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Study on the Impact of Opening to the Outside World on the Potential of Green Development – An Empirical Test Based on Panel Data from 31 Provinces in China

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Abstract: Based on the provincial level data of China from 2010 to 2020, this paper uses panel fixed effect model, regulatory effect model and semi parametric regression to empirically test the impact of opening up on green development potential. The main conclusions are as follows: On the whole, the relationship between foreign trade and green development potential presents an inverted "U"-shaped nonlinear relationship; The upgrading level of industrial structure and urbanization process play an inverted "U" regulatory role in the impact of import and export dependence on green development potential. This study has strong theoretical and practical significance in promoting high-level opening up, implementing new development concepts and realizing green development under the new situation of international economy and trade.

Keywords: opening to the outside world; the potential of green development; industrial structure; urbanization process

JEL Classification: F12

1. Introduction

Since the reform and opening up, China's economy has developed rapidly and its foreign trade has made remarkable achievements. Based on its strength in labor and natural resource endowment, China's manufacturing industry has actively participated in the international division of labor and become the "world's factory". However, the extensive trade development mode of "big in, big out, two ends out" has led to increasingly serious problems of environmental pollution and excessive energy consumption. In 2009, China surpassed the United States to become the world's largest energy consumer. It now leads the world in air pollutants, mainly sulfur dioxide, sewage and solid waste emissions. As China's economy shifts from high-speed growth to high-quality development, optimizing the economic structure, transforming growth drivers, promoting supply-side structural reform, promoting economic development quality, efficiency and momentum reform, and improving total factor productivity have become inevitable requirements for the new normal of China's economic development (Cai et al., 2008).The new development concept points out the direction and focus of China's development in the future. The 19th National Congress of the Communist Party of China also made it clear that the country's economic development priority has shifted to the development of a green economy, rather than only considering the efficiency of economic growth of the desired output. At the same time, four ministries, including the National

Development and Reform Commission, the Ministry of Commerce, the Ministry of Foreign Affairs and the Ministry of Environmental Protection, jointly issued the Guiding Opinions on Promoting Green Belt and Road Construction. This is also the first time that specific measures on green trade have been elaborated in an important policy document, showing its importance. Green development is a growth approach that considers economic growth, the environment and energy conservation. The potential of green development is based on regional sustainable development, and there is room to improve the level of green development by optimizing the allocation of production factors (Hu & Zhou, 2014). The realization of green development depends on the effective exploitation of green development potential. Therefore, green development potential indicates the sustainability of regional economic development, and can provide strong support for the optimization and upgrading of China's industrial structure and the realization of high-quality and sustainable development.

Foreign trade can exert positive and negative impacts on green development in many aspects through resource allocation (Peng et al., 2013), factor endowment (Fu et al., 2010), financial regulation (Huang et al., 2014), human capital (Yu, 2010), foreign investment (Sheng & Lv, 2012), economic output (Li et al., 2011), etc. Therefore, it is difficult to judge the final impact of foreign trade on the potential of green development emotionally, so empirical research is indispensable. In view of the existing literature, Grossman and Krueger (1995) proposed the environmental Kuznetz curve (EKC) in a pioneering way, arguing that the relationship between environmental pollution level and per capita income is inverted U-shaped, and this hypothesis has been verified by a large number of subsequent studies by scholars. According to Sun et al. (2014), opening to the outside world has a negative effect on green growth, and there are obvious regional differences. In the framework of biased technological progress, Jing and Zhang (2014) investigated the mechanism of environmental control and opening to the outside world affecting green technological progress, and obtained by using panel data regression that the impact of import rate on green total factor productivity was positive, while export rate was negative. Lu et al. (2018) explained the relationship between trade openness, industrial geography and green development by constructing an energy-saving technological progress model. The research results show that there is an inverted U-shaped relationship between import and export dependency and green economic development, while export dependency has a positive promoting effect. Qi and Chen (2018) used the panel smooth Threshold regression (PSTR) model to analyze the impact of environmental regulations on the efficiency of China's green economy. The study shows that there is a nonlinear relationship between opening up and green economy efficiency, and the influence of foreign trade on green economy efficiency turns from positive to negative after the threshold of environmental regulation intensity is crossed. Liu and Ren (2020) analyzed the nonlinear relationship between opening to the outside world and green economy development by using inter-provincial panel data, and the study showed that there was an N-shaped nonlinear relationship between opening to the outside world and green economy development level, with obvious regional heterogeneity.

In general, scholars in the existing studies have realized that there is not a simple linear correlation between opening up and green development, but they have not reached an agreement on the specific nonlinear relationship. In addition, most of the existing researches

are limited to the increment and efficiency of green development, without focusing on "development", and even less focus on "development potential".

In view of this, on the basis of theoretical analysis, this paper constructs a comprehensive evaluation index system of green development potential, uses panel data regression to conduct an empirical study on the relationship between opening up and green development potential, and further tests the regulatory effects of industrial structure and urbanization process. Finally, the robustness of the basic model is verified by semi-parametric regression method and instrumental variable method, which has strong theoretical and practical significance for promoting high-level opening to the outside world, implementing new development concepts and realizing green development under the new international economic and trade situation.

2. Theoretical Mechanism and Research Hypothesis

Based on Talberth and Bohara's (2006) green GDP and open model, this paper constructs a green economic growth model. According to Solow model under closed economy, economic output (Y) is related to factors of production including capital (K), labor (L) and technology (A). Assuming that the per capita output meets the constant returns to scale, there are, i.e. Y = F（K, L,A）

$$Y_t = C_1 A_t^{\alpha} K_t^{\beta} L_t^{\gamma} \tag{1}$$

where C_1 is constant, A_t is green technology progress, K_t is capital input and L_t is labor input, α and β are elastic coefficients greater than 0 and less than 1.

Grossman and Krueger (1991) decomposed the impact of trade on environment into three aspects: scale effect, structure effect and technology effect. For developing countries, the impact of technology effect is the most positive, that is, green technology progress can help developing countries mitigate environmental deterioration in the process of opening up to the outside world to a certain extent (Sun et al., 2014). According to previous literature, green technology progress will be influenced by pure technology progress, degree of openness, industrial structure, urbanization process and other aspects. To simplify the analysis, the relationship between green technology progress and the rate of pure technology progress and the degree of opening to the outside world can be expressed as follows:

$$A_t = C_2 T_t^{\delta_1} O_t^{\delta_2} \tag{2}$$

where C_2 is a constant, T_t represents the rate of pure technical progress, O_t is the openness to the outside world, both $\delta_1 \; and \; \delta_2$ are variables affect the elasticity greater than 0 and less than 1 . Substituting equation (2) into equation (1), we can get:

$$Y_t = C_1 \cdot C_2^{\alpha} \cdot T_t^{\alpha\delta_1} \cdot O_t^{\alpha\delta_2} \cdot K_t^{\beta} \cdot L_t^{\gamma} \tag{3}$$

As can be seen from equation (3), the output of green economy is the result of the combined action of various input factors, which is influenced by technological progress, opening to the outside world, capital input and its elastic coefficient, etc., so there may be a nonlinear relationship.

Further, according to the existing literature, scholars generally pay attention to the moderating role of industrial organizations and urbanization level in the influence of opening up on the level of green development (Managi & Kaneko, 2006; Jing & Zhang, 2014; Zhou & Gong, 2016). According to Ricardo's theory of comparative advantage, sectors with higher relative labor productivity will take the lead in specialized production. Moreover, foreign direct investment, technological progress and the introduction of senior talents mostly affect the tertiary industry, so the upgrading of industrial structure can affect the relationship between them (Liu & Ren, 2020). In addition, with the proposal of Chinese-style modernization, urbanization, as one of the important symbols of modernization level, can promote the transformation of rural surplus population and accelerate the process of urban development and industrialization. But at the same time, it is bound to have a negative impact on resources and environment and increase the pressure of green development. Therefore, it is of practical significance to study the regulating effect of urbanization process on trade opening and green development potential (Yuan, 2018). To sum it up, this paper puts forward the following hypothesis.

- Hypothesis 1: Foreign trade has a nonlinear effect on green development potential.
- Hypothesis 2: Industrial structure and urbanization process play a moderating role in the process of opening to the outside world affecting green development potential.

3. Model Design and Variable Description

3.1. Model Construction

To verify the above research hypothesis, the following panel data model can be constructed to study the relationship between foreign trade and green development potential:

$$GFDP_{it} = \alpha_0 + \beta \sum_n Open_{it}^n + \alpha_1 CONS_{it} + \alpha_2 FINV_{it} + \alpha_3 POPD_{it} + \alpha_4 INF_{it} + \alpha_5 UNE_{it} + \mu_i + v_t + \varepsilon_{it} \quad (4)$$

In model (4), *i* represents the region and *t* represents the year. Open refers to the degree of open to the outside world, and this part it is divided into export dependency (EXR) and import dependency (IMR) respectively. n = 1, 2 is used to explore the nonlinear relationship between foreign trade and green development potential. According to the above, there may be a nonlinear relationship between opening up and green development potential, so this part intends to test the linear and nonlinear relationship between foreign trade and green development level respectively.μ_i is the individual heterogeneity that does not change with time and hard to observe individual heterogeneity. v_t is the time effect. ε_{it} is the random disturbance term.

In order to further test the nonlinear regulating relationship between industrial structure upgrading and urbanization level on opening up and green development level, this part constructs the following regulating effect model by referring to the practice of Lu Fei et al. (2018):

$$GFDP_{it} = \alpha_0 + \beta \sum_n Open_{it}^n + \gamma \sum_n INUS_{it}^n + \theta \sum_n Open_{it}^n \times INUS_{it}^n + \alpha_1 CONS_{it} + \alpha_2 FINV_{it} + \alpha_3 POPD_{it} + \alpha_4 INF_{it} + \alpha_5 UNE_{it} + \mu_i + v_t + \varepsilon_{it} \quad (5)$$

$$GFDP_{it} = \alpha_0 + \beta \sum_n Open_{it}^n + \gamma \sum_n URB_{it}^n + \theta \sum_n Open_{it}^n \times URB_{it}^n + \alpha_1 CONS_{it} + \alpha_2 FINV_{it} + \alpha_3 POPD_{it} + \alpha_4 INF_{it} + \alpha_5 UNE_{it} + \mu_i + v_t + \varepsilon_{it} \quad (6)$$

Where the value of n is 1, 2. If the coefficient of the interaction term is significant, then the moderating effect is present. If the coefficient of the interaction between the quadratic variables is significant, it indicates that there is a nonlinear adjustment effect. The implications of the other variables are consistent with the base model.

3.2. Variable Measure and Description

Explained variable: green development potential. It is difficult for a single index to interpret the content of green development potential. Existing documents have constructed green development indicators from different perspectives (Su et al., 2013; Peng & Wu, 2010; Qian & Liu, 2013; Xue, 2012). This paper draws on the practice of Liao and Huang (2018) to make a comprehensive evaluation of green development potential by constructing an index system of green development potential and using factor analysis method. Based on previous research and data availability, this paper measures the future growth potential of green economy from three dimensions: investment in science and technology education, urban infrastructure and government environmental governance. Table 1 reveals the selection of specific subdivision indicators.

Table 1. Construction of green development potential index system

Target Layer	Guideline Layer	Indicator Layer	Indicator Properties
Green development potential	Investment in science and technology education	Expenditure on science and technology as a share of GDP	positive
		Share of enterprise R&D expenditure in GDP	positive
		Full-time equivalent of R&D personnel (person years)	positive
		Proportion of population with college degree or above	positive
	Infrastructure development	Gas penetration	positive
		Per capita park green space (square meters per person)	positive
		Total urban passenger transport	positive
	Government environmental governance	Expenditure on environmental protection as a proportion of government expenditure	positive
		Proportion of investment in industrial pollution control in GDP	positive

Core explanatory variable: Openness to outsiders. Openness to the outside world is the core explanatory variable of this part. Based on the availability of data and drawing on the practice of Lili et al. (2020), export dependency (EXR) and import dependency (IMR) are used to measure openness to the outside world. Export dependency is obtained by the share of total export trade to GDP, and import dependency is depicted by the share of total import trade to GDP.

Adjust variables. The study of Liu et al. (2020) shows that the relationship between industrial structure upgrading and urbanization process has a nonlinear regulating effect on opening up and green economy development, and green development potential is an important part of green economy development. Therefore, this part believes that industrial structure upgrading and urbanization process will affect the relationship between opening up and green economy development potential. The industrial structure upgrading (INUS) will be measured by the proportion of the total output value of the secondary and tertiary industries in GDP. The level of urbanization (URB) is characterized by the urbanization rate, that is, the proportion of urban population in the total population.

Control variables. In order to control the influence of other factors on the potential of green development, this part draws on previous practices and selects CONS (social consumption scale), fixed asset investment scale (FINV), population density (POPD), inflation level (INF) and urban unemployment rate (UNE) as control variables to be incorporated into the model. Social consumption scale refers to the proportion of total retail sales of consumer goods in GDP. The scale of fixed asset investment is the proportion of fixed asset investment in GDP. Population density is the number of regional population/regional area. The inflation level is measured by the consumer price index.

Based on the availability of data, this paper takes the panel data of 31 provinces and cities in China during 2010–2020 as the research samples, and the data are mainly from China Statistical Yearbook, China Energy Yearbook, China Environmental Statistical Yearbook, China High-tech Statistical Yearbook, etc., and obtained through corresponding calculation and sorting. In order to avoid the influence of extreme values on the study, the variables in this paper were reduced tail by 1% and 99%, and the data after processing were used for subsequent analysis. The data processing software used in this paper is Stata15.1.

3.3. Measure Results and Feature Analysis

Analysis of measure results of explained variables. As shown in Table 1, this paper selected 9 sub-indexes to measure the score of green development potential, and carried out factor analysis with Stata15.1 software. Bartlett sphericity test rejected the null hypothesis that the variables were not correlated, and the value of KMO test was 0.60,indicating that the above variables were suitable for factor analysis.

Figure 1 is the radar map of the mean green development potential scores of 31 provinces and cities in China from 2010 to 2020. It is stratified according to the green development potential scores of each province and city, with the scores increasing from inside to outside.

The same level means that the green development potential is at the same level. It's not hard to spot. Guangdong, Beijing and Jiangsu ranked the top three in terms of green development potential, significantly ahead of Zhejiang, Shanghai and Shandong. The western regions of Tibet, Guangxi and Yunnan have the greatest potential for green development. The radar map shows that the green potential of different regions presents a big difference, with the top green potential mostly in the eastern region and the bottom green potential mostly in the western region.

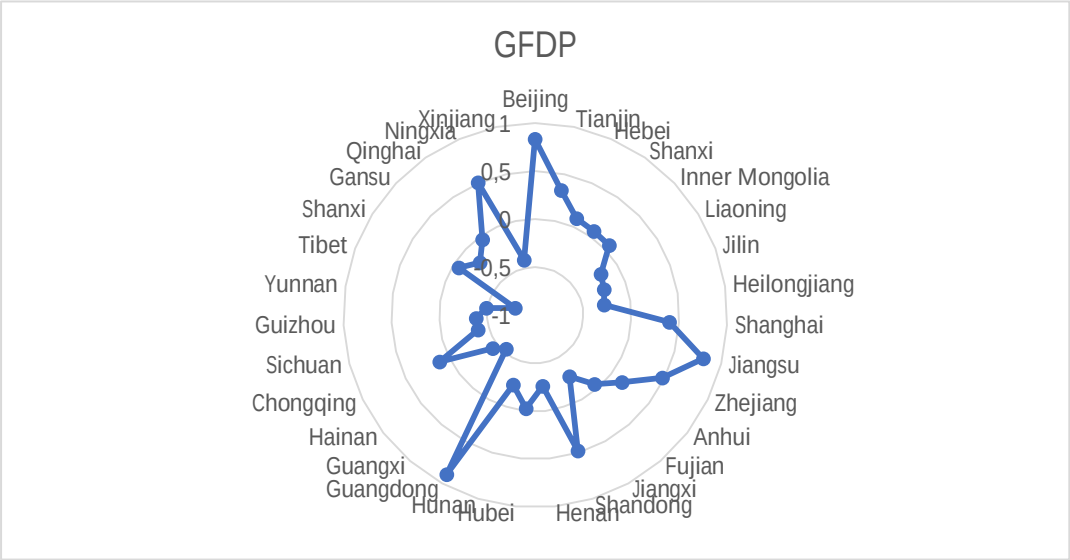

Figure 1. Radar map of green development potential scores

Descriptive statistics and analysis of variables. In this paper, the equilibrium panel observation samples of 341 provinces, autonomous regions and municipalities in China during 2010–2020 were formed. Table 2 shows the descriptive statistical results of the core variables in the paper.

Table 2. Descriptive analysis results

Variables	Obs	Mean	Std.Dev.	Min	Max	Skew.	Kurt.
GFDP	341	-0.003	0.499	-1.033	1.357	0.495	3.019
EXR	341	0.021	0.023	0.002	0.102	1.904	6.199
IMR	341	0.02	0.03	0.001	0.175	3.037	13.028
INUS	341	0.9	0.051	0.751	0.996	-0.265	3.344
URB	341	0.555	0.136	0.237	0.893	0.576	3.552
UNE	341	3.31	0.652	1.31	4.4	-0.873	3.839
CONS	341	0.134	0.053	0.06	0.376	2.069	9.249
POPD	341	0.28	0.117	0.09	0.552	0.637	2.564
FINV	341	10.382	0.479	9.201	11.245	-0.34	2.338
INF	341	1.024	0.015	0.984	1.059	0.203	4.05

Feature fact analysis. Before modeling, this paper first observed and analyzed the linear and nonlinear relationships between opening to the outside world and green development potential through the scatter plot. The left figure in Figure 2 is a linear fitting curve. We find that most points are located near the straight line, indicating that there may be a linear relationship between export dependence and green development potential. The right figure in Figure 2 is a quadratic

fitting curve. It is not difficult to see that the right figure in Figure 2 does not present a complete inverted "U"-shaped curve, and the points are mainly distributed in the left half branch. Combined with the left figure in Figure 2, it can be seen that export dependency and green development potential present a co-direction change relationship, that is, export trade promotes regional green development potential. The left figure in Figure 3 shows the linear fitting diagram of import dependency and green development potential, but when import dependency is greater than 10%, the points are not distributed near the line. Compared with the quadratic fitting curve in the figure on the right, there is an inverted "U"-shaped relationship between import dependency and green development potential, and most of the points are around the estimation of the curve, indicating that the inverted "U" curve can better fit the relationship between import dependency and green development potential than the linear one.

Figure 2. Scatter plots of the linear and quadratic terms of green development potential and export dependency

Figure 3. Scatter plots of the linear and quadratic terms of green development potential and import dependency

4. Model Design and Variable Description

4.1. Benchmark Regression Analysis

Although the relationship between opening to the outside world and green development potential can be roughly inferred in the above scatter plot, the scatter plot does not consider

the influence of control variables, and the graph is often subjective, and cannot truly reflect the causal relationship between opening to the outside world and green development potential. Therefore, OLS estimation of model (4) should be further carried out to control the influence of regional and annual effects. Cluster robustness criteria were used to modify the model for the influence of heteroscedasticity.

Table 3. Benchmark regression results

	(1)	(2)	(3)	(4)
	GFDP	GFDP	GFDP	GFDP
EXR	6.6705***	3.3287		
	(4.6842)	(0.7761)		
EXR2		35.2127		
		(0.8351)		
IMR			4.7175***	12.3399***
			(3.3956)	(4.5986)
IMR2				-52.3700***
				(-3.6496)
UNE	0.0140	0.0143	0.0452	0.0292
	(0.3759)	(0.3827)	(1.1471)	(0.7163)
CONS	1.7402***	1.8068***	0.5061	0.7576
	(3.9509)	(3.9296)	(0.7631)	(1.2142)
POPD	-0.4199**	-0.4205**	-0.3391*	-0.4322**
	(-2.2648)	(-2.2950)	(-1.8773)	(-2.3591)
FINV	0.2268***	0.2431***	0.2315***	0.2394***
	(4.0378)	(4.0116)	(3.7176)	(3.9371)
INF	8.9239**	9.0147**	6.9722	7.2451
	(2.0249)	(2.0675)	(1.5694)	(1.6417)
_cons	-11.7944***	-12.0297***	-9.7599**	-10.1617**
	(-2.6513)	(-2.7302)	(-2.1666)	(-2.2746)
Obs.	341	341	341	341
R-squared	0.5254	0.5269	0.4977	0.5133

T-values are in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

Table 3 shows the benchmark regression results. Equations (1) and (2) estimate the relationship between export dependence and green development potential. Equation (3) and (4) estimate the relationship between import dependence and green development potential. The coefficient of EXR in equation (1) is 6.6705, and passes the 1% significance level test, indicating that export dependence has a significant promoting effect on green development potential. In equation (2), the quadratic coefficient of EXR, EXR2, is positive but not significant, indicating that the nonlinear relationship between export dependency and green development potential is not significant. In equation (3), the IMR coefficient is significantly positive, indicating that the import dependency has a linear relationship with the green development potential. In equation (4), the coefficient of IMR2 is significantly negative, and the coefficient of IMR is significantly positive, indicating that the import dependence on green development potential presents a significant nonlinear relationship, and an inverted "U" shape. From the goodness of fit point of view, the inverted "U" shape has stronger explanatory power for green development potential. From the perspective of control variables, the influence of unemployment rate on green development potential is not

significant, and the scale of social consumption only shows a significant positive impact on the export dependence equation. Population density has a significant negative impact on the green development potential, and fixed asset investment scale has a significant positive impact on the green development potential.

Although the quadratic coefficient in equation (4) is significant, it does not mean that there must be an inverted "U" type relationship, so further extreme point analysis and inverted "U" type relationship test are needed. In this paper, the "utest" command in Stata15.1 software was used for the test. By taking the partial derivative of equation (4) GFDP with respect to IMR, the extreme point is 0.1178, which falls within the 95% confidence interval. Slope has a negative boundary and passes the 5% significance level test, indicating that there is an inverted "U" -shaped relationship between import dependency and green development potential, which can also be verified by the inverted "U"-shaped existence test. The p value is less than 0.05, rejecting the null hypothesis of linearity or "U" type. The inflection point analysis can be further conducted by combining Table 3 and Table 4. The results show that the influence of import dependency on green development potential has an inflection point (0.1178). When the import dependency is less than 0.1178, the import dependency has a significant promoting effect on green development potential. Obviously, the continuous increase in foreign exchange earnings from exports enables the home country to have the financial resources to carry out environmental governance and ecological protection, and enhance residents' "green" happiness. At the same time, a wider participation in international competition will also help improve the efficiency of resource utilization in the whole society. To a certain extent, the increase of trade dependence will promote economic development and improve backward domestic production. However, if it reaches a certain level and fails to realize the "flying geese transformation", the spatial advantage of products will be further solidified, which is not conducive to the realization of green development.

Table 4. Inverted "U"-shaped existence test results

	Lower bound	Upper bound
Interval	0.0008	0.1745
Slope	12.2548	-5.9375
t-value	4.6017	-1.9932
P>t	0.0000	0.0235
Extreme point	95% confidence interval	
0.1178	[0.0924; 0.1731]	
Inverted "U"-shaped existence test	t-value	1.99
	P-value	0.0235

4.2. Robustness Test

Instrumental variable regression. Although the base model controls the influence of regional and annual effects, and selects population density, fixed asset investment, and scale of social consumption as control variables, there may still be endogeneity problems caused by missing variables in the model, resulting in bias in OLS estimation. In order to consider the effects of endogeneity, this paper borrows from previous practices and takes the lag period of export dependency and import dependency as instrumental variables, respectively, and uses the

two-step optimal generalized moment method (GMM2S) to estimate. The lag period of the opening-up level is correlated with the variables of the current period, and the opening-up period of the previous year is not correlated with the perturbation term of the current year, which meets the requirements of the instrumental variables.

Table 5 reveals the GMM2S estimation results of the instrumental variable method. In the first stage, the F statistics were all relatively large, and the unidentifiable test rejected the null hypothesis, indicating that endogenous variables and instrumental variables had a strong correlation, and there was no weak instrumental variable problem. According to the estimation results, the coefficient of EXR is positive at the significance level of 1%, the coefficient of IMR is significantly positive, and the coefficient of IMR2 is significantly negative. The extreme point of 0.1129 can be obtained by obtaining the partial derivative, which is close to the 0.1178 of the benchmark model, indicating that the relationship between opening up and green development potential is consistent with that of the benchmark model after considering the endogenous influence. This indicates that the model is robust to a certain extent.

Table 5. IV-GMM2S estimation results

	(1)	(2)
	GFDP	GFDP
EXR	7.8325***	
	(5.3395)	
IMR		16.0748***
		(5.5950)
IMR2		-71.1893***
		(-4.8086)
UNE	0.0081	0.0211
	(0.2163)	(0.5167)
CONS	1.6848***	0.5345
	(3.7451)	(0.8472)
POPD	-0.4495**	-0.4959**
	(-2.3264)	(-2.5503)
FINV	4.4364	2.3417
	(0.8233)	(0.4285)
INF	0.2609***	0.2830***
	(4.6282)	(4.5405)
_cons	-7.5063	-5.5609
	(-1.3608)	(-0.9920)
Stage one F value	4,328.868	865.594
Unidentifiable test	63.968***	63.232***
area	control	control
year	control	control
Obs.	310	310
R-squared	0.5424	0.5277

T-values are in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

Semi-parametric regression results. Next, the estimation method of the benchmark model was changed, and the robustness test was carried out by referring to the practice of Liu and Sun (2020), which could estimate the dynamic local linear panel data model, and the semi-

parametric model was established with the opening to the outside world as the key explanatory variable. Table 6 discloses the semi-parametric regression results.

Table 6. Semi-parametric regression results

	(1)	(2)
	Export dependence	Import dependency
	GFDP	GFDP
UNE	0.0156	0.0320
	(0.4225)	(0.8167)
CONS	1.8421***	0.9490
	(4.1993)	(1.6118)
POPD	-0.4149**	-0.4299**
	(-2.2817)	(-2.4207)
INF	7.6407***	7.0356**
	(2.7917)	(2.5562)
FINV	0.2326***	0.2352***
	(3.8345)	(3.9472)
G(Open)	--	--
Obs.	341	341
area	control	control
year	control	control
R-squared	0.3988	0.3491

T-values are in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

The kernel regression curves of export dependency and import dependency and green development potential as shown in figure 4 can be obtained by semi-parametric regression. According to the left side of Figure 4, at the significance level of 5%, the regression of export dependency and green development potential kernel density presents a linear upward trend, which verifies the positive promoting relationship between export dependency and green development potential. The right side of Figure 4 shows the kernel regression diagram of import dependency and green development potential. At the significance level of 5%, import dependency and green development potential show a significant inverted U-shaped relationship. After changing the estimation method, the nonlinear relationship between them still exists. Based on the above analysis, it can be seen that the model presented in this paper is robust.

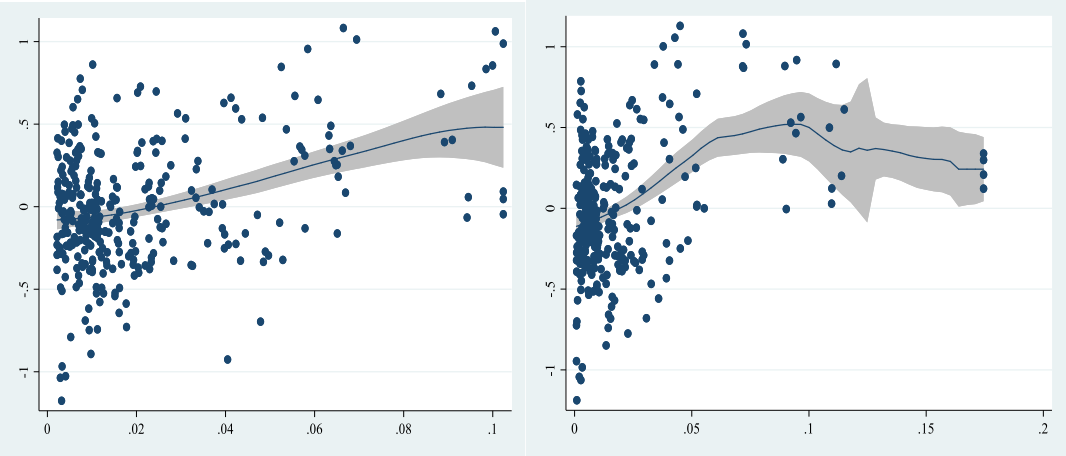

Figure 4. Kernel regression diagram of export and import dependence and green development potential

4.3. Test of Moderating Effect

On the basis of the benchmark model, models (1-2) and (1-3) were further estimated, so as to verify the moderating effect of industrial structure upgrading and urbanization level on the relationship between opening up and green development potential.

Table 7. Test results of the moderating effect

	(1)	(2)	(3)	(4)
	Explained variable: GFDP			
	Export dependency		Import dependency	
	Industrial structure	Urbanization	Industrial structure	Urbanization
Open	-1,804.4862***	-61.2420***	-23.0382	-61.8338***
	(-4.6193)	(-3.9253)	(-0.5052)	(-3.6381)
Open2			970.6891**	559.4452***
			(2.1163)	(5.2068)
INUS	-70.4451***		-3.1871	
	(-4.7300)		(-0.2331)	
INUS2	41.8509***		4.9681	
	(4.9665)		(0.6437)	
URB		-1.1376		5.7763***
		(-0.6072)		(3.2697)
URB2		2.4809		-3.9880**
		(1.6436)		(-2.1681)
Open × INUS	3,882.1329***		24.8318	
	(4.7442)		(0.5400)	
Open × INUS2	-2,083.1701***		-998.2529**	
	(-4.8597)		(-2.1538)	
Open × URB		215.8963***		80.5900***
		(4.6578)		(3.4123)
Open × URB2		-168.8808***		-813.4844***
		(-5.0590)		(-5.3828)
UNE	-0.0058	-0.0053	-0.0141	-0.0314
	(-0.1899)	(-0.1625)	(-0.3637)	(-0.8030)
CONS	-0.1536	0.3566	0.0341	0.9182*
	(-0.3743)	(0.7677)	(0.0674)	(1.8029)
POPD	-0.2726	-0.4890***	-0.3369**	-0.3922**
	(-1.6295)	(-2.8598)	(-2.0155)	(-2.4765)
INF	10.3779***	10.6030***	9.4680***	10.3144***
	(2.9678)	(2.9337)	(2.6683)	(2.7403)
FINV	-0.0147	0.0447	-0.0155	0.0252
	(-0.2565)	(0.6156)	(-0.2445)	(0.3048)
_cons	19.0615**	-11.4694***	-10.5942	-12.5467***
	(2.5114)	(-3.0713)	(-1.4422)	(-3.2488)
area	control	control	control	control
year	control	control	control	control
Obs.	341	341	341	341
R-squared	0.6704	0.6295	0.6537	0.6058

T-values are in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

In equation (1) in Table 7, the interaction coefficient of industrial structure and export dependency is significantly positive, while the quadratic product coefficient is significantly

negative, indicating that industrial structure has a significant inverted U-shaped adjustment effect on the relationship between export dependency and green development potential, that is, when the industrial structure advanced level is lower than a certain level, The upgrading of industrial structure will strengthen the promoting effect of export dependency on green development potential, and when the upgrading level of industrial structure is greater than the critical level, the upgrading of industrial structure will weaken the promoting effect of export dependency on industrial structure upgrading. In equation (2), the interaction term between urbanization level and export dependency is significantly positive, while the coefficient of the secondary interaction term is significantly negative, indicating that the influence of export dependency on green development potential has an inverted "U"-shaped adjustment effect of urbanization process. When the level of urbanization is low, the urbanization process strengthens the promoting effect of export dependency on green development potential, while the high level of urbanization will not be conducive to the positive effect of export dependency on green development potential. In equation (3), the interaction term between industrial structure upgrading and import dependency is positive but not significant, while the coefficient of the quadratic interaction term is significantly negative, indicating that the relationship between industrial structure upgrading and import dependency and green development potential has a nonlinear regulating effect, and industrial structure upgrading weakens each other at the beginning and end of the term. Finally, the influence degree of import dependence on green development potential is weakened. In equation (4), the influence of urbanization level on import dependency and green development potential also has an inverted "U" shape. The results show that too low or too high urbanization level is not conducive to the promoting effect of import dependency on green development potential. Therefore, local governments should promote urbanization step by step, and the urbanization rate should be maintained at a reasonable level. Only in this way can it have a resonance effect with local trade and green development.

5. Conclusions

This paper empirically analyzes the relationship between opening-up and China's green development potential by using panel data from 31 provincial levels in China from 2010 to 2020 as samples. The results show that there is an inverted U-shaped nonlinear relationship between foreign trade and green development potential. The influence of import dependency on green development potential has an inflection point (0.1178). When import dependency is less than 0.1178, import dependency has a significant promoting effect on green development potential. After crossing the critical value, import dependency has a significant negative effect on green development potential. When the adjustment effect is considered, the relationship between the import and export dependency of the industrial structure and the green development potential has a significant inverted U-shaped adjustment effect, that is, when the industrial structure advanced level is lower than a certain level, the industrial structure advanced level will strengthen the promoting effect of the export dependency on the green development potential, when the industrial structure advanced level is greater than the critical level, the upgrading of industrial structure will weaken the promoting effect of

export dependence on the upgrading of industrial structure. The influence of import and export dependence on green development potential also has an inverted U-shaped moderating effect of urbanization process. When the level of urbanization is low, the urbanization process strengthens the promoting effect of export dependency on green development potential, while a high urbanization level will not be conducive to the positive effect of export dependency on green development potential. In view of the above conclusions, this paper puts forward the following policy suggestions: First of all, the development of foreign trade should be under the leading role of the government, grasp the evolution difference between it and the green development potential, and control the openness to the outside world within a reasonable level, in order to promote green development. Secondly, the empirical results show that the upgrading of industrial structure will strengthen the promoting effect of opening up on green development potential, but when it exceeds the critical level, it will play a reverse effect. Therefore, overall planning and allocation should be made to control the industrial structure at a reasonable level. Finally, we should grasp the urbanization process well and give full play to its regulating role in the process of opening up affecting the potential of green development.

Conflict of interest: none

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