b) refers to the direction vectors for decreasing inputs, increasing desirable outputs and decreasing undesirable outputs, respectively; (s_p^x, s_m^y, s_n^b) denotes the slack vectors for redundant inputs, inadequate desirable outputs and redundant undesirable outputs, respectively.

Drawing from the study of Oh (2010), we construct the Global Malmquist–Luenberger index based on SBM-based directional distance function as follows:

$$GML_t^{t+1} = \frac{1 + \vec{S}^G\left(x^t, y^t, b^t; g^x, g^y, g^b\right)}{1 + \vec{S}^G\left(x^{t+1}, y^{t+1}, b^{t+1}; g^x, g^y, g^b\right)}, \tag{4}$$

where, the GML index denotes the change from time t to time t + 1.

Then, the egq in 1998 would be egq in 1997 multiplied by the GML index. At the same time, egq of each province in 1997 is 1. Therefore, the egq in 1998 can be expressed as: $egq_{1998}=egq_{1997} \times GML_{1997}^{1998}$. The egq of other years can be calculated similarly.

2.2.2. Explanatory variables and descriptive statistics

In our model, we concentrate on the role played by the industrial structure. In the empirical study, we controlled for possible confounding effects by including various relevant control variables, such as human capital, innovation capacity, the level of economic development. However, certain variables should be calculated with its original data. The GTFP, who assesses the economic growth quality, is measured through input (Li and Lin, 2016), desired output (Long et al., 2018) and undesired output (He et al., 2013). Input includes labor input, capital input and energy input. Labor input is measured by the number of year-end of employed persons in each province, where a unit is 10 thousand persons (Song et al., 2018). Capital input is calculated through capital stock. Capital stock was estimated through perpetual inventory method (Goldsmith, 1951) in this paper, and the formula is $K_{it} = K_{i(t\text{-}1)}(1-\delta) + I_{it}$, where K_{it}, I_{it} denote the actual capital stock and the gross fixed capital formation in province i at time t, respectively. δ refers to the depreciation rate. According to the research of Zhang and Tan (2016), we adopt the value of 9.6% as depreciation rate. Year 1997 is the base period. Energy input is measure by total energy consumption which is used to measure energy input. It can be express that GDP divided by GDP per unit of energy consumption. The unit of energy input is 10000tce. We used the real GDP to measure desired output. Real GDP is converted based on the year 1997 to ensure data are comparable. Undesired output mainly includes waste water, waste gas as well as solid waste. Because provincial solid waste is unavailable, we exclude it from this paper. Consequently, we consider industrial waste discharge and total industrial waste gas discharge as undesirable outputs. The unit of waste water and waste gas are 10000 tons and 100 million cube meters, respectively.

Industrial structure is measured by the coefficient of industrial structure, which can reflect the industrial distribution. According to the principle of industrial evolution from "Petty-Clark" law, we adopt the sum of the added value proportion of the three industries accounting for the added value of the primary industry to calculate the coefficient of industrial structure, so as to reflect the allocation of factors in the three industries and reflect the change of industrial structure. Industrial structure of province i at time t is measured by:

$$indu_{it} = \frac{GDP_{it}^{1}}{GDP_{it}^{1}} + \frac{GDP_{it}^{2}}{GDP_{it}^{1}} + \frac{GDP_{it}^{3}}{GDP_{it}^{1}}, \quad (5)$$

where $GDP_{it}^{1}, GDP_{it}^{2}, GDP_{it}^{3}$ refer to the gross regional product of the primary industry, the secondary industry and the tertiary industry, respectively.

Additionally, human capital is the years of education of the labors and measured by millions of persons. Innovation capacity denotes the natural logarithmic forms of patent applications per million people. The level of economic development is measured by per capita gross regional product, where a unit of is one thousand yuan.

In our empirical analysis, we employ original data from different sources. In measuring economic growth quality, we make use of the data of the labor of China's 30 provinces during 1997–2015, total year consumption of every area and data on waste gas and waste water from EPS macro database. Meanwhile, we also obtain the data on the gross fixed capital formation for 1997–2015 and real GDP from National Bureau of Statistic of China. In addition, we calculate structural transformation, human capital and innovation capacity on the basis of data from EPS macro database.

The descriptive statistics of variables are presented in Table 1. Descriptive statistics are presented to summarize the basic characteristics of data in this study concerning on China's 30 provinces during the period 1990–2014. For each variable, we present the mean, standard deviation (Std. Dev.), minimum (Min), 0.25, 0.5 and 0.75 quantiles and maximum (Max). As shown in the first row, the average economic growth quality of China's 30 provinces is 1.012 with the minimum value 0.320 and the maximum 3.000, while there is no significant divergence on the mean of economic growth quality and the 0.5 quantile 0.75. The second row reports the variation of industrial structure. The logarithm of coefficient of industrial structure ranges from 1.009 to 5.433, while the average is 2.239 which signally higher than the 0.5 quantile 2.052. Besides, different quantiles can describe different distribution trends. According to last three rows, the $\ln hc$ ranges from 5.789 to 10.800, and the $\ln inno$ ranges from 4.820 to 13.131. And we find that the average per capita GDP is 25.239, which is significantly higher than 0.5 quantile 19.056, and there is great difference between the minimum 2.364 and the maximum 107.960.

Table 1. Descriptive statistics.

Variable	Mean	Std.Dev.	Min	0.25	0.5	0.75	Max
egq	1.012	0.431	0.320	0.788	0.950	1.121	3.000
lnindu	2.239	0.818	1.009	1.743	2.052	2.426	5.433
lnhc	8.487	0.848	5.789	8.053	8.548	8.996	10.800
lninno	8.981	1.655	4.820	7.794	8.887	10.176	13.131
perGDP	25.239	21.292	2.364	8.732	19.056	35.170	107.960

Notes: "ln" means the variable in natural logarithms.

2.3. Testing the impact of industrial structure on economic growth quality

The unit root test is performed to check whether the variables are stationarity before we test the impact of industrial structure on economic growth quality (Muller and Elliott, 2003). Table 2 reports the results for a battery of unit root tests for egq, $\ln indu$, $\ln hc$, $\ln inno$ and $perGDP$. In particular, we report results from two tests of the null hypothesis that each series contains a unit root. The first is the Levin-Lin-Chu unit-root test (Levin et al., 2002); the second is the standard Augmented Dickey-Fuller t-test (Dickey and Fuller, 1981). In all two cases, the tests reject the null hypothesis of contain unit roots at the 5% level of significance. Consequently, we can conclude that all variables are stationary.

Table 2. Unit root test.

variables	LLC	ADF			
		Inverse chi-squared(60)	Inverse normal	Inverse logit t(154)	Modified inv. chi-squared
egq	0.000	0.000	0.000	0.000	0.000
	(−5.579)	(144.664)	(−5.262)	(−5.690)	(7.729)
lnindu	0.0001	0.000	0.000	0.000	0.000
	(−3.732)	(147.489)	(−6.350)	(−6.453)	(7.987)
lnhc	0.000	0.000	0.000	0.000	0.000
	(−4.1523)	(157.881)	(−6.051)	(−6.353)	(8.935)
lninno	0.023	0.000	0.000	0.000	0.000
	(−2.0044)	(171.526)	(−7.915)	(−8.174)	(10.181)
perGDP	0.000	0.000	0.000	0.000	0.000
	(−7.405)	(120.700)	(−3.461)	(−3.515)	(5.541)

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

In order to test the impact of industrial structure on economic growth quality, we employ the panel regression model to estimate the parameter for the full sample, subsample of the east, subsample of the middle and subsample of the west. A summary of the estimation results for fixed effects model is presented in Table 3.

Table 3. The result of impact of industrial structure on economic growth quality.

	FE	GMM	2SLS	East	Middle	West
lnindu	0.1669**	0.2635***	0.2635***	0.8696***	−0.1314	−0.2713***
	(0.0684)	(0.0316)	(0.0292)	(0.1176)	(0.1163)	(0.0564)
lnhc	−0.2509***	0.1186**	0.1186**	−0.3649***	−0.2264	0.1376**
	(0.0660)	(0.0488)	(0.0482)	(0.1020)	(0.1405)	(0.0547)
lninno	−0.1210***	−0.1380***	−0.1380***	−0.3522***	0.0048	0.0236
	(0.0241)	(0.0314)	(0.0295)	(0.0495)	(0.0450)	(0.0201)
perGDP	0.0147***	0.0074***	0.0074***	0.0200***	0.0057	−0.0021
	(0.0014)	(0.0015)	(0.0013)	(0.0022)	(0.0040)	(0.0013)
Constant	3.4827***	0.4639**	0.4639**	4.7238***	3.0289***	0.1848
	(0.4573)	(0.2119)	(0.2212)	(0.7375)	(1.1053)	(0.3452)
N	540	510	510	198	144	198
R-squared	0.2820	0.3675	0.3675	0.6710	0.0427	0.1838
F-statistic	35.57	-	-	21.20	70.84	62.48

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

In general, industrial structure has a positive correlation with economic growth quality. As seen in the Table 3, the results imply this positive correlation, which is significant at 5% level. The coefficient indicates that one percent improvement in the coefficient of industrial structure increases leads to a 0.167 increase in economic growth quality. This result may be closely related to these reasons. First, the development of clean and pollution-free industries, especially tertiary industries, are beneficial to the improvement of GTFP and then economic growth quality. Second, because of the upgrade of technological level, the economic growth quality is promoted by reducing pollutant emissions. Moreover, the promotion of allocation efficiency and specialization can not only improve the competitiveness of the industrial department (Feldman and Audretsch, 1999), but also help raise the quality and level of the service industry (Miles, 2008). And this cooperation mechanism can further improve the economic growth quality. The industrial structure in the east of China shows positive correlation with the economic growth quality. On the contrary, the industrial structure in the west of China shows negative correlation with the economic growth quality. Due to imbalance of economic development in the east and west of China, the different industrial structure levels result in different roles in improving the economic growth quality. A reasonable industrial structure is a significant factor on economic growth quality. On the one hand, the west of China with a low industrial development, on the other hand, there are many constraints on the upgrading industrial structure. Base on above, the west of China with an unreasonable industrial structure. Therefore, a low industrial structure level in the west of China indeed restrains the economic growth quality of China and goes against the sustainable development. The economic development in the east addresses a much larger weight than that in the west of China. This results in the fact that the signs of correlation between industrial structure and economic growth quality are consistent for the full sample and the subsample of the east.

3. Structural deceleration by the impact of industrial structure on economic growth quality

The impact of industrial structure on economic growth quality provides some information for the structural deceleration of China. This is investigated in this section through a panel quantile regression analysis in this section.

3.1. Panel quantile regression model

The impact of industrial structure on economic growth quality has been attributed, in no small part, to differences at quantiles of economic growth quality. On one hand, as a developing country, China is in a pivotal transformation stage, where the economic growth quality is transferring from low to high level. On the other hand, when the economic growth quality is at a low quantile, optimization and upgrading of industrial structure can be more capable to improve allocation efficiency, environmental quality and productivity, thus improves the economic growth quality much more easily. In short, the impact of industrial structure on economic growth quality at different quantiles shows different degrees. Therefore, we employ panel quantile regression model to further investigate the impact of industrial structure on economic growth quality at different quantiles.

Panel quantile regression model is a powerful tool to provide a more complete picture for the relationship between industrial structure and economic growth quality. Compared with some conventional regression, panel quantile regression may be preferable. While usual regressions, like

OLS, only consider the mean, quantile regression can evaluate the different points on the full conditional distribution of the dependent variable (Canay, 2011). Therefore, this method can avoid heterogeneity problems effectively in the data distribution, and it is robust to the presence of heteroscedasticity, outliers and structural change. It allows us to draw conclusion on the impacts of industrial structure on economic growth quality in different provinces at different quantiles of the economic growth quality distribution.

We specify the following panel quantiles function:

$$Q_{egq_{it}}\left(\tau \mid \theta_i, \delta_t, X_{it}\right) = \theta_i + \delta_t + \beta_{1\tau} \ln indu + \beta_{2\tau} \ln hc_{it} + \beta_{3\tau} \ln inno_{it} + \beta_{4\tau} perGDP_{it} + \varepsilon_{it}, \quad (6)$$

where i and t represent province and time respectively; egq_{it} is a dependent variable refers to economic growth quality; $\ln indu_{it}$ is an independent variable denotes industrial structure; $\ln hc_{it}$, $\ln inno_{it}$, $perGDP_{it}$ are control variables denote human capital, innovation capacity and the level of economic development respectively. The specification also includes province-fixed effects θ_i, and year-fixed effects δ_t, ε_{it} is a stochastic disturbance term.

3.2. Empirical results: structural deceleration

The empirical results are presented in Table 4, 5, 6 and 7. Table 4 shows the panel quantile regression results for full sample, while Table 5, 6 and 7 show the panel quantile regression results for subsamples in the east, middle and west of China respectively. As shown in Table 4, the impact of 1% increase taken by the industrial structure on the economic growth quality is 0.263 at the 10% percentile, in comparison to only 0.105 at the 90% percentile. It is evident that this positive effect of industrial structure on economic growth quality decreases gradually with increased quantiles. We conclude that the structural deceleration has happened in China. Although the industrial structure still plays a positive role in the economic growth quality, the effect is decreasing. Since China was experiencing its transformation stage at the low quantile of economic growth quality, it is easier to optimize and upgrade industrial structure. Meanwhile, the industrial structure could show notably positive effect on the environment quality as well as productivity, which improve the GTFP and then the economic growth quality, recalling that GTFP as the measurement assessing the economic growth quality. However, we note that the structural deceleration does not happen in the east of China. The industrial structure still plays an important role in improving the economic growth quality. One can see from Table 5 that there is jump between the contributions of industrial structure to the economic growth quality at the quantile 75% and 90%, where the corresponding contributions are given as 0.2593 and 0.4047 respectively. This might be due to a relatively rational industrial structure in the east of China and it keeps a notable effect on the economic growth quality at each stage. The industrial structure in the middle shows negative effect on the economic growth quality. In addition, one can see from Table 6 that the negative effect is anabatic with the increase of economic growth quality. In other words, in the middle of China, the industrial structure absolutely restrains the improvement of economic growth quality. The panel quantile regression results for subsample of the west are not remarkable. The level of industrial structure is relatively low, such that it cannot contribute clearly to the economic growth quality at each stage.

Table 4. Panel quantile regression results for full sample.

	QR_10	QR_25	QR_50	QR_75	QR_90
lnindu	0.263***	0.198***	0.171***	0.102***	0.105**
	(0.044)	(0.027)	(0.033)	(0.034)	(0.046)
lnhc	−0.016	0.091**	0.098*	0.099*	0.275***
	(0.072)	(0.044)	(0.054)	(0.055)	(0.074)
lninno	−0.065	−0.081***	−0.132***	−0.125***	−0.211***
	(0.044)	(0.027)	(0.033)	(0.034)	(0.046)
perGDP	0.001	0.0004	0.007***	0.013***	0.020***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
constant	0.693**	0.300	0.784***	0.933***	0.221
	(0.332)	(0.202)	(0.248)	(0.255)	(0.343)
N	540	540	540	540	540

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Panel quantile regression results for subsample of the east.

	QR_10	QR_25	QR_50	QR_75	QR_90
lnindu	0.2676***	0.2254***	0.2431***	0.2593***	0.4047***
	(0.0596)	(0.0310)	(0.0310)	(0.0462)	(0.0502)
lnhc	0.2624	0.1928**	0.2301***	0.3251***	0.2067
	(0.1609)	(0.0836)	(0.0837)	(0.1247)	(0.1354)
lninno	−0.2109**	−0.3255***	−0.3275***	−0.3663***	−0.3308***
	(0.1011)	(0.0525)	(0.0526)	(0.0783)	(0.0850)
perGDP	0.0040	0.0146***	0.0150***	0.0174***	0.0167***
	(0.0031)	(0.0016)	(0.0016)	(0.0024)	(0.0026)
Constant	−0.2954	1.3383***	1.1044***	0.6800	1.1977**
	(0.6678)	(0.3467)	(0.3474)	(0.5173)	(0.5619)
N	198	198	198	198	198

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Panel quantile regression results for subsample of the middle.

	QR_10	QR_25	QR_50	QR_75	QR_90
lnindu	−0.1503***	−0.2196**	−0.2855***	−0.3152**	0.3705
	(0.0361)	(0.1084)	(0.0828)	(0.1562)	(0.5746)
lnhc	−0.3847***	0.1972	−0.1596	−0.5573**	0.0549
	(0.0556)	(0.1673)	(0.1278)	(0.2410)	(0.8865)
lninno	−0.1485***	−0.2070***	−0.0927*	0.1015	−0.1770
	(0.0243)	(0.0729)	(0.0557)	(0.1050)	(0.3864)
perGDP	0.0204***	0.0107**	0.0123***	0.0104	0.0252
	(0.0017)	(0.0052)	(0.0040)	(0.0075)	(0.0278)
Constant	5.1399***	1.0890	3.3879***	5.3879***	1.3618
	(0.3746)	(1.1261)	(0.8599)	(1.6222)	(5.9669)
N	144	144	144	144	144

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Panel quantile regression results for subsample of the west.

	QR_10	QR_25	QR_50	QR_75	QR_90
lnindu	0.4960**	−0.1024	0.0102	0.0765	0.1296
	(0.2113)	(0.1543)	(0.0624)	(0.0552)	(0.1183)
lnhc	0.0435	0.0633	0.1255***	0.1096***	0.1593**
	(0.1393)	(0.1017)	(0.0411)	(0.0364)	(0.0780)
lninno	−0.0510	−0.0442	−0.0430*	−0.0045	−0.0527
	(0.0756)	(0.0552)	(0.0223)	(0.0197)	(0.0423)
perGDP	−0.0080*	−0.0002	−0.0026*	−0.0037***	−0.0002
	(0.0047)	(0.0034)	(0.0014)	(0.0012)	(0.0026)
Constant	−0.1518	0.9156	0.3185	0.1109	0.0052
	(0.8721)	(0.6368)	(0.2573)	(0.2277)	(0.4884)
N	198	198	198	198	198

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4. Influencing mechanism: moderating effect

In this section, we will take a further step to detect the influencing mechanism of industrial structure on economic growth quality.

4.1. The moderating effect of human capital

Human capital exerts a moderating effect on the impact of industrial structure on economic growth quality. On the one hand, an increase in human capital directly relates to the improvement of employees' ability, enhancing labor productivity, as well as be conducive to optimize industrial structure. On the other hand, human capital may introduce more advanced knowledge and managerial skills to update industrial structure. In other words, the increase of human capital can be beneficial to optimize industrial structure and improve productivity, thus improve the economic growth quality. Therefore, based on model (2), we add human capital and industrial structure as interaction term to explore the moderating effect of human capital. The model can be represented by the following formulas:

$$Q_{egq_{it}}\left(\tau \mid \theta_{i1}, \delta_{t1}, X_{it}\right) = \theta_{i1} + \delta_{t1} + \beta_{1\tau} c\ln indu + \beta_{2\tau} c\ln hc_{it} + \beta_{3\tau} c\ln indu\_c\ln hc_{it} + \beta_{4\tau} c\ln inno_{it} + \beta_{5\tau} cperGDP_{it} + \varepsilon_{it}, \quad (7)$$

where i and t represent province and time respectively; egq_{it} is a dependent variable refers to economic growth quality; $\ln indu_{it}$ is an independent variable denotes industrial structure; $\ln hc_{it}$, $\ln inno_{it}$, $perGDP_{it}$ are control variables denote human capital, innovation capacity and the level of economic development respectively; $c\ln indu\_c\ln hc$ stands for interaction terms. The symbol c before variables means that the variables have been centralized (the follow-up c is the same). The specification also includes province-fixed effects θ_{ij}, and year-fixed effects δ_{tj}, ε_{it} is a stochastic disturbance term.

The estimates presented in Table 8 focus on moderating effect of human capital on the impact of industrial structure on economic growth quality. To be more precise about the impact of industrial structure on economic growth quality, we further investigate the moderating effect of human capital under different economic growth quality levels. The results are respectively reported for the 10th, 25th, 50th, 75th, 90th quantiles of the conditional economic growth quality distribution in Columns 3–7.

Human capital plays a positive moderating effect on the impact of industrial structure on economic growth quality and it is heterogeneous at different quantiles of economic growth quality. The positive sign on coefficient of $c\ln indu\_c\ln hc$ directs that human capital improves the positive effect of industrial structure on economic growth quality. The reason for this phenomenon may be that human capital improves the ability of employees and enhance labor productivity to strengthen the impact of industrial structure on economic growth quality. Besides, the significant divergence of moderating effect of human capital at different quantiles can be observed. The coefficient of interaction between industrial structure and human capital is 0.202 at the 10th quantile, in comparison to 0.133 at 90th quantile, which implies that this positive moderating effect of human capital on the impact of industrial structure on economic growth quality inclines to decrease.

Table 8. Results of moderating effect of human capital.

	FE	QR_10	QR_25	QR_50	QR_75	QR_90
clnindu	0.142**	0.263***	0.175***	0.179***	0.180***	0.135***
	(0.059)	(0.026)	(0.032)	(0.029)	(0.032)	(0.051)
clnhc	−0.210***	−0.031	0.088*	0.172***	0.117**	0.290***
	(0.057)	(0.042)	(0.052)	(0.047)	(0.051)	(0.083)
clnindu_clnhc	0.280***	0.202***	0.193***	0.201***	0.162***	0.133***
	(0.022)	(0.025)	(0.031)	(0.028)	(0.031)	(0.050)
lninno	−0.029	−0.053**	−0.088***	−0.120***	−0.068**	−0.154***
	(0.022)	(0.026)	(0.033)	(0.029)	(0.032)	(0.052)
perGDP	0.007***	0.001	−0.00003	0.002*	0.007***	0.013***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)
_cons	1.029***	1.022***	1.565***	1.941***	1.585***	2.380***
	(0.193)	(0.224)	(0.280)	(0.250)	(0.273)	(0.444)
N	540	540	540	540	540	540
R-squared	0.460					
F-statistic	85.86					

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.2. The moderating effect of innovation capacity

Innovation capacity plays the moderating effect on the impact of industrial structure on economic growth quality. Innovation improves the industrial structure through both acquiring new products and improving existing varieties. Besides, increasing innovation capacity can be capable to transform useful knowledge, promote technological progress (Li et al., 2019; Wen et al., 2019). As a result, it can reduce the emission of pollutants to improve environment quality, as well as improves the industrial structure. Consequently, industrial structure raised economic growth quality. Therefore, based on model (2), we add innovation capacity and industrial structure as interaction term to explore the moderating effect of innovation capacity. The model can be represented by the following formulas:

$$Q_{egq_{it}}\left(\tau \mid \theta_{i2},\delta_{t2},X_{it}\right)=\theta_{i2}+\delta_{t2}+\beta_{1\tau}c\ln indu+\beta_{2\tau}c\ln inno_{it}+\beta_{3\tau}c\ln indu\_c\ln inno_{it}+ \beta_{4\tau}c\ln hc_{it}+\beta_{5\tau}cperGDP_{it}+\varepsilon_{it}, \quad (8)$$

where i and t represent province and time respectively; egq_{it} is a dependent variable refers to green total factor productivity; $\ln indu_{it}$ is an independent variable denotes industrial structure; $\ln hc_{it}$, $\ln inno_{it}$, $perGDP_{it}$ are control variables denote human capital, innovation capacity and the level of economic development respectively; $c\ln indu\_c\ln \mathrm{inno}$ stands for interaction terms. The specification also includes province-fixed effects θ_{ij}, and year-fixed effects δ_{tj}, ε_{it} is a stochastic disturbance term.

The estimates presented in Table 9 focus on moderating effect of innovation capacity on the impact of industrial structure on economic growth quality. Besides, we also further investigate the moderating effect of innovation capacity under different economic growth quality levels. The results are respectively reported for the 10th, 25th, 50th, 75th, 90th quantiles of the conditional economic growth quality distribution in Columns 3–7.

Innovation capacity exerts a positive moderating effect on the impact of industrial structure on economic growth quality and it is heterogeneous at different quantiles of economic growth quality. The results in table 9 reveal that the interaction of industrial structure and innovation capacity acts on economic growth quality positively. This result suggests that innovation capacity accelerates the positive effect of industrial structure on economic growth quality. Besides, innovation capacity plays heterogeneous moderating effect at different quantiles. The coefficients of interaction term $c\ln indu\_c\ln \mathrm{inno}$ are 0.108, 0.121, 0.139, 0.142 and 0.137 respectively, at the 10th-90th quantile. These results indicate that as the quantiles of economic growth quality increases, the positive moderating effect of innovation capacity on the impact of industrial structure on economic growth quality increases, implying that provinces with higher economic growth quality may result in better innovation capacity to enhance the positive effect of industrial structure on economic growth quality.

Table 9. Results of moderating effect of innovation capacity.

	FE	QR_10	QR_25	QR_50	QR_75	QR_90
clnindu	0.120**	0.251***	0.161***	0.166***	0.115***	0.126**
	(0.056)	(0.041)	(0.031)	(0.024)	(0.026)	(0.056)
clninno	0.009	−0.063	−0.089***	−0.054**	0.016	−0.073
	(0.021)	(0.041)	(0.031)	(0.024)	(0.026)	(0.056)
clnindu_clninno	0.146***	0.108***	0.121***	0.139***	0.142***	0.137***
	(0.009)	(0.020)	(0.015)	(0.012)	(0.013)	(0.027)
lnhc	−0.172***	−0.023	0.090*	0.081**	0.047	0.224**
	(0.054)	(0.065)	(0.049)	(0.038)	(0.041)	(0.089)
perGDP	0.004***	0.0008	0.0005	−0.000009	0.003**	0.005*
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
_cons	2.276***	0.741	−0.023	0.187	0.591*	−0.799
	(0.443)	(0.562)	(0.428)	(0.333)	(0.355)	(0.770)
N	540	540	540	540	540	540
R-squared	0.529					
F-statistic	113.33					

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.3. The moderating effect of economic development level

Economic development level plays a moderating effect on the impact of industrial structure on economic growth quality. High economic development level promotes the evolution of industrial structure by creating more advanced technology (Li and Zhong, 2019), accelerating innovation and promoting coordinated development of industrial structural contradictions, further improves economic growth quality. That is to say, economic development level accelerates the influence of industrial structure on economic growth quality. Therefore, based on model (2), we add economic development level and industrial structure as interaction term to explore the moderating effect of economic development level. The model can be represented by the following formulas:

$$\begin{aligned} Q_{egq_{it}}\left(\tau \mid \theta_{i3}, \delta_{t3}, X_{it}\right) = \theta_{i3} + \delta_{t3} + \beta_{1\tau} c\ln indu + \beta_{2\tau} cperGDP_{it} + \beta_{3\tau} c\ln indu\_cperGDP_{it} + \\ \beta_{4\tau} c\ln hc_{it} + \beta_{5\tau} c\ln hc_{it} + \varepsilon_{it} \end{aligned}, \quad (9)$$

where i and t represent province and time respectively; egq_{it} is a dependent variable refers to economic growth quality; $\ln indu_{it}$ is an independent variable denotes industrial structure; $\ln hc_{it}$, $\ln inno_{it}$, $perGDP_{it}$ are control variables denote human capital, innovation capacity and the level of economic development respectively; $c\ln indu\_cperGDP$ stands for interaction term of industrial structure and economic development level. The specification also includes province-fixed effects θ_{ij}, and year-fixed effects δ_{tj}, ε_{it} is a stochastic disturbance term.

The estimates presented in Table 10 focus on moderating effect of economic development level on the impact of industrial structure on economic growth quality. Furthermore, we also investigate the moderating effect of economic development level under different economic growth quality levels. The results are respectively reported for the 10th, 25th, 50th, 75th, 90th quantiles of the conditional GTFP distribution in Columns 3–7.

Economic development level exerts a positive moderating effect on the impact of industrial structure on economic growth quality, but there is similar at different quantiles of economic growth quality. The positive impact of the interaction between industrial structure and economic development level can be observed in Table 10. The results confirm that economic development level stimulate the positive influence of industrial structure on economic growth quality. In other words, the moderating effect of economic development level is positive. We can interpret these results as evidence that economic development level promotes the evolution of industrial structure and further improves the economic growth quality. Moreover, the coefficient of $c\ln indu\_cperGDP$ is relatively stable and fluctuates between the ranges of 0.007 to 0.009. That is to say, there is no significant difference among different quantiles of economic growth quality. The moderating effects of economic development level are similar regardless of quantiles of economic growth quality.

Table 10. Results of moderating effect of economic development level.

	FE	QR_10	QR_25	QR_50	QR_75	QR_90
clnindu	−0.057	0.224***	0.074***	0.093***	0.074**	0.022
	(0.050)	(0.054)	(0.025)	(0.025)	(0.030)	(0.051)
cperGDP	−0.001	−0.001	−0.002	−0.0007	0.003**	0.007***
	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)
clnindu_cperGDP	0.008***	0.007***	0.009***	0.008***	0.007***	0.008***
	(0.0004)	(0.001)	(0.0005)	(0.0006)	(0.0007)	(0.001)
lnhc	−0.060	−0.080	0.014	−0.022	0.046	0.176**
	(0.048)	(0.081)	(0.037)	(0.038)	(0.044)	(0.076)
lninno	0.061***	−0.013	−0.035	−0.003	−0.026	−0.081*
	(0.019)	(0.052)	(0.024)	(0.024)	(0.028)	(0.048)
_cons	0.866***	1.375***	0.923***	1.081***	0.905***	0.464
	(0.376)	(0.353)	(0.162)	(0.165)	(0.195)	(0.331)
N	540	540	540	540	540	540
R-squared	0.628					
F-statistic	170.55					

Notes: (1) Standard errors are in parentheses. (2) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5. Conclusions and policy implications

The article's empirical challenge is to obtain the effect of industrial structure on economic growth quality in China. We use the Global Malmquist-Luenberger index based on SBM-based directional distance function to measure economic growth quality for 30 provinces from China over the period of 1998 to 2015. First, we use panel regression model to test the effect of industrial structure on economic growth quality. The data samples involve full sample, subsample of the east, subsample of the middle and subsample of the west. Then, we employ panel quantile regression model to investigate the impact of industrial structure on economic growth quality under different quantiles of economic growth quality. Finally, we attempt to explore the influencing mechanism by considering moderating effects of intervening variable.

The main conclusions are as follows. First, industrial structure shows a positive correlation with economic growth quality by full sample as well as subsample of the east in China. However, it is negatively correlative with economic growth quality by subsamples of the middle and west in China. This is not surprising since the east always plays the key role in the development of Chinese economy involving the economic aggregate and economic quality. Second, structural deceleration happens in the economic growth quality of China. However, industrial structure still accelerates the economic growth quality in the east of China due to a relatively rational industrial structure. Industrial structure shows negative effect on the economic growth quality in the middle of China and meanwhile, such negative effect are anabatic, which implies an unreasonable industrial structure. The effect of industrial structure in the west of China during the increasing process of economic growth quality is not very clear. Indeed, the industrial development contributes slightly to the economy involving the economic growth quality in the west of China. Third, both human capital and innovation capacity play positive moderating effects on the impact of industrial structure on economic growth quality and it is heterogeneous at different quantiles of economic growth quality. On the other hand, although economic development level also exerts a positive moderating effect on the impact of industrial structure on economic growth quality, it is similar at different quantiles of economic growth quality.

Our conclusion leads to the following two policy implications. On the one hand, China's economy has been transitioning from a phase of rapid growth to a stage of high-quality development. It's urgent for government to set more effective policies to optimize and upgrade of industrial structure. At the same time, they can improve the resource allocation efficiency as well as the quality of environment, thus improve the economic growth quality. On the other hand, we can also enact some polices on raising human capital, innovation capacity and economic development level to upgrade industrial structure and then improve economic growth quality. For example, increasing human capital can improve not only labor allocation efficiency, but also advanced technology. Innovation promotes the technological progress and reduces the emission of pollutants. Economic development level promotes the evolution of industrial structure. Thereby, it can further upgrade industrial structure and improve economic growth quality through these channels.

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Conflict of interest

The authors declare no conflict of interest.

References

Adom PK, Bekoe W, Amuakwa-Mensah F, et al. (2012) Carbon dioxide emissions, economic growth, industrial structure, and technical efficiency: Empirical evidence from Ghana, Senegal, and Morocco on the causal dynamics. *Energy* 47: 314–325.

Ambec S, Cohen MA, Elgie S, et al. (2013) The Porter hypothesis at 20: can environmental regulation enhance innovation and competitiveness? *Rev Environ Econ Policy* 7: 2–22.

Canay IA (2011) A simple approach to quantile regression for panel data. *Econometrics J* 14: 368–386.

Corradini M, Costantini V, Mancinelli S, et al. (2014) Unveiling the dynamic relation between R&D and emission abatement: national and sectoral innovation perspectives from the EU. *Ecol Econ* 102: 48–59.

Cheng Z, Li L, Liu J (2018) Industrial structure, technical progress and carbon intensity in China's provinces. *Renew Sust Energy Rev* 81: 2935–2946.

Cheng Y, Shao T, Lai H, et al. (2019) Total-Factor Eco-Efficiency and Its Influencing Factors in the Yangtze River Delta Urban Agglomeration, China. *Int J Environ Res Public Health* 16: 3814.

Dickey DA, Fuller WA (1981) Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica J Econometric Society,* 1057–1072.

Ding S, Knight J (2009) Why has China grown so fast? The role of structural change. Department of Economics Discussion Paper No. 415

Feldman MP, Audretsch DB (1999) Innovation in cities: Science-based diversity, specialization and localized competition. *Eur Econ Rev* 43: 409–429.

Fukuyama H, Weber WL (2009) A directional slacks-based measure of technical inefficiency. *Socio-Econ Plann Sci* 43: 274–287.

Feng C, Huang JB, Wang M (2018) Analysis of green total-factor productivity in China's regional metal industry: A meta-frontier approach. *Resour Policy* 58: 219–229.

Goldsmith RW (1951) A perpetual inventory of national wealth. *Stud Income Wealth* 14: 5–73.

Hausman JA (1978) Specification tests in econometrics. *Econometrica J Econometric Society*, 1251–1271.

He F, Zhang Q, Lei J, et al. (2013) Energy efficiency and productivity change of China's iron and steel industry: Accounting for undesirable outputs. *Energy Policy* 54: 204–213.

Hashmi R, Alam K (2019) Dynamic relationship among environmental regulation, innovation, CO_2 emissions, population, and economic growth in OECD countries: A panel investigation. *J Clean Prod* 231: 1100–1109.

Kanamura T (2017) Supply-side perspective for carbon pricing. *Quant Financ Econ* 3: 109–123.

Kwakwa PA, Alhassan H, Aboagye S (2018) Environmental Kuznets curve hypothesis in a financial development and natural resource extraction context: evidence from Tunisia. *Quant Financ Econ* 2: 981–1000.

Levin A, Lin CF, Chu CSJ (2002) Unit root tests in panel data: asymptotic and finite-sample properties. *J Econometrics* 108: 1–24.

Li B, Wu S (2017) Effects of local and civil environmental regulation on green total factor productivity in China: A spatial Durbin econometric analysis. *J Clean Prod* 153: 342–353.

Li K, Lin B (2016) Impact of energy conservation policies on the green productivity in China's manufacturing sector: Evidence from a three-stage DEA model. *Appl Energy* 168: 351–363.

Li Z, Dong H, Huang Z, et al. (2019) Impact of foreign direct investment on environmental performance. *Sustainability* 11: 3538.

Li Z, Liao G, Albitar K (2019) Does corporate environmental responsibility engagement affect firm value? The mediating role of corporate innovation. *Bus Strategy Environ* 29: 1045–1055.

Li Z, Liao G, Wang Z, et al. (2018) Green loan and subsidy for promoting clean production innovation. *J Clean Prod* 187: 421–431.

Li Z, Zhong J (2019) Impact of economic policy uncertainty shocks on China's financial conditions. *Financ Res Lett*.

Liu Z, Xin L (2019) Has China's Belt and Road Initiative promoted its green total factor productivity?—Evidence from primary provinces along the route. *Energy Policy* 129: 360–369.

Long X, Wu C, Zhang J, et al. (2018) Environmental efficiency for 192 thermal power plants in the Yangtze River Delta considering heterogeneity: a metafrontier directional slacks-based measure approach. *Renew Sust Energy Rev* 82: 3962–3971.

Miles I (2008) Patterns of innovation in service industries. *IBM Syst J* 47: 115–128.

Müller UK, Elliott G (2003) Tests for unit roots and the initial condition. *Econometrica* 71: 1269–1286.

Oh DH (2010) A global Malmquist-Luenberger productivity index. *J Prod Anal* 34: 183–197.

Song M, Du J, Tan KH (2018) Impact of fiscal decentralization on green total factor productivity. *Int J Prod Econ* 205: 359–367.

Tripathy N (2019) Does measure of financial development matter for economic growth in India? *Quant Financ Econ* 3: 508–525.

Wen F, Min F, Zhang YJ, et al. (2019) Crude oil price shocks, monetary policy, and China's economy. *Int J Financ Econ* 24: 812–827.

Zhang JS, Tan W (2016) Study on the green total factor productivity in main cities of China. *Zbornik Radova Ekonomski Fakultet u Rijeka* 34: 215.

Zhang YJ, Liu Z, Zhang H, et al. (2014) The impact of economic growth, industrial structure and urbanization on carbon emission intensity in China. *Natural Hazards* 73: 579–595.

Zhou X, Zhang J, Li J (2013) Industrial structural transformation and carbon dioxide emissions in China. *Energy Policy* 57: 43–51.