The influence of local officials' promotion incentives on carbon emission in Yangtze River Delta, China

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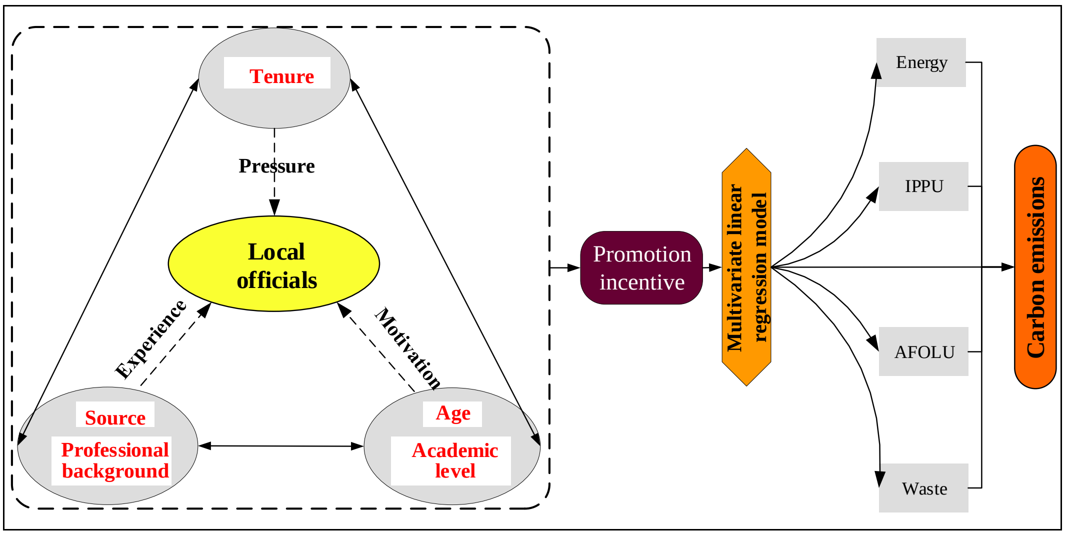
Highlights:

- A theoretical framework was constructed to analyse the influence of promotion incentives on carbon emissions.
- Local officials' promotion sources, tenure and age significantly influenced total carbon emission.
- Local officials with a professional background in economics and management has a significant influence on carbon reduction.

Abstract: China's carbon emissions is heavily influenced by economic growth, which can be largely related to the local officials' promotion incentives. The current study was conducted to test the hypothesis that the influence of local officials' individual characteristics on carbon emissions was driven by the promotion incentives. Yangtze River Delta where carbon emissions accounted for around 13.95% of China's total emissions was selected as the research area. The multiple linear regression model was applied to determine the relationship between local officials' characteristics and total carbon emissions and carbon emissions from different sectors. The results indicated that local officials' promotion source, tenure and age significantly influenced the total carbon emission. Despite insignificance influence of officials' academic level on carbon emissions, the professional background in economics and management had a significant influence on carbon reduction. Our results indicated the importance of local officials' promotion incentives for carbon emission in China. Therefore, low carbon development should be included as an important part of official promotion system.

Keywords: Carbon Emissions; Local Officials; Promotion Incentives; Yangtze River Delta; China

Graphical abstract:



1 Introduction

Human activities have accelerated the increase in greenhouse gases (GHGs) in atmosphere, which exacerbate global warming (Anagnostou et al., 2016; Friedlingstein et al., 2014; MacDougall and Friedlingstein, 2015). In 2016, CO_2 concentration reached at 403.3±0.1 ppm, CH_4 reached at 1853±2 ppb and N_2O reached at 328.9±0.1 ppb, increasing by 45%, 157% and 22% than pre-industrial level (before 1750) (Yang et al., 2013). Particularly, China surpassed the US and became global largest CO_2 emitter in 2005 (Janssens-Maenhout et al., 2017). With sustained economic growth and rapid urbanization and industrialization, China's total carbon emissions may continue to increase in the next years. In the Paris climate conference, China announced that the country will achieve the peak of CO_2 emission by around 2030, with best efforts to peak early (Liu et al., 2014). On June 1, 2017, the US declared its withdrawal from the Paris Agreement, which will very likely impact carbon emission from the US. Nevertheless, China still plan to launch the national carbon emissions trading market. Therefore, China's action on carbon emission receives increasing global attention (Gibney, 2016).

In spite of many studies, the driving mechanism of China’s carbon emission is still not well known. The driving factors include appearance factors and fundamental factors(Geist and Lambin, 2002). In general, appearance factors include economy, population, energy and technology (Ang and Su, 2016; Ye et al., 2017). The traditional theories, such as the environmental Kuznets down "U" curve, carbon emissions decoupling, pollution shelter and other theories, come from the economic point of view to explain the mechanism of carbon emissions. The fundamental factors, including laws and regulations, national and government policies, land use, and human behaviour (Lai et al., 2016), are more responsive to an in-depth explanation of the driving mechanisms.

According to North’s theory of institutional change (Besley et al., 2012), material and human capital growth and technological progress are only the result of economic growth, rather than the inherent source of growth, and are the root determinants of institutional arrangements. In west governments, the political reputation model explains the impact of political incentives on regional development. To seek re-election, politicians revise policies on taxation, environment and education according to voters’ preferences (Ales et al., 2014). Different from their counterparts, Chinese local officials are more likely to be held to “higher authorities' appointment” rather than voter election. The most influential theories of China's economic growth miracle are “Federalism, Chinese Style” (Jin et al., 2005) and “Promotion Tournament Model Theory” (Pu and Fu, 2018), which states that the incentives of local officials are an important engine of China's economic development. Many studies have found that the main reason for China's increasing CO_2 emission is the extensive economic growth (Liu and Diamond, 2005; Zhang et al., 2013). And therefore there may be some relationships between the incentives of official promotion and carbon emission in China. Understanding the influence of local officials on carbon emissions is very important for global climate action, especially for China, the largest CO_2 emitter. However, previous researches largely overlooked the role of government officials in carbon emission.

Officials are different actors. They act also according to their own political demands to make the appropriate promotion response. The most extreme example is the recent change of the American president and the following climate policy to further support fossil energy. To the best of our knowledge, there is no available study on the influence of local official on carbon emissions in China. To meet the knowledge gap, the relationship between carbon emissions and characteristics of local officials motivated by the promotion incentives were analysed. Totally 25 cities in the Yangtze River Delta (YRD), one of the areas with most rapid increase in carbon emissions in China (Li et al., 2017), were researched during the period of 2000-2010. The results reveal the underlying drivers of carbon emission and provide a new perspective of China's carbon reduction.

2 Material and methods

Based on a theoretical framework, multiple linear regression models were constructed to calculate the relationship between local officials' characteristics and carbon emissions, including total carbon emission and carbon emissions from the four sectors including Energy, IPPU (industrial processes and product use), AFOLU (agriculture, forestry and other land use), and Waste.

2.1 Multiple linear regression model

2.1.1 Variable selection

In China, the carbon emissions are mainly driven by GDP, GDP per capita (PGDP), population (POP), fixed asset investments (INV) and industrial structure (second industry accounted for GDP, IS) (Peters et al., 2017). Therefore, the above factors were selected as control variables.

Constitution of the Communist Party of China requires the contingent of cadres has four principles including "revolutionization", "young", "knowledge" and "specialization". It also stipulates that each tenure of local official is five years and officials must retire at the age of 60 years old (Burns and Wang, 2010). Due to the measure difficulty of "revolutionary", age, tenure and education have become more important factors in local officials' promotion. Educational background of local officials can be measured by both profession and academic level (Dreher et al., 2009). The promotion source was the key variable influencing local officials' promotion experience (Chen et al., 2017; Dreher et al., 2009). As the saying goes, "a new broom sweeps clean". Compared with officials promoted from their home cities, those transferred from other cities usually developed strategies to showcase their unique ideas and highlight their future performance. However, due to the lack of sufficient awareness of the local information, the new policies may not be in line with local situation, and the environmental costs brought about by these policies can be very high (Duan and Hu, 2014). Therefore, promotion source was chosen to represent the promotion experience of local officials.

Multicollinearity verification was conducted for all variables using the Variance Inflation Factor (VIF) in Stata13.0. The maximum VIF is 9.46, less than 10. Due to the significant collinearity between GDP with other variables, GDP was excluded, but

PGDP, POP, INV and IS were included as the control variables (Krebs et al., 2012).

Based on the above analysis, a theoretical framework was constructed to analyse the influence of local officials' promotion incentives on carbon emission in three ways: promotion experience, pressure during current tenure and motivation for future promotion.

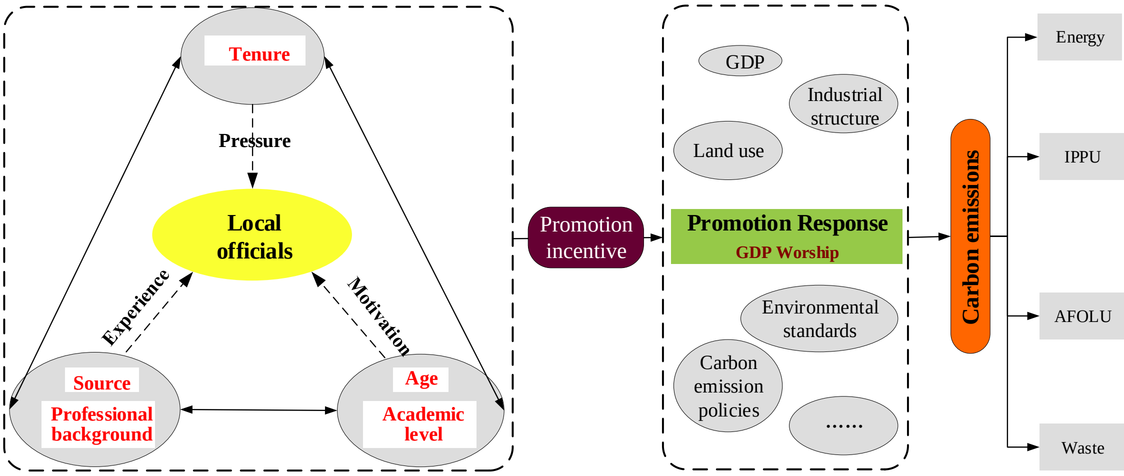


Fig. 1. The analytical framework of local official's promotion incentives and carbon emissions.

Notes: GDP represents gross domestic product; IPPU represents carbon emission from industrial processes and product use sector; and AFOLU represents carbon emissions from agriculture, forestry and other land use sector.

2.1.2 Model establishment

The panel data of 25 cities in the YRD from 2000 to 2010 were applied to examine the specific impact of the promotion of local officials on the carbon emissions by estimating the following econometric model (Sun et al., 2017):

$$E_{it}^{r} = C + \alpha_j X_{it}^{j} + \beta_k L_{it}^{k} + \mu_{it} \quad (1)$$

where E_{it}^{r} represents the carbon emissions in city *i* during the period *t*, the total carbon emissions and carbon emissions from Energy, IPPU, AFOLU, and Waste. *C* represents a constant term, and X_{it}^{j} represents control variables. L_{it}^{k} represents local officials' individual characteristics; μ_{it} denotes the error term; and α_j and β_k are the regression coefficients of variable groups X_{it}^{j} and L_{it}^{k}. According to the previous theoretical framework, the above model was developed by selecting five aspects to measure the heterogeneity of local officials including the mayor and the municipal party secretary using Equations (2) and (3):

$$E_{it}^{r} = C + \alpha_1 PGDP_{it} + \alpha_2 POP_{it} + \alpha_3 INV_{it} + \alpha_4 IS_{it} + \beta_1 Msource_{it} + \beta_2 Mpro\_economic_{it} + \beta_3 Mtenure_{it} + \beta_4 Mage_{it} + \beta_5 Macademic\_level_{it} + \mu_{it} \quad (2)$$

$$E_{it}^{r\prime} = C + \alpha_1 PGDP_{it} + \alpha_2 POP_{it} + \alpha_3 INV_{it} + \alpha_4 IS_{it} + \beta_6 Psource_{it} + \beta_7 Ppro\_economic_{it} + \beta_3 Ptenure_{it} + \beta_4 Page_{it} + \beta_5 Pacademic\_level_{it} + \mu_{it} \quad (3)$$

where $source_{it}$ is the promotion sources of city *i* in period *t* (0 = promote from local city, 1 = promote from another city). $pro\_economic_{it}$ denotes that the local officials of *i* in period *t* have a professional background in economics and management (0 = no economic and management professional background, 1 = have such professional background). $tenure_{it}$ denotes the current tenure of the local officials in city *i* in period *t*. age_{it} denotes the age of local officials of city *i* in period *t* (unit: year). aca_level_{it} denotes the academic level of local officials (1 = Associate degree, 2 = Bachelor degree, 3 = Master degree and 4 = Doctoral degree).

Based on all data from 25 cities during the period of 2000-2010, software STATA Version 13 (Stata Corp, College Station, Texas, USA) was used to conduct the above models. Panel data generally had a difference between the fixed effect (FE) model, random effect (RE) model or ordinary least square (OLS) model (Xu et al., 2015). An F test with Clustering Robust Standard Errors suggested that the FE-model was better than the OLS-model. The further analysis using the Hausman test indicated p value greater than 0.05 (Yang et al., 2017), so the RE-model was considered as the most effective model.

2.2 Research area and data source

The YRD is located in the eastern coast of mainland China, including Shanghai direct-controlled municipality, Jiangsu Province and Zhejiang Province and 25 prefecture-level cities (Fig. 2). The YRD accounted for 2.19% of China's land area, 11.59% of China's population and 20.02% of China's GDP in 2015 (National Bureau Statistics of China, 2016). The YRD has developed into one of China's economic centres, as well as the world's sixth largest urban agglomeration (Li et al., 2018).

However, the YRD consumed 13.69% of China's energy and emited 13.95% of China's s total carbon emissions in 2015, equivalent to Japan's carbon emissions (Janssens-Maenhout et al., 2017). Environmental pollution has been a big challenge in the region, especially with frequent hazes. In 2015, the annual days with safe air quality decreased to less than 250 days. YRD has been a microcosm of whole China's carbon emission and air pollution. The research in YRD will be helpful to understand carbon emission in other regions in China, and it may also provide experience for cities in other countries.

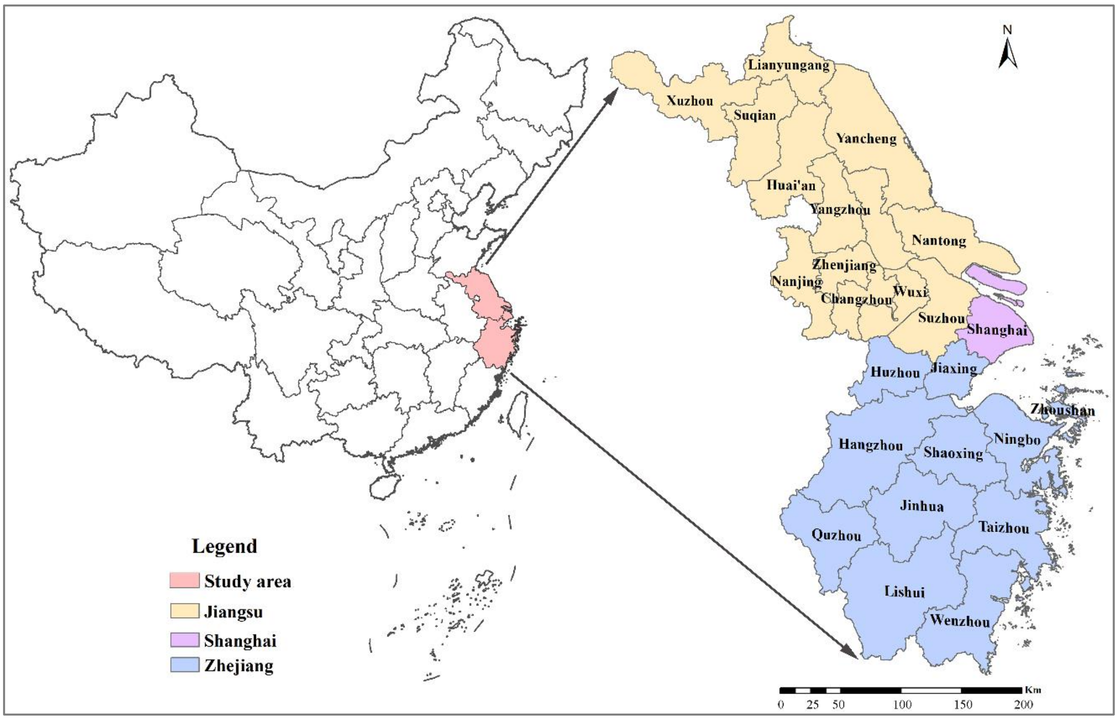


Fig. 2. Research area in the Yangtze River Delta, China

Local officials' individual characteristics were obtained from several databases. The tenure and name of the mayor and municipal party committee of the city were obtained from Zecheng Net (http://www.hotelaah.com/liren/index.html). Based on the name of the official, all local official's yearly resumes were searched in Baidu (www.baidu.com), and the resumes include the promotion source, professional background, tenure, age and academic level. It is worth noting that some local officials were not appointed at the same time. If the appointment date was before June, officials' tenure was counted from that year. Otherwise, it was calculated from next year. GDP per capita (PGDP), population (POP) and investment in fixed assets and secondary industry values (INV) were obtained from the annual Shanghai Statistical Yearbook, Jiangsu Statistical Yearbook and Zhejiang Statistical Yearbook for the period of 2001-2011.

High-precision spatial grid (0.1° x 0.1°) carbon emissions data obtained from the Emission Database for Global Atmospheric Research (EDGAR), a widely used database for carbon emissions and air pollution research (Janssens-Maenhout et al., 2017; Peters et al., 2017), were used to calculate the carbon emissions from 25 cities in the YRD. Table 1 shows the descriptive statistics of the variables. It is noteworthy that the education levels of some local officials are missing, and the panel data are unbalanced.

Table 1

Data description.

	Variable	Unit	Observations	Mean	Std. deviation	Minimum	Maximum
EC	Total	TgC	275	8.56	9.87	0.01	62.77
	Energy	TgC	275	6.31	8.08	0.01	51.3
	IPPU	TgC	275	1.11	1.36	0	9.53
	AFOLU	TgC	275	0.74	0.83	0	4.66
	Waste	TgC	275	0.38	0.34	0	1.42
PGDP		10^6 CHY/person	275	277.58	188.76	39.71	952.28
POP		10^6 person	275	5.18	2.71	1.05	15.31
INV		10^9 CHY	275	84.20	85.37	4.22	463.05
IS		%	275	51.83	6.36	29.6	66.6
Source	Msource	/	275	0.73	0.45	0	1
	Psource	/	275	0.48	0.5	0	1
Professional background	Mpro_economic	/	263	0.59	0.49	0	1
	Ppro_economic	/	263	0.46	0.5	0	1
Tenure	Mtenure	year	275	2.82	1.81	1	9
	Ptenure	year	275	3.16	1.93	1	10
Age	Mage	year	275	49.58	4.65	39	70
	Page	year	275	51.85	4.51	43	73
Academic level	Maca_level	/	269	1.84	0.77	0	3
	Paca_level	/	265	1.82	0.67	0	3

Notes: EC refers to carbon emission. PGDP refers to GDP per capita. POP refers population. INV refers to fixed asset investment. IS refers to industrial structure. M refers to the mayor. P refers to the municipal party committee.

2.3 Calculation of carbon emissions

EDGAR provides data that contain not only the total CO_2, CH_4 and NO_2 but also emissions data for different sectors. However, the sectors were classified in accordance with the IPCC1996 code. According to “2006 IPCC Guidelines for National Greenhouse Gas Inventories”, sectors were reclassified to Energy, IPPU, AFOLU, and Waste using ArcGIS 10.2 (ESRI Inc, Redlands, California, USA) (Table 2).

Table 2

Carbon emissions from difference sectors.

Categories	CO_2	CH_4	N_2O
Energy	Energy industry; Transformation non-energy use; Combustion in manufacturing industry; International and domestic aviation; Road transportation; Non-road ground transport; International and domestic shipping; Energy for buildings; Fugitive from solid; Oil production and refineries;	Energy manufacturing transformation; Non-road transportation; Road transportation; Energy for buildings; Fugitive from solid; Oil production and refineries; Gas production and distribution;	Energy manufacturing transformation; Non-road transportation; Road transportation; Energy for buildings; Oil production and refineries;
IPPU	Non-metallic mineral processes; Chemical processes solvents; Metal processes;	Industrial process and product use;	Industrial process and product use;
AFOLU	Agricultural soils; Large Scale Biomass Burning;	Enteric fermentation; Manure management; Agricultural soils; Agricultural waste burning;	Manure management; Agricultural soils; Indirect N_2O emissions from agriculture; Agricultural waste burning;
Waste	Solid waste disposal; Fossil Fuel Fires;	Solid waste disposal; Waste water; Fossil Fuel Fires;	Waste solid and wastewater; Fossil Fuel Fires; Indirect emissions from NO_x and NH_3.

Notes: IPPU refers to industrial processes and product use sector. AFOLU refers to agriculture, forestry and other land use sector.

Regarding the greenhouse gases, the warming effects of CO_2, CH_4 and N_2O were 76%, 16% and 6.2%, respectively (Pachauri et al., 2014). To estimate the total warming effect, different greenhouse gases were converted to CO_2-equivalent emissions and then converted into the amount of carbon emissions as follows:

$$E_{carbon} = (E_{CO_2} + GWP_{CH_4} * E_{CH_4} + GWP_{N_2O} * E_{N_2O}) * M_{r_C}/M_{r_{CO_2}} \quad (4)$$

where the Global Warming Potential (*GWP*) represents the warming capacity of greenhouse gases relative to the carbon dioxide (CO_2). GWP_{CH_4} and GWP_{N_2O} adopt the 100-year GWP (GWP_{100}) standard value in "the Climate change 2014: synthesis report", which are 28 and 265, respectively (Pachauri et al., 2014). E_{carbon}, E_{CO_2}, E_{CH_4} and E_{N_2O} represent the emissions of carbon, CO_2, CH_4 and N_2O, respectively. M_{r_C} and $M_{r_{CO_2}}$ are the relative molecular mass of C and CO_2, M_{r_C} = 12, and M_{r_C} = 44.

3 Results

3.1 Spatiotemporal pattern of carbon emission

Carbon emissions rapidly increased from 135.62 TgC yr^{-1} to 308.87 TgC yr^{-1} from 2000 to 2010, with an average annual growth rate of 7.77% (Fig. 3). The growth rate showed an inverted U-shaped curve, from 2.32% in 2001 to 15.25% in 2004, and then fell to 5.25% in 2010. From the emission structure, in 2010, the YRD exhausted 502.31 $TgCO_2eq\ yr^{-1}$. CO_2 accounted for 90.4%. CH_4 and N_2O contributed only 7.3% and 2.3%, respectively. In terms of the emission sectors, the Energy sector accounted for the highest proportion of carbon emissions, from 68.78% in 2000 to 75.69% in 2010. IPPU sector contributed 12.35% - 13.96% of total carbon emissions between 2000 and 2010, with average growth rate of 8.98%. AFOLU and Waste contributed 6.87% and 3.48% of total carbon emissions, respectively; and the average annual growth rates were 1.97% and 2.20%, respectively.

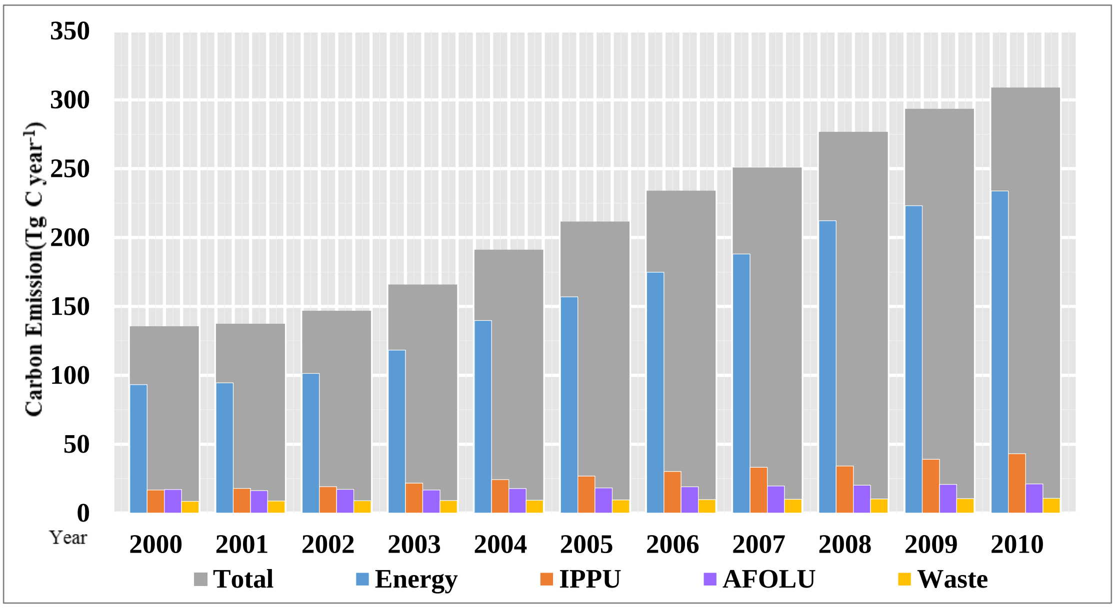


Fig. 3 Carbon emissions in Yangtze River Delta from 2000 to 2010

The total carbon emissions in the YRD experienced a rapid growth process but with markedly spatial differences (Fig. 4). In 2000, Shanghai had the largest carbon emissions, followed by Xuzhou and Yancheng, while Zhoushan had the smallest one. In 2005, the carbon emissions from Shanghai, Taizhou, Suzhou, Ningbo, Wenzhou and other cities increased markedly. In 2010, the total carbon emissions in all cities further increased. The higher carbon emissions were concentrated mainly in Shanghai City, North Jiangsu Province and the coastal area in Zhejiang Province, while the lower carbon emissions appeared mainly in the southwest of Zhejiang Province. The highest value of 62.77 TgC in Shanghai was more than 2380 times greater than the lowest value of 0.03 TgC in Zhoushan.

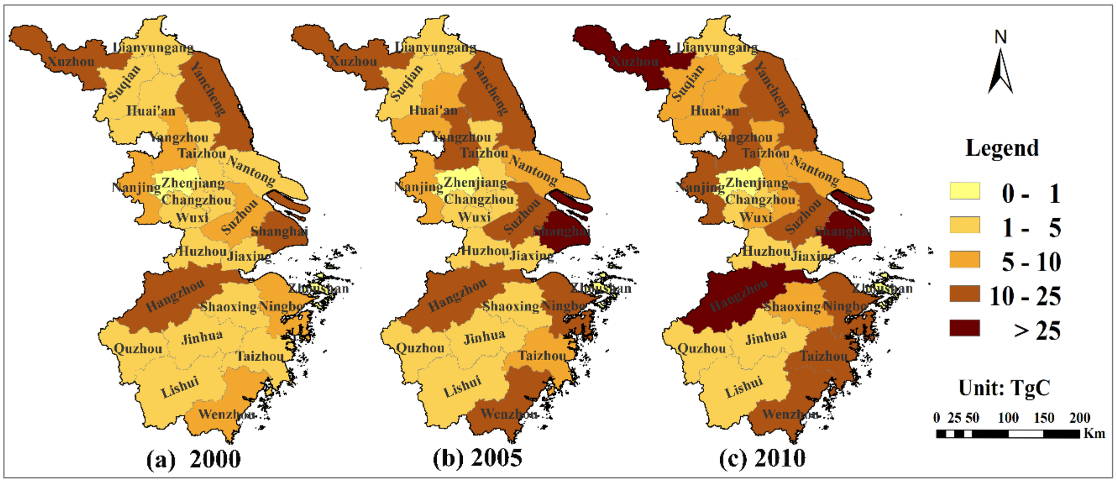


Fig. 4 Spatial pattern of carbon emissions in the Yangtze River Delta from 2000 to 2010

3.2 Total carbon emissions

Models (1) and (2) indicated that the coefficients of the control variables (INV, POP and IS) played prominent roles in carbon emissions. The effects of INV and IS were significantly positive at the 1% level, suggesting that economic, fixed asset investments and secondary production significantly affect carbon emissions. The estimated coefficient of the variable POP is also positive, but not as significant as the other variables, and significant at the 5% level, indicating that the impact of the population on carbon emissions may be limited. However, PGDP is significantly negative at the 1% level, indicating that PGDP growth can reduce carbon emissions. According to the theory of Environmental Kuznets Curve (EKC), the carbon emissions in the YRD region exceeded the critical point of the EKC; with the further increase in income per capita, carbon emissions will gradually decrease (Jalil and Mahmud, 2009; Stern and Common, 2001).

There are some significant correlations between carbon emissions and local officials' promotion experience, pressure during current tenure and motivation of future promotion (Table 3).

3.2.1 Local officials' promotion experience

Local officials’ promotion experience was mainly reflected in the promotion source and professional background. From the promotion source of local officials (Table 2), the average of Msource was 0.73, and the average of Psource was 0.48, indicating that 73% mayors and 48% municipal party secretaries were promoted from other cities. The estimated coefficients for Msource and Psource were both significantly positive at the levels of 5%, respectively. Therefore, the promotion source of local officials had a certain impact on carbon emission. The mayors and municipal party secretaries who were transferred from other cities were more likely to cause an increase in carbon emissions than locally promoted officials.

The estimated coefficients of Mpro_economic and Ppro_economic were negative, but only Ppro_economic passed the 10% significance level test, indicating that municipal party secretaries with a professional background in economics or management were conducive to carbon reduction.

3.2.2 Local officials' promotion pressure

Fig. 5 shows that the YRD's local officials had a shorter tenure. The average tenure of mayors and municipal party secretaries were 3 years and 4 years, respectively, much shorter than the statutory five-year tenure. This phenomenon was more obvious for the mayors than the municipal party secretaries. The regression coefficients of Ptenure was significant at the 1% level, and the mayors' tenure had insignificant effect on local carbon emissions. As the tenure increased, the influence of the municipal party secretaries on carbon emissions was in accordance with the inverted U-shaped curve. The inflection point of the curve was approximately 4.3 years.

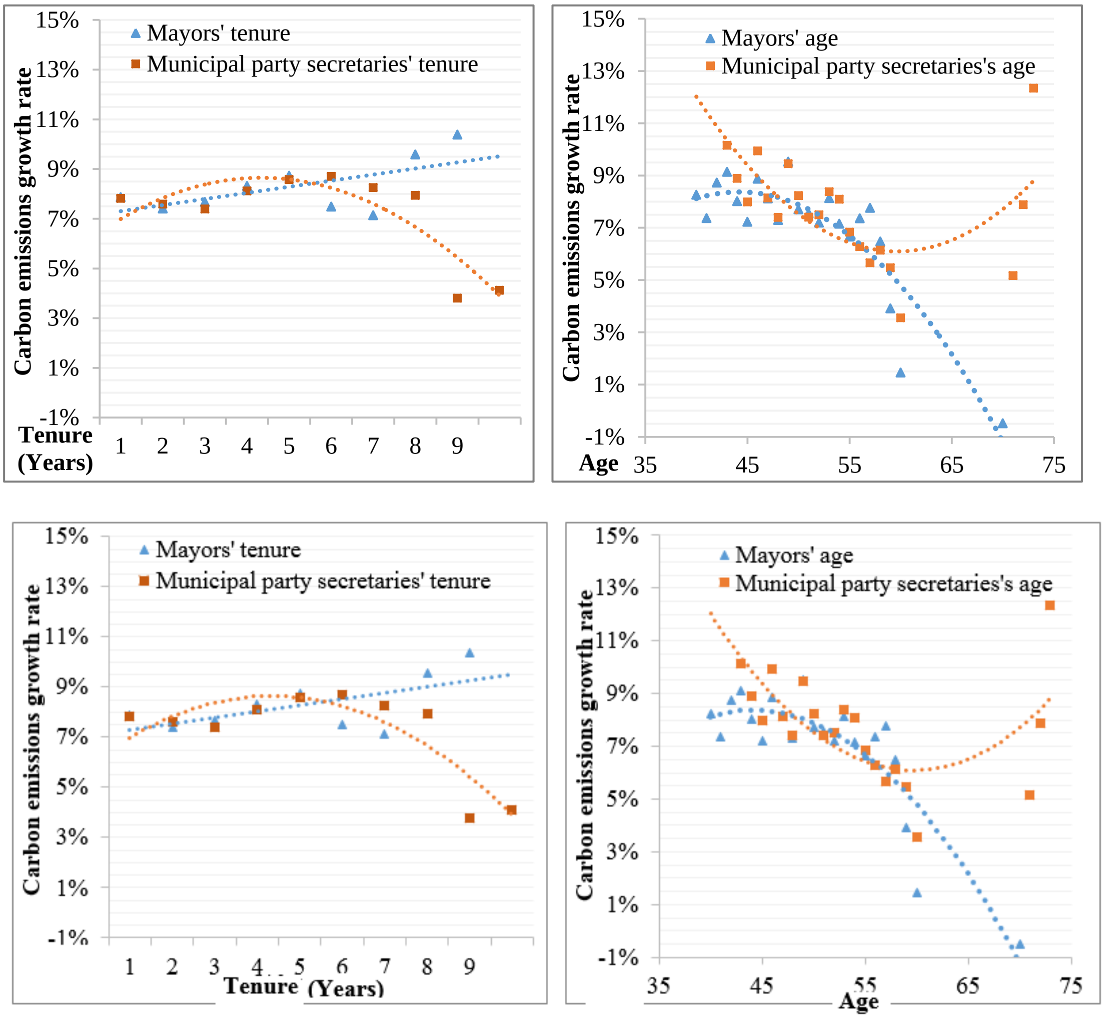


Fig. 5 Carbon emission growth rates on different local officials' tenures and ages

3.2.3 Local officials' promotion motivation

Local officials' age had a positive effect on the total carbon emissions, but only the mayors' age was statistically significant (Table 3). Furthermore, there was a non-linear relationship between the age of local officials and the growth rate of carbon emissions (Fig. 5). The mayors' age and carbon emissions showed an inverted U-shaped curve, while the municipal party secretaries' age and carbon emissions showed a U-shaped curve. The marginal effect of the mayors on carbon emissions shows a change from positive to negative as the age increases. However, the effect of age of the municipal party secretaries on carbon emissions was insignificant.

Local officials had a higher academic level. Around 95.51% of the mayors and municipal party secretaries had bachelor degree or above, and 14.00% of local officials had doctoral degrees. The overall proportion of mayors with a master or doctorate degree was higher than the proportion of the municipal party secretaries. The estimated coefficient of Paca_level was positive and significant, while the Maca_level was positive but insignificant.

3.3 Carbon emissions from different sectors

To further explore the effect of officials' promotion on carbon emissions, the total carbon emissions were decomposed into four sectors including Energy, IPPU, AFOLU and Waste and a random effect model was conducted (Table 3). Local officials' promotion sources, professional background, academic level, tenure and age had significant effects on carbon emissions from different sectors. The effects of local officials' individual characteristics on total carbon emissions and carbon emissions from different sectors were relatively consistent.

The tests of goodness of fit of the four sectors were different (Table 3). Energy sector had the best fit, with R^2 values of 0.8466 and 0.8612, respectively; and the AFOLU sector had the minimum, with R^2 of 0.5349 and 0.6045. This indicates that the promotion of local officials had a larger impact on carbon emissions from Energy sector, but limited impact on the carbon emissions from AFOLU sector. However, the results of the model estimates in each sector were similar as the total carbon emissions.

Table 3

The influence of local officials' individual characteristics on carbon emission

Model	EC		Energy		IPPU		AFOLU		Waste	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PGDP	-7.74e-07***	-2.97e-05***	-1.08e-05***	-1.38e-05***	-2.57e-06***	-7.49e-06**	-5.35e-06***	-5.52e-06***	-7.04e-07***	-8.29e-07***
POP	0.0234**	0.0281**	0.0198***	0.0230**	0.00310***	0.00303***	0.0004899*	0.000408	0.00112***	0.00113***
INV	0.00536***	0.00560***	0.00433***	0.00448***	0.000775***	0.000854***	0.000185***	0.000199***	4.30e-05***	4.49e-05***
IS	0.131**	0.151***	0.106**	0.126***	0.0253***	0.0293***	0.00948***	0.00721***	0.00119***	0.000407
Msource	0.222**		0.176*		0.0142*		-0.00073		-0.00161	
Mpro_economic	-0.157		0.0234		0.0696		0.0187		-0.000913	
Mtenure	0.00413**		-0.00224		0.00984*		0.00359*		0.000347*	
Mage	0.168***		0.157***		0.0193**		0.00497***		0.000701*	
Maca_level	0.236		0.187		0.0105		0.00979		0.00443*	
Psource		0.865**		0.808**		0.118**		-0.0529***		0.00911***
Ppro_economic		-0.00588*		0.0271		-0.0379*		0.0234**		-0.00512*
Ptenure		-0.313***		-0.267***		-0.0530***		-0.00481*		-0.000304*
Page		-0.208		-0.160***		-0.0410***		-0.00463**		-0.00191***
Paca_level		0.688***		0.507*		0.134***		0.0241***		0.0145***
Constant	6.342*	-13.55***	4.946**	-11.24***	1.097***	-1.689***	-0.292**	-0.138***	-0.315***	-0.358***
R^2	0.8572	0.8407	0.8466	0.8612	0.8238	0.8034	0.5349	0.6045	0.8095	0.8396

Notes: *, **, and * indicate significances at levels of 1%, 5%, and 10%, respectively. 1, 3, 5, 7, and 9 were conducted using Equation 2. 2, 4, 6, 8, and 10 were conducted using Equation 3.**

3.4 Robustness test

Because model outputs depend on model setting and indicator construction, robustness tests were performed to verify the stability and reliability of the results. The robustness was examined by adjusting model's core variables and samples.

(1) Change variables. The square term of tenure ($tenure^2$) and age (age^2) were included, and the robustness was evaluated. The results show that the coefficients of the variables such as source, pro_economic, tenure, age, and aca_level in Table 4 were mostly consistent with those in Table 3, indicating the robustness of the previous results.

(2) Change samples. There are 138 mayors and party committee secretaries in the current research, among which 16 people, such as Chen Liangyu, Mao Xiaoping, and Ji Jianye, were withdrawn due to job-related crime or malfeasance. Same as the adjustment of variables, such mayors and municipal party committee secretaries were excluded and a robustness test was conducted. The results were still robust.

Table 4

Results of robustness tests

Model	EC		EC	
	(11)	(12)	(13)	(14)
PGDP	-7.74e-06***	-2.97e-05***	-7.74e-07***	-3.59e-05***
POP	0.0235***	0.0282***	0.0234***	0.0272***
INV	0.00530***	0.00554***	0.00536***	0.00574***
IS	0.133**	0.134***	0.131**	0.152***
Msource	0.0324**		0.222	
Mpro_economic	-0.0975		0.157	
Mtenure	0.00413**		-0.00413	
Mage	1.604***		-0.168***	
Maca_level	0.263		0.236	
Psource		0.819**		-0.142
Ppro_economic		-0.0339*		-0.117
Ptenure		-0.338***		-0.461***
Page		-1.172		0.218***
Paca_level		0.728***		0.768**
$Mtenure^2$	-0.102			
$Ptenure^2$		0.0573***		
$Mage^2$	-0.0143***			
$Page^2$		0.0193*		
Constant	-37.48*	20.85**	6.342	-13.07***
R^2	0.6867	0.7079	0.8381	0.8572

Notes: *, **, and * indicate significances at the levels of 1%, 5%, and 10%, respectively. 11 and 13 were conducted using Equation 2. 12 and 14 were conducted using Equation 3.**

4 Discussion

In this study, a theoretical framework was developed to explore the influence of local officials with different characteristics on carbon emissions under the incentives of promotion in 25 cities in the YRD. The results indicate that local officials were not conducive to local carbon reductions under promotion incentives. In addition, local officials' promotion experience, pressure and motivation had different effects on changes in carbon emissions.

4.1 The significant effect of local officials' promotion incentives on carbon emissions

Since the Reform and Opening policy in late 1970s, there is a phenomenon of "GDP worship" in Chinese officials (He et al., 2018). Local officials equalled reducing carbon emissions to slowing GDP growth at least in their administration period, and therefore local officials paid little attention to reduce carbon emissions (Smith, 2013). Promotion incentives influence the local officials' performance on carbon reduction, but the influence on mayors and municipal party secretaries are more complicated and probably less affected by the economic performance (Zhu, 2011). In addition, the marked economic differences between cities reduce the comparability.

Local officials neither feel pressure to act on carbon emissions from the central government nor do they have to deal with international pressures (Ye et al., 2008). Under the promotion incentives, local officials tend to develop industries with fast GDP growth and often with high energy consumption, such as cement, steel, aluminium, chemicals, and energy industries (Cai et al., 2016; Heede, 2014). In the AFOLU sector, although local officials had great enthusiasm for building land expansion, the carbon emissions from land use change are also influenced by natural factors, such as climate, soil and vegetation type (Lai et al., 2016; Liu et al., 2014). Therefore, the model's fitting effect was relatively poor (R^2 = 0.5349 and 0.6045). China has established regulations of waste management, the enforcement of regulation by local officials are not very successful (Yang, 2014; Yang et al., 2016). Due to the scarcity of political resources and economic resources, local officials often relaxed the standards of environmental regulation, increasing carbon emissions in the waste sector, and creasing "pollution haven" in some areas (Yang et al., 2018) (Fig. 1).

4.2 Effects of local officials' individual characteristics on carbon emissions

Local official's individual characteristics can affect the government's development policies, which in turn will influence carbon emissions from the area (Dreher et al., 2009). Moreover, because the present study was conducted in one of China's most rapidly growing areas, the YRD, the effects can be much larger.

First, compared to officials transferred from other cities, locally promoted mayors and municipal party secretaries had better performance in terms of carbon reductions. Locally promoted officials who are familiar with the area situation will have the advantage to keep economic growth with relative less carbon emissions (Chen et al., 2017). Comparatively, officials who were transferred from other cities have relative less knowledge of local environment. They usually choose a new policy to replace the old policy to show their performance (Yang et al., 2016). In addition, they have to take a longer time to get the balance of economic development and environmental protection, with the possibility of increasing carbon emissions.

Second, local officials’ tenure had a more complex impact on carbon emission. The carbon emissions during municipal party secretaries’ tenure increased first and then decreased, an inverted U-shaped curve. A limited tenure for local officials will very possibly push them to take short-term policies and ignore the potential negative environmental impacts (Besley and Case, 1995). To show their “performance” and “ability”, new officials have to quickly carry out a variety of projects to stimulate economic development, with the result of often unavoidably high carbon emissions. With the extension of tenure, officials obtain more clear information about their promotion, and the incentives effect on officials may decline gradually. At the same time, the officials’ enthusiasm of developing economy reduced slowly. When the promotion of local officials become gradually stable (Julio and Yook, 2012), supervision also increases. With less sacrificing environment in exchange for economic development, the increase in carbon emissions will reverse. However, before leaving, officials may take into account the lagging effect of a low-carbon development. And their attitude towards carbon reduction can once again become negative, with a result of rebounded carbon emissions.

Third, the age of 60 has been set up as the retire age for city mayors in China. Therefore, the younger local officials, the higher expectations of promotion (Bu et al., 2016). To catch more promotion opportunities, young officials may prefer economic development to environmental protection, with the consequence of increasing carbon emissions (He et al., 2018; Pu and Fu, 2018). Our results indicate that after this turning point of 46.57 years old, the promotion incentives reduced markedly.

Finally, local officials’ education is mainly reflected in the academic level and professional background. First, there is no significant relationship between local officials’ academic levels and carbon emissions. This is in stark contrast to the results of South India where officials with higher education level can improve the allocation of regional resources, with a lower carbon emissions (Besley et al., 2012). Academic requirement is important for cadre selection and appointment in China, so local officials are keen to obtain high academic levels. Most local officials in the YRD have a Master's degree. Considering already heavy workload, there is wide concern how the local officials have sufficient time to complete the required courses for their part-time academic education. In China, higher education levels do not always equal to stronger awareness and more knowledge of environmental protection. Second, local officials who have a professional background in economic or management, are conducive to carbon reduction. From the turnover of Chinese leaders, it can be seen that Chinese officials’ professional backgrounds gradually change from expert technical type to public management type (Yang et al., 2013). Previous officials are representatives of technical experts, and they pay more attention to the construction of big infrastructure projects, for example highway and coal-power plant. Although this helped the Chinese economy to take off, it came with a rapid increase in carbon emissions. Officials with professional background in economics or management are familiar with the laws of the macroeconomic operation, and can pay more attention to the long-term sustainable development in the area (Qi et al., 2008; Zheng et al., 2014).

4.3 Policy implications of local officials' governance and carbon reduction

To reduce carbon emissions, more attention should be paid to the fundamental factors causing the increase in carbon emissions. Local officials' promotion incentives should be improved at the institutional level. Our results provide suggestions for official selection and promotion in practice. First, more officials should be appointed from local cities. Second, the tenure of local officials can be, to some extent, extended. Third, less attention should be paid to the academic level above bachelor degree, but more attention should be given to the academic background.

"GDP worship" cannot sustain economic development and environmental protection, for example carbon reduction. In the evaluation of local officials, the proportion of GDP should be further reduced, but the proportion of environmental protection, particularly carbon reduction, should be increased. A multi-objective evaluation system including economic development and environmental protection should be adopted. In addition, low-carbon development should be prioritized.

4.4 Limitation and future research

Same as many studies, there are some limitations in the current study. EDGAR provided the carbon emissions grid data up to 2010, so it is unavailable for the analyses after 2011. In particular, the Chinese government has paid more attention to environmental protection after 2012 (Yang et al., 2015), and the effect of local officials' performance on carbon emissions may change. In addition, only the promotion source, education, tenure and age were selected to reflect the heterogeneity of local officials, and these characteristics may be imperfect to reflect the differences between all local officials. Local officials' gender, as well as the careers of military, state-owned enterprises, universities, and others can also affect their promotion (Dreher et al., 2009; Ericson, 2009). More research on these areas will improve our understanding of local official promote and carbon emissions in China.

5 Conclusions

From the three aspects of promotion experience, pressure during current tenure and motivation for future promotion, a theoretical framework was constructed to explore the influence of local officials' promotion incentives on China's carbon emissions in 25 cities in the Yangtze River Delta. The results indicated that:

(1) Locally promoted mayors and municipal party secretaries had better performance of reducing carbon emissions, compared to officials transferred from other cities.

(2) With the increase in tenure, the effect of local officials on carbon emissions had an inverted U-shaped relationship.

(3) Younger local officials were more likely to lead to increase in carbon emissions.

(4) The increase in the local officials' academic levels did not promote a reduction in carbon emissions. However, local officials with economic or managerial professional backgrounds were more conducive to carbon reduction.

Therefore, encouraging promotion from their home cities, extending the tenure of local officials, and paying more attention to academic background rather than academic level can be helpful for China's carbon reduction.

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