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Did investment become green in China? Evidence from a sectoral panel analysis from 2003 to 2012

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ABSTRACT

Under conditions of policy incentives and energy transition, an investment is considered to become green if greater investment would support a reduction in the proportion of total energy consumption involving coal use. However, few empirical studies have attempted to investigate green investment in China at the sector level. Using panel data for 5 sectors in China between 2003 and 2012, we tested the relationships between investment and different factors, including carbon dioxide (CO_2) emission reduction policies and energy structure, by building panel models for the national sample. The results demonstrated that investment did not become green and mainly relied on gross domestic product (GDP) during the 2003–2012 period in China. Although investments in the industry sector and the commerce and services sector were weakened by the CO_2 emission regulations, Chinese climate policies had no effect on investment in the agriculture sector or the construction sector and had a positive effect on investment in the transportation sector. Moreover, the proportion of total energy consumption involving coal use had no effect on investment in the construction sector or the commerce and services sector but had a negative effect on investments in the agriculture sector and the transportation sector. Investment in the industry sector showed strong viscosity to low-price coal consumption. Finally, we propose a series of policy implications based on the test results, which may guide green investment.

1. Introduction

China became the world's second largest economy in 2010. Due to its coal-dominant energy consumption structure, the rapidly growing economy has driven China to become the world's current largest carbon dioxide (CO_2) emitter, releasing 9153.90 million tons of CO_2, representing 27.3% of the total global CO_2 emissions in 2015 (BP, 2016). Given the global environmental crisis and international pressure on China, the Chinese government promised to reach peak CO_2 emissions before 2030 and to achieve a carbon intensity (carbon emissions per unit of GDP) reduction of 60–65% below the 2005 level by 2030 in the Intended Nationally Determined Contributions in 2015 (Zhao et al., 2015; Ge et al., 2016a,b). Sectoral development, especially the increase in the value added, is the foundation of economic growth. More than 90% of the total national CO_2 emissions came from the sectoral production activities with manufacturing at 47%, thermal power generation at 32% and the transportation sector at 6% of China's total (Liu, 2015). Therefore, most energy-saving and emission-reducing measures have been implemented in the industrial sectors, including the "Top 1000 Enterprises Energy Saving Program" and the "10 Key Energy Saving Projects Program" (Xu et al., 2014; Wang et al., 2016).

As a crucial factor influencing production, capital investment can enhance the productivity of industrial sectors and promote economic development (Dzhumashev et al., 2016). Due to currently stable energy efficiency and energy structure in sectoral production, more capital investment should lead to more serious CO_2 emissions. Therefore, a low-carbon transition in China requires large capital investments, especially fixed assets investment, in clean sectors or a decline in carbon-intensive sectors. A large number of policies should be formulated and implemented to guide capital investment to be greener through tax adjustments and fiscal expenditure (Eyraud et al., 2013).

Although the target of CO_2 emission reduction was first proposed in 2009 and suggested that China would cut its CO_2 emissions per unit of gross domestic product (GDP) by 40%–45% of 2005

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levels by 2020, the Chinese government started substantive efforts in 2007 to reduce CO_2 emissions. In that year, the 20-ministry National Leading Group to Address Climate Change (NLGACC) was established, and the National Climate Change Program was promulgated (Gilley, 2012). At that time, many policies involving renewable energy development and CO_2 emission reduction were introduced with great intensity, such as the 11th Five-year Plan for Renewable Energy in 2008 and National Adaptation to Climate Change Strategy in 2013. These policies primarily emphasize the importance of a low-carbon industrial structure through the exertion of taxes on carbon-intensive sectors (e.g., an export tax on coal and some non-ferrous metal products) and conducting an energy-saving assessment on fixed asset investment projects. The Chinese government hopes the above policies can fulfill political commitments to CO_2 emission reduction in 2020 and 2030. From 2005 to 2015, CO_2 emissions intensity decreased from 1.70 kg per GDP to 1.03 kg per GDP, as shown in Fig. 1.

In our study, green investment is defined as the capital invested to reduce fossil energy consumption and CO_2 emissions in the production and consumption of products or services. The purpose of this paper is to examine whether fossil energy conservation and CO_2 emission reduction have become key drivers of both investment in China and profits under gradually increasing government regulations. This will allow a better understanding of what policies have been successful and how current policies should be adjusted to promote green investment.

To the best of our knowledge, most current studies consider investment to be the driver of CO_2 emissions (Iyer et al., 2015; Tang and Tan, 2015; Zhang and Zhou, 2016), while only a few studies focus on green investment. Eyraud et al. (2013) provides the trends and determinants of investments in renewables and confirms the powerful influence of public policies (e.g., high taxation on fossil fuels) on the investment. Cucchiella et al. (2015) also analyze financial investment in the renewable energy sector. Unlike the regulation perspective in Eyraud et al. (2013), Lee and Min (2015) use a sample of Japanese manufacturing firms to estimate the impact of investments in green research and development on carbon emissions and obtain a negative relationship between them. Sudmant et al. (2015) scrutinize four city-level studies of the scope of investment in low-carbon technology and find that significant opportunities are not being exploited in the cities of the developing world. Specifically, the question of whether the investment considers energy-saving and carbon reduction in China has not been studied.

The paper is organized as follows: section 2 presents a brief review of the literature and the hypotheses proposed; section 3 documents the nature of the data, their measurement and the empirical methodology; section 4 reports the empirical results and their discussion; and finally, section 5 concludes the paper and presents policy implications.

2. Brief literature review and hypotheses

The relevant hypotheses to be tested in the empirical analysis section are the following:

2.1. Relationship between coal consumption and investment

Hypothesis 1. The lower the proportion of total coal consumption, the greater the investment in low coal-consuming sectors.

Coal combustion is the most important factor associated with CO_2 emissions in China (Ge et al., 2016a,b). Therefore, green investment would go to the sectors that have a low proportion of total energy consumption involving coal use. By contrast, because of the path dependency of energy production and consumption, investments in coal-intensive industries would continue to maintain low costs and high returns (Kuper and van Soest, 2003; Lauridsen and Jensen, 2013). Particularly under local government protectionism, which represents local economic interests, China may face a situation of coal overcapacity (Zhang et al., 2017). This would act as a barrier to green investment. However, energy-saving policies would break this path dependency through administrative orders on the usage amount and price effect. Policies on coal consumption control would limit output or increase the cost of energy consumption, which would prompt investment to flow to low coal-consuming sectors (Voica et al., 2015). For instance, recently, efforts to change the energy infrastructure in China constituted a main driver for technology investment in coal-intensive industries because of higher production costs in those industries (You and Xu, 2010). Moreover, uncertainty is inherent in investment because the latter is affected by the comparison between the intensity of policy regulation and the coal price (Neuhoff et al., 2006; Pahle et al., 2011). Mestl et al. (2005) found that in Taiyuan City, China, investment in cleaner production differed between sectors because of

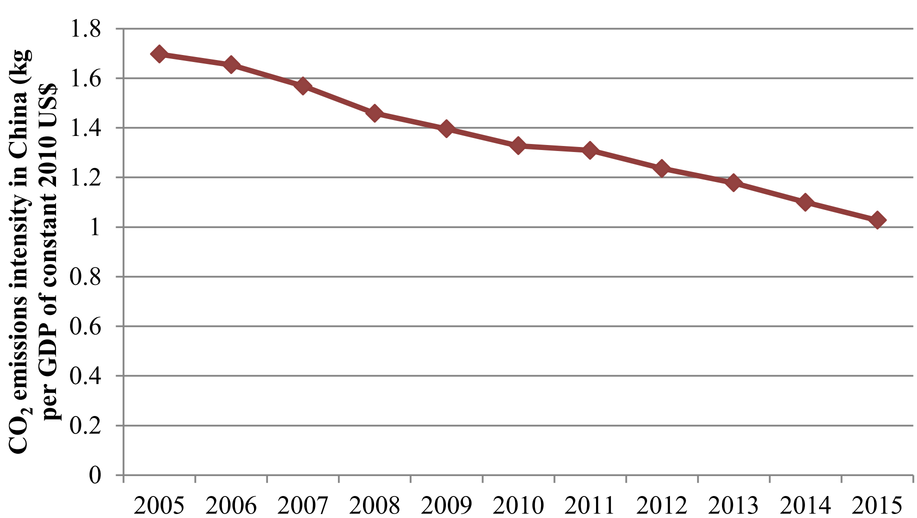

Fig. 1. CO_2 emissions intensity in China, 2005–2015 (kg per GDP with a constant of 2010 US$).
Data source: World Bank (2016), BP (2016).

different production costs and financial barriers. Zhou et al. (2014), Chen et al. (2016), and Wang and Du (2016) all reported uncertainties in investments between sectors. In this study, the proportion of total energy consumption involving coal use is taken as one determinant of sectoral investment.

2.2. Relationship between CO_2 emission regulation and investment

Hypothesis 2. Policies for CO_2 emission reduction guide investments to inflow to low carbon- and coal-consuming sectors.

CO_2 emission reduction policies guide investment to be greener by increasing production costs or decreasing profits in carbon-intensive sectors. According to the pollution haven hypothesis, fossil energy and CO_2 emissions are considered to be important determinants of foreign direct investment (FDI) (Pao and Tsai, 2011). This is because weak environmental regulations in some developing countries attract numerous high-polluting industries that move from developed countries with strict environmental regulations (Hoffmann et al., 2005; Mukhopadhyay, 2006; Dean et al., 2009). Under carbon emission regulation policies, producers would seek to develop cost-efficient methods to decrease emissions, mainly by switching their investments to carbon emission abatement efforts (Bouchery et al., 2011). Sekar et al. (2007) and Eyraud et al. (2013) indicated that a carbon pricing scheme (e.g., feed-in tariffs and carbon emission trading) could force out investment in carbon-intensive sectors and emancipate the green investment. Zhou et al. (2014) found that a carbon tax could provide the strongest signal for investment in low-carbon technology, while a market-based measure could provide firms with flexibility. Hoffmann found that an emissions trading scheme in the EU constituted a main driver for small-scale investments with brief amortization times but exerted a limited impact on large-scale investments in power plants (Hoffmann, 2007). Carbon emission regulation policies could also encourage firms to reduce their carbon emissions levels by directly investing in greener transportation fleets (Bae et al., 2011), energy-efficient warehousing (Ilic et al., 2009), and environmentally friendly manufacturing processes (Liu et al., 2012). Considering the factor of uncertainty, Toptal et al. (2014) specified the effects of the regulation parameters based on investment availability. China has proposed and implemented a series of carbon emission reduction policies since 2007, such as the National Climate Change Program (2013–2020) and local policies, to cope with climate change. Most importantly, seven provinces and cities were identified as the first group of carbon emission trading pilot areas by the National Development and Reform Commission of China in 2011 (Ge et al., 2016a,b). These above policies are expected to guide investment toward sectors with low carbon consumption.

2.3. Economic determinants of investment

GDP and interest rates are the traditional determinants of investment, a fact that has been confirmed by most studies, such as Chikán and Kovács (2009), Hobdari et al. (2009), Eyraud et al. (2013), and Akoto (2016).

Many studies have also reported a positive causal link between rapid economic growth and high rates of investment. More rapid growth of added value in a production sector generates larger profit margins and attracts more investment. Blomström et al. (1996) found that economic growth could increase investment. Similar results were reported in Carroll and Weil (1994) and Podrecca and Carmeci (2001). More specifically, Madsen (2002) found that investment in non-residential buildings and structures is predominantly motivated by economic growth. Mehrara and Musai (2013) investigated the causal relationship between GDP and investment for countries in the Middle East and North Africa (MENA) and likewise suggested that greater economic growth spurred increases in investment.

Interest rates affect the costs of investments. Therefore, an increase in interest rates increases the cost of borrowing and decreases investment levels. Kohu (1987) found that investment is sensitive to changes in interest rates. Greene and Villanueva (1990), Larsen (2004), Karim and Azman-Saini (2013), and Tolis et al. (2010) all confirmed that interest rates are important determinants of investment.

Therefore, we propose the following two hypotheses:

Hypothesis 3. A higher GDP attracts more investment in each sector.

Hypothesis 4. A lower interest rate promotes investment in every sector.

3. Data and empirical methodology

3.1. Data specifications and descriptive statistics

The selection of the sample period is based on the availability of annual data, spanning the period 2003 to 2012. Because this study focuses on sectoral investment, the panel data set included 5 sectors: the agriculture sector, the industry sector, the construction sector, the transportation sector, and the commerce and services sector. The considered time series data on investment, GDP, interest rate, and energy structure are obtained from the statistical data online database published by the China Statistics Bureau and the World Development Indicators (WDI), an online database published by the World Bank. The measurement of the above variables is as follows. Investment (INV) is defined as the total investment in fixed assets for each sector that is then deflated by the price index for investment in fixed assets. GDP is measured in the constant price of the Chinese Yuan (CNY) in 2003 using a GDP deflator for each sector. The interest rate (LIR) is the real interest rate for China as obtained from the WDI. The energy structure (ECS) is defined as the proportion of total energy consumption involving coal use. Moreover, to estimate the effect of the CO_2 emission reduction policy on investment flows, we define a policy dummy variable with an intervention effect from 2008.

Table 1 shows the summary statistics associated with the investment, GDP, interest rate, and energy structure variables. The highest mean of investment (55,787.85) is in the industry sector; GDP (95,895.93) is also in the industry sector, and energy structure (23.92) is in the commerce and services sector. The lowest mean of investment (1251.22) is in the construction sector; GDP (12,667.86) is in the transportation sector, and energy structure (2.69) is also in the transportation sector. Moreover, the industry sector has the highest variation (defined by the standard deviation) in investment (33,417.87), GDP (30,764.27), and energy structure (2.89), while the construction sector has the lowest variation in investment (811.35), and the agriculture sector has the lowest variation in GDP (2987.28) and energy structure (1.07).

Because the above variables are measured in different units, it is necessary to normalize the data series and transform all the variables into a uniform measurement. Data series are transformed into natural logarithms, which can help to avoid the problems associated with their distributional properties (Paramati et al., 2016).

Table 2 presents the correlations between the panel data variables that have been transformed into natural logarithms. The correlation analysis indicates a positive correlation between sectoral GDP and sectoral investment. The real interest rate is

Table 1
Descriptive statistics for all variables used in this survey.

Variables	Agriculture			Industry			Construction			Transportation			Commerce and services		
	Mean	Std.dev.	CV	Mean	Std.dev.	CV	Mean	Std.dev.	CV	Mean	Std.dev.	CV	Mean	Std.dev.	CV
INV	2368.52	2054.83	0.87	55787.85	33417.87	0.60	1251.22	811.35	0.65	14081.60	6703.62	0.48	4643.32	3276.57	0.71
GDP	21836.24	2987.28	0.14	95895.93	30764.27	0.32	14252.31	5437.47	0.38	12667.86	3171.99	0.25	26581.60	9883.60	0.37
LIR	5.91	0.68	0.12	5.91	0.68	0.12	5.91	0.68	0.12	5.91	0.68	0.12	5.91	0.68	0.12
ECS	18.89	1.07	0.06	23.68	2.89	0.12	11.85	2.08	0.18	2.69	1.20	0.45	23.92	2.25	0.09

Notes: Std. dev.: standard deviation; CV: coefficient of variation (standard deviation-to-mean ratio).

Table 2
Correlations for the panel data set.

	INV	GDP	LIR	POL	ECS
INV	1.00	–	–	–	–
GDP	0.72	1.00	–	–	–
LIR	0.11	0.11	1.00	–	–
POL	0.37	0.32	−0.15	1.00	–
ECS	−0.15	0.51	−0.07	−0.13	1.00

Notes: INV: investment; GDP: gross domestic product; LIR: real interest rate; POL: CO_2 emission reduction policies; ECS: proportion of total energy consumption involving coal use.

positively correlated with sectoral investment. CO_2 emission regulation and sectoral investment are positively correlated. However, a negative correlation exists between sectoral energy structure and sectoral investment.

3.2. Empirical methodology

Given that the goal is to investigate the effects of energy structure and CO_2 emission regulation on investment in different sectors, the empirical analysis makes use of the panel model. We propose the basic model specification as follows:

$$INV_{it} = \beta_0 + \beta_{1i}GDP_{it} + \beta_{2i}LIR_{it} + \beta_{3i}POL_{it} + \beta_{4i}ECS_{it} + \mu_{it} \quad (1)$$

where the subscripts i and t denote the sector and time, respectively, β_0 denotes the constant term, β represents the coefficients for each explanatory variable, and μ denotes the random disturbance term in the model. Moreover, all the variables are expressed in logarithmic form to overcome heteroscedasticity to some extent.

3.2.1. Unit root test

Before implementing the models, assessing the stability of panel data using the unit root test is important to avoid spurious regressions (He et al., 2016). Different test methods can be applied to the panel data; however, the two methods that are widely used are unit root testing for the same root and unit root testing for different roots. If the data are balanced, the Levin-Lin-Chu (LLC) unit root test (Levin et al., 2002) can be used when the same root is tested, whereas the Fisher-Phillips-Perron (Fisher-PP) unit root test (Maddala and Wu, 1999) can be used when different roots are considered. We use the two tests together to improve the reliability of the results. Here, the unit root test lag length is determined by the Schwarz Information Criterion (SIC). The test results are shown in Table 3.

The LLC test indicated that all the variables were statistically significant at the 1% level. The Fisher-PP test demonstrated that the INV and LIR variables were statistically significant at the 5% level, while the GDP and ECS variables were statistically significant at the 1% level. Therefore, we selected these variables to perform the panel estimation.

Table 3
Results of unit root tests for panel data.

Variable	LLC test		Fisher-PP test	
	Statistic	Prob.	Statistic	Prob.
INV	-4.5934^{***}	0.0000	19.3632^{**}	0.0359
GDP	-3.1326^{***}	0.0009	24.6594^{***}	0.0060
LIR	-5.0891^{***}	0.0000	20.2161^{**}	0.0273
ECS	-5.9853^{***}	0.0000	45.7457^{***}	0.0000

Notes: ***, **, and * indicate significant at 1%, 5% and 10% levels, respectively.

3.2.2. Hausman test

Based on the procedures for panel estimation, the fixed effect model should be made and estimated. According to the results in Table 4, because the probability value of the F-test statistic (Prob > F = 0.00) in the fixed effects test, the individual effect was comparatively significant and the mixed regression could not be adopted, necessitating the use of the panel model. Moreover, according to the results of the random effects test, the probability value of the chi square test statistic was also 0.00, which indicates that the null hypothesis could be rejected at the 1% level of significance. Therefore, the random effects model should be abandoned and the fixed effects model should be selected.

3.2.3. Model form

After determining the F-test and Hausman test results, the model form should be selected from the pooled regression model, the varying intercept model and the varying coefficient model to analyze the specific relationships between INV, GDP, LIR, POL and ECS. There are two classic null hypotheses that address regression form selection. The first approach is to build a pooled regression model that has the same intercept and slope coefficient, while the second approach is to estimate a varying intercept model that has different intercept but same slope coefficient. Based on the F1 value calculated using equation (2) and the F2 value calculated using equation (3) as presented in Table 5, the varying coefficient model is selected for this investigation.

$$F1 = \frac{(S2 - S2)/(N-1)K}{S1/[NT - N(K+1)]} \qquad F1 \sim [(N-1)K, N(T-K-1)] \quad (2)$$

Table 4
Results of fixed effects and random effects tests.

Effects tests	Statistic	Prob.
Test cross-sectional fixed effects	54.98^{***}	0.00
Test cross-sectional random effects	60.13^{***}	0.00

Notes: ***, **, and * indicate significant at 1%, 5% and 10% levels, respectively.

Table 5
Results of model form tests.

	Sum squared resid	N	K	T	F2	F1
Pooled regression model	S3=12.12					
Varying coefficient model	S1=0.38	30	4	10	39.10^{**} (2.01)	5.80^{**} (2.07)
Varying intercept model	S2=1.77					

Notes: ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

$$\mathrm{F2}=\frac{(S3-S1)/[(N-1)(K+1)]}{S1/[NT-N(K+1)]}\quad \mathrm{F2}\sim[(N-1)(K+1),N(T-K-1)] \tag{3}$$

3.2.4. Residuals tests

After determining the fixed effects model and varying coefficient model, we performed three different tests on the residuals (He et al., 2016). The tests indicated cross-sectional dependence between the groups, autocorrelation within the groups, and groupwise heteroscedasticity.

Thus, we adopted the feasible generalized least squares (FGLS) method to estimate the varying coefficient model with fixed effects in this study. The FGLS avoids autocorrelation within the group as well as groupwise heteroscedasticity and cross-sectional dependence. Moreover, according to Beck and Katz (1995), the FGLS can be applied when T > N.

4. Empirical results and discussion

As observed from Table 6, the impacts of CO_2 emission reduction policies and energy structure on investment were different between sectors.

First, CO_2 emission reduction policies effectively prevented the growth of investment in the industry sector and the commerce and services sector, as indicated by the negative coefficient of POL in the industry sector (−0.22) and in the commerce and services sector (−0.52) at the 1% level. By contrast, the coefficient of POL in the transportation sector was positive at the 10% level (0.51). This result may indicate that substantial investment flowed into the transportation sector to improve energy efficiency and promote the substitution of electric vehicles for gasoline and diesel vehicles, following the guidelines of governmental regulation for CO_2 emissions (Liu et al., 2017). For the agriculture sector and the construction sector, the coefficients of POL were 0.19 and −0.17, respectively but these correlations were not statistically significant. These results indicate that the driving effect of CO_2 emission reduction policies on investment was not evident in these two sectors. This lack of evidence stems from the fact that the CO2 emission reduction policies from 2003 to 2012 focused on the industry sector, and few of these policies involved the construction or agriculture sectors (Kuper and van Soest, 2003; Smith et al., 2007; Jiang and Tovey, 2010). Therefore, although the Chinese government gradually strengthened its CO_2 emission reduction regulations, investment in the construction sector and the agriculture sector was not affected.

Second, the proportion of total energy consumption involving coal use significantly affected the agriculture sector, the industry sector, and the transportation sector. However, the coefficients of ECS in the construction sector (−0.02) and the commerce and services sector (0.27) were not statistically significant, which indicates that the driving effect of energy structure on investment was not evident in these two sectors. In the agriculture sector and the transportation sector, the coefficients of ECS were −1.31 and −2.28, respectively and these correlations were statistically significant at the 1% level. These results indicate that investors paid attention to the coal-dominated energy structure and reduced support for coal consumption. Compared to investors in the agriculture sector, investors in the transportation sector paid more attention to energy structure because the absolute value of the coefficient of ECS in the transportation sector (2.28) was greater than that in the agriculture sector (1.31). Surprisingly, the coefficient of ECS in the industry sector was positive at the 1% level of significance (0.65), which indicates that the higher the proportion of total energy consumption involving coal use, the greater the investment in the industry sector. Although the Chinese government has implemented numerous policies aiming to restrict coal consumption in the industry sector, investment showed strong viscosity. This result is mainly because the energy structure of the industry sector has relied on consumption of low-price coal (Shealy and Dorian, 2010; Wang et al., 2014). Under the constraints of technical development and policy incentives, clean energy use has been costly and energy inefficient in sectoral production, which would increase the cost of production and decrease the profits of investors (Bloch et al., 2015). Therefore, investment in the industry sector showed a direct relationship with the energy structure.

In addition to climate policy and energy structure, GDP and LIR affected investment.

As shown in Table 6, the coefficients of GDP for all sectors except the transportation sector were positive at the 1% significance level, and the coefficients of GDP were significantly greater than those of the other variables. These results indicate that GDP was the most important factor driving sectoral investment. The coefficient of GDP for the transportation sector was −3.63, which was significant at the 10% level. This finding indicates that GDP was the obstructive

Table 6
Estimated results for the sectoral panel.

Dependent variable: total investment in fixed assets					
Variables	Agriculture	Industry	Construction	Transportation	Commerce and services
Constant	-10.20^{**} (−2.49)	-10.20^{**} (−2.49)	-10.20^{**} (−2.49)	-10.20^{**} (−2.49)	-10.20^{**} (−2.49)
GDP	6.05^{***} (6.97)	2.54^{***} (20.92)	1.76^{***} (3.45)	-3.63^{*} (−1.88)	2.73^{***} (12.36)
LIR	−0.15 (−0.27)	-0.36^{**} (−2.28)	−0.41 (−0.61)	0.74 (1.07)	-1.02^{***} (−3.00)
POL	0.19 (0.88)	-0.22^{***} (−3.50)	−0.17 (−0.62)	0.51^{*} (1.98)	-0.52^{***} (−3.64)
ECS	-1.31^{***} (−3.62)	0.65^{***} (3.76)	−0.02 (−0.04)	-2.82^{***} (−2.83)	0.27 (0.61)

Notes: ***, **, and * indicate significance at 1%, 5% and 10% levels, respectively.

factor for investment. Similar to the reason that POL affected investment, in the transportation sector, a large amount of investment was used to substitute the fossil fuel with clean fuels (e.g., bioethanol) and promote electric vehicle production. This led to an inverse relationship between GDP and investment in the transportation sector. The greatest coefficient of GDP in each sector demonstrated that investment was mainly driven by GDP and mildly driven by environmental benefits.

LIR significantly affected investment only in the industry sector and the commerce and services sector. The coefficients of LIR were negative in the industry sector, with a value of −0.36 at the 5% significance level, and in the commerce and services sector, with a value of −1.02 at the 1% significance level. These results indicate that the lower the real interest rate, the smaller the investment in these two sectors.

In summary, the empirical results supported Hypothesis 3, which predicted that higher GDP attracted more investment for most sectors. Hypothesis 4 was also supported by our tests, showing that a lower interest rate promotes investment in every sector. Hypotheses 1 and 2 were only partly supported. The results revealed that uncertainty constituted a driving effect of energy structure and CO_2 emission regulation policies for sectoral investments. Regarding Hypothesis 1, the proportion of total energy consumption involving coal use negatively affected investment in the agriculture and transportation sectors, but positively affected investment in the industry sector. Regarding Hypothesis 2, the CO_2 emission regulation policies significantly decreased investment in the industry sector and the commerce and services sectors while increasing investment in the transportation sector.

5. Conclusions and policy implications

The aim of this study was to empirically explore whether investment became green in China over the period of 2003–2012. The findings may be somewhat disappointing. Although regulations on CO_2 emissions and coal consumption became more stringent, investors predominantly paid attention to GDP and paid little attention to environmental benefits. The Chinese climate policies and energy structure did not comprehensively affect investment in the construction sector, which is the sector widely recognized to be intensive in fossil fuel use and carbon emissions for energy consumption (Ge et al., 2016a,b; Shao et al., 2016). Regarding the industry sector, investment showed strong viscosity to low-price coal consumption, while the climate policies reduced this viscosity to a certain degree. The transportation sector was undergoing a process of energy and vehicle substitutions; thus, the climate policies encouraged investment flow into this sector. Moreover, the climate policies decreased investment in the commerce and services sector and had no effect on the agriculture sector. The coal-dominated energy structure also hindered investment in the agriculture sector but showed no influence on investment in the commerce and services sector.

Our analysis highlights the current challenges related to green transformation in China from an investment perspective. First, the long-term economic growth model that relies on industrial development further strengthens the stickiness of investment in high-carbon sectors such as the coal-intensive industry and oil-intensive transportation sectors. Second, the Chinese government may need to increase the economic cost of carbon emissions for investment purposes, thus allowing China to bear the risk of an economic downturn. Third, different carbon emission reduction measures are required to regulate different sectors. These three challenges could inform a new perspective for studies on carbon emission reduction in developing countries, particularly in countries experiencing industrialization and low-carbon development.

The findings of the above empirical analysis point to the following policy implications.

First, due to the small number of policies, the regulatory focus should currently be turned to the construction sector in China. The current green building evaluation standards are extremely easy for developers to meet, and they should be improved. Moreover, a future carbon emission trading framework should include the construction sector to increase the cost of energy consumption and encourage technological innovation in saving energy and reducing emissions. Additionally, the government provides subsidies to developers to use solar and geothermal energy during the construction process.

Second, to separate viscosity from investment in coal consumption, a substantial increase in the cost of coal use should be implemented by the government. At the same time, the government should provide subsidies for clean energy (e.g., biomass gasification) or relatively clean fossil energy (e.g., shale gas) during the production process. The above measures are expected to widen the gap between the costs and benefits of coal use for investors and producers.

Third, in the transportation sector, due to the long payback period of the charging infrastructure, when the electric vehicle is rapidly promoted, the government should simultaneously encourage the production of relatively clean natural gas vehicles or biofuel vehicles (e.g., ethanol-driven vehicles).

Finally, climate policies on livestock management, rice farming techniques, soil carbon storage, and biomass fuels should be implemented and improved, as there are few regulatory policies affecting the agriculture sector. Because agriculture is a low value-added sector, the government should use subsidies rather than increase costs to encourage green investment in this sector.

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