# Financial Pressure, Energy Consumption and Carbon Emissions: A Quasi-Natural Experiment Based on the Educational Authority Reform

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At present, China is in the period of large-scale tax and fee cuts and external pandemic shocks. Local governments' financial pressure has intensified. There is a lack of existing studies on how it will affect local carbon emissions. This paper uses the quasi-natural experiment of the 2010 educational authority reform to measure exogenous changes in financial pressure. It adopts the continuous double differential method to empirically investigate the impact of local financial pressure on carbon emissions. The results of the paper are as follows. First, the financial pressure generated by the educational authority reform has significantly increased local carbon emission intensity. This indicates that local governments will address carbon emissions in other ways when they feel financial pressure. Second, to ease financial pressure, local governments will regulate high energy-consuming enterprises and utilize their high production value and strong tax-generating ability to scale up their production capacity and obtain more tax revenues, which will lead to a large amount of carbon emissions. This study is of important reference significance for how to deal with financial pressure from now on and how to well handle the relationship between local finance and carbon emissions.

**Keywords:** financial pressure, educational authority reform, high energy consuming enterprise, carbon emissions

## 1. Introduction

Carbon dioxide, the culprit of the greenhouse effect, not only damages the environment but also hinders the sustainable development of countries. China has set an exemplar in cutting its carbon emissions. In 2020, President Xi Jinping said for the

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first time that China would scale up its nationally determined contributions (NDC) by adopting more vigorous policies and measures, strive to peak $CO_2$ emissions before 2030, and achieve carbon neutrality before 2060. In 2021, China included carbon neutrality and carbon peaking in the Report on the Work of the Government. Although China has made great advances in reducing its carbon emissions,[1] it still has a long way to go before meeting its overall goal.[2] After entering the new normal, China has continued to slow down its economic growth. The country, affected by external shocks like the pandemic and the declining global economy, is not optimistic about its financial situation, with the revenue-expenditure imbalance intensified. For the country as a whole, the gap in fiscal revenue and expenditure increased from RMB 1.62 trillion in 2015 to RMB 3.76 trillion in 2020.[3] For provinces, their local governments face great financial pressure From 2015 to 2020, the public budget of each province cannot meet the expenditure and the gap is growing. By taking Sichuan Province as an example, under the double impact of tax and fee cuts and the epidemic, the revenue-expenditure gap in 2020 was as high as RMB 694.27 billion, which was 0.67 times higher than that in 2015. Other provinces also have serious revenue and expenditure shortfalls, with as many as 9 provinces with a gap of over RMB 450 billion.[4] As a result, financial pressure arising from revenue and expenditure shortfalls have forced the government to adopt a range of measures to increase revenue and alleviate pressure.

At present, the coexistence of increased financial pressure and intensified carbon emissions allows us to doubt their relationship. In other words, it is doubtable about whether the intensified carbon emissions are the result of local governments' distorted behaviors for easing financial pressure. For example, local governments encourage and support the fast development of energy-intensive enterprises to relieve financial pressure, which may lead to large amounts of carbon dioxide emissions. However, there is a lack of relevant empirical studies. Therefore, this paper explores the relationship between financial pressure and carbon emissions. First, it depicts financial pressure. In previous studies, financial pressure is mostly measured using the revenue-expenditure gap method. If carbon emissions are the result of the distorted behavior of local governments, the adoption of the revenue-expenditure gap may cause endogenous problems. On the one hand, financial behaviors result from financial pressure; and on the other hand, third-party factors that affect financial pressure and government behaviors (carbon emissions) may be omitted, leading to endogenous bias due to

[1] One of the effects: China's carbon emission intensity in 2019 dropped by about 48.1% over 2005.

[2] By the end of 2019, China's carbon dioxide emissions per unit of GDP were about 47.9% lower than in 2005, which remains a shortfall from the national carbon reduction target that "by 2030, the country's carbon dioxide emissions per unit of GDP will be more than 65%, a figure lower than in 2005". The data comes from *China's Policies and Actions for Addressing Climate Change (2020)*.

[3] The data are derived from the CEIC database.

[4] The remaining eight provinces are Henan, Hubei, Hunan, Hebei, Yunnan, Shandong, Jiangsu and Guangdong. The data is from db.cei.cn.

missing variables. To solve this problem, this paper uses the 2010 educational authority reform as a quasi-natural experiment to empirically test the impact of financial pressure on carbon emissions. The 2010 educational authority reform means that "the ratio of national financial expenditure on education to GDP should be gradually increased to 4% by 2012" as clearly stated in *China's National Outline for Medium and Long-Term Education Reform and Development Planning (2010–2020)*. To achieve this goal, local governments must squeeze funding for other projects out of their limited revenues for a short period of time, thus increasing their funds for education. This can easily lead to financial pressure on local governments.

New insights in this paper are reflected in the following aspects. First, from the perspective of financial pressure, the mechanism of carbon emissions is explored to study the relationship between financial pressure and carbon emissions. Most of the current studies focus more on the relationship between financing pressure and local government behavior, land transfer or bond financing. However, little attention is paid to the relationship between financial pressure and carbon emissions at the current stage. This paper adopts a new approach to exploring their relationship. Second, from a micro perspective, this paper takes the intersection of the energy-consuming industries mentioned in the *Energy Efficiency Benchmark and Baseline in Key Areas of High Energy-Consuming Industries (2021)* with the carbon market-covered industries in each pilot region of carbon emissions trading. It summarizes those with high energy consumption and high carbon emissions, matches them with the database of China's industrial enterprises to select those with high energy consumption and high carbon emissions, and constructs a pathway to explore the relationship between financial pressure, high energy-consuming enterprise and carbon emission. It may demonstrate the pathway role of high energy-consumption enterprises, meaning that local governments may govern high energy-consuming enterprises under financial pressure and expand their production and output. However, this leads to more carbon dioxide emissions. Third, China should not only maintain financial sustainability at this stage but also achieve the goals of carbon neutrality and carbon peaking. This paper has policy implications on how to coordinate financial sustainability and carbon emissions reduction.

## 2. Literature Review and Research Hypothesis

### *2.1. Literature Review*

Many scholars at home and abroad are focusing on studying financial pressure. Regarding the concept of financial pressure, the academic community has not yet reached a well-defined and uniform definition, but the mainstream literature such as Chen (2016), Xi *et al*. (2017a) and Xu *et al*. (2020) used the financial imbalance to define financial pressure. For the measurement of financial pressure,

scholars have various practices, mainly summarized in the following two ways. The first is the use of actual data to construct the financial pressure indicator. Some scholars focus on financial revenue and expenditure and use the difference to measure financial pressure, including the absolute value of financial revenue & expenditure gap (Gu and Cai, 2005), the absolute value of net financial revenue and the relative amount of net financial revenue to financial revenue (Zheng, 2020), the ratio of budget-based revenue & expenditure gap to budget revenue (Tang and Tang, 2017), and the financial self-sufficiency rate derived from the ratio of local financial revenue to expenditure (Cao *et al*., 2019). Other scholars have found a way to indirectly measure financial pressure, such as the financial pressure portrayed by the potential default rate of government debt (Zhu *et al*., 2019), the financial pressure measured by vertical financial imbalance (Chu and Chi, 2018), and the pressure measured by unexpected extrabudgetary revenue (Cao *et al*., 2014). The second uses quasi-natural experiment of policy shock to measure financial pressure. They include reflecting the change in financial pressure with the income tax share (Xu *et al*., 2020), calculating the change in financial pressure through the cancellation of the agricultural tax reform (Xie *et al*., 2017), measuring the change in financial pressure with the house purchase restriction policy (Zhao and Fan, 2021), explaining the change in financial pressure with that in the share of local value-added tax (Xi *et al*., 2017b), measuring the exogenous shock of financial pressure changes through replacing business tax with value-added tax (Cao *et al*., 2019), determining financial pressure with the quasi-natural experiment of educational authority reform (Xi and Huang, 2020), and measuring financial pressure of a city where the minister worked before his promotion (Fan, 2015).

Some scholars pay attention to the relationship between financial pressure and environmental pollution. Lu *et al*. (2019) found that the financial pressure caused by the replacement of business tax with value-added tax may significantly increases the environmental pollution in the sample area by more than 11%. Hu and Zong (2021) explored that financial pressure may aggravate trans-boundary air pollution. The closer to the provincial boundary, the more serious the air pollution; the greater the financial pressure, the more significant the boundary effect of air pollution. Peng and Dong (2019) used the abolition of agricultural tax reform as an indicator to measure financial pressure and explored the relationship between financial pressure and smog pollution. They found that after the abolition of agricultural tax, local financial pressure increased significantly. To alleviate the impact of the declining agricultural tax revenue, local governments ensured the stability of tax sources by reducing environmental regulations, which worsened the urban air quality.

Some scholars have begun to study carbon emissions in the light of the current goals of carbon peaking and carbon neutrality. Some literature studies calculation methods for carbon emissions, such as emission factor method, life-cycle assessment

(LCA) and input-output analysis (IOA) (Meangbua *et al*., 2019). Some literature researches the spatial distribution and evolutionary relationship of carbon emissions in China (Wu *et al*., 2018). Others study the influencing factors of carbon emissions, arguing that the industrial structure may affect the amount of carbon emissions (Yuan and Zhou, 2021), the per capita income in cities, the urban population and other factors may impact the carbon emissions (Tang *et al*., 2021). Some scholars study the impact of carbon emissions from a micro perspective, such as the impact of carbon emissions on the corporate leverage ratio (Chen *et al*., 2021), and the impact of carbon emissions from enterprises on stock returns (Han and Fan, 2021).

Although the factors influencing financial pressure and carbon emissions and the resulting impacts have been studied from multiple perspectives throughout the existing literature, few literature has linked the two aspects to analyze the mechanism and impact pathways of financial pressure and carbon emissions. Given this point, this paper conducts experimental work, creatively associates the two respects, and explores their relationship and transmission paths.

### *2.2. Research Hypothesis*

Based on the available literature, we speculate that carbon emissions may be the result of local governments' distortions to ease financial pressure and further analyze their relationship.

First, financial pressure, high energy-consuming enterprises and carbon emissions. A lot of literature presents that local governments' financial pressure is closely related to corporate behaviors (Li and Huang, 2021; Tao and Li, 2021). When the fiscal gap widens and financial pressure rises, local governments employ a variety of means to increase revenue and relieve financial pressure. For example, Xie *et al*. (2017), Hu and Zong (2021) found that the environmental deregulation is an important measure for local governments to ensure the stability of tax sources. Peng and Dong (2019) suggested that local governments may ease financial pressure by expanding industrial scale. Whether deregulation or scaling up, local governments should target local enterprises with high output value and tax-generating capacity, such as high energy-consuming industrial enterprises. The reason is that, from the perspective of industry attributes, high energy-consuming industries are mostly from manufacturing, with large output values and high tax burdens. They are high-tax industries, serving as an important source of local government's revenue (Tao *et al*., 2009; Fang and Zhang, 2013). There is a two-way causal relationship between high energy-consuming enterprises and economic development. In other words, they can mutually promote each other. Vigorously developing high energy-consuming enterprises can drive economic growth and create a large tax base for local governments (Xu *et al*., 2012). In addition,

according to the studies of Geng (2008), Wang and Zhong (2016), attracting high energy-consuming enterprises through deregulation and other means is an important means for local governments to drive local economic development and increase financial revenue. Therefore, when financial pressure increases, local governments may relax energy conservation regulations or energy consumption controls on high energy-consuming enterprises or introduce industrial policies conducive to their development to secure the tax base and narrow the fiscal gap. According to existing studies, when regulation is relaxed, enterprises usually increase their production capacity and efficiency (Xu and Qi, 2017). When the government seeks the development of the industrial sector, expansion and capacity increase occur naturally (Peng and Dong, 2019). In conclusion, this paper argues that the financial pressure alleviation measures implemented by the government may act on high energy-consuming enterprises to prompt them to expand their production and output, which will inevitably lead to large amounts of carbon dioxide emissions. This leads to the following hypotheses:

Hypothesis 1: Financial pressure may increase local carbon emissions, and the two are positively correlated.

Hypothesis 2: To ease financial pressure, a range of local government actions may lead to high energy-consuming enterprises expanding capacity and increasing output, resulting in a significant increase in local carbon emissions.

Second, financial pressure and existing high energy-consuming enterprise. The underlying premise for hypothesis 2 is that the number of high energy-consuming enterprises remains unchanged, and that the government relieves financial pressure through the stock channel (by changing the capacity of existing enterprises). It should be noted, however, that local governments may attract more enterprises when lowering the threshold of entry. For example, Liu *et al*. (2019) have verified that lowering the export tax rebate rate could enable high energy-consuming, high-polluting and resource-intensive enterprises to increase unevenly. In other words, in areas with greater financial pressure, lowering the export tax rebate rate can result in a significant rise in the number of such enterprises. It is thus conceivable that, if the government deregulates, high energy-consuming enterprises in other places may be inclined to locally establish plants. Even if the capacity of original enterprises remains unchanged (the stock channel is blocked), the total local capacity will increase and so will carbon emissions significantly, meaning that the incremental channel will play a more significant role in alleviating financial pressure on local governments. So, when financial pressure leads to an increase in local carbon emissions, does it have such an impact through existing or newly established enterprises, or both? This paper argues that the government relieves financial pressures through existing enterprises. The increase of local carbon emissions comes from existing enterprises' increased production capacity rather than new enterprises' capacity. There are two reasons. First, investment promotion requires

a variety of supporting preferential policies. Simply the deregulation method may not become a distinctive advantage for local governments to attract investment. Without other preferential policies, the possibility of enterprises entering the local market is not too high. The so-called other supporting preferential policies are often tax relief and financial subsidies. However, these policies are significantly contrary to the original intention of local governments to alleviate financial pressure. As such, it is of little possibility to introduce such policies. Second, it often takes a long time from the preliminary investigation to the formation of production capacity. Therefore, the way of reliance on newly established enterprises to relieve financial pressure timely cannot work in the short term. This paper therefore proposes the third hypothesis.

Hypothesis 3: The government relieves financial pressure through existing enterprises. The increase of local carbon emissions comes from existing enterprises' increased production capacity rather than new enterprises' capacity.

## 3. Research Design

### *3.1. Construction of Econometric Model*

This paper uses the index for measuring financial pressure as a quasi-natural experiment of educational authority reform. For the selection of such a quasi-natural experiment, there are two main reasons. First, the educational authority reform will make the superior government set a target for local governments, and local governments will rapidly expand the education expenditure to achieve the target, which may lead to the widening fiscal gap and the increasing pressures on governments (Xi and Huang, 2020; Guo, 2021). Therefore, the quasi-natural experiment can be used to measure financial pressure. Second, the educational authority reform is not related to enterprise behavior, so it can better avoid the impact of enterprise behavior on financial pressure. This reform is an impact on all parts of the country. The traditional double difference model cannot distinguish the treatment group from the control group according to whether it is impacted or not. In this paper, the continuous double difference method is adopted to solve this problem. The proxy variable of impact is set by the strength of reform impact. This is used to form an interactive term with impact time to obtain the treatment effect (Nunn and Qian, 2011). The model design is as follows:

$$y_{i,t} = \beta_0 + \beta_1 \times edurate_{i,t} \times policy_t + \beta_2 \times edurate_{i,t} + \beta_3 \times policy_t + \gamma X + \delta_i + \rho_t + \varepsilon_{i,t} \quad (1)$$

Where $y_{i,t}$ is the carbon intensity at city level and $policy_t$ denotes the policy dummy variable for the educational reform impact. The specific time when the reform target was proposed was in July 2010. Local governments prepared the budget

expenditures in the previous year. They were unlikely to immediately change the scale and structure of expenditures in that year. They could only meet the target by changing the next year's budget (Xi and Huang, 2020; Guo *et al*., 2021). There is also a lag in the utility of policies for enterprises after they are formulated. In addition, the data on carbon emissions are measured after emissions are discharged in that year. Carbon emissions in 2010 were less likely to be affected. Therefore, the time is set in 2011, that is, when $t \geqslant 2011$, it is $policy_t = 1$ and otherwise it is 0. For the selection of appropriate continuous variables is more critical, we refer to the practice of Xi and Huang (2020), using the 2010 data to construct the financial pressure indicator. Its main reason is that the proposed time of the policy was in July 2010 and most of the time was not subject to reform impacts, which may yield a certain effect on that year. In the implementation, the policy often takes a period of time to take effect. To put it differently, there is a lag in policy effects, so the paper uses the 2010 data to construct more of a conservative estimate based on due considerations. The goal of educational authority reform is that China's national education expenditures could reach 4% of GDP in 2012. It is possible to choose the areas where the educational share had reached 4% before the policy impact as the control group and the areas where it had not reached 4% as the treatment group. The logic is that the reform are more impactful on regions that have not yet reached the 4% share of education expenditures than on those that had already reached it in 2010. Therefore, the continuous variable $edurate_{i,2010}$ can be set and the formula is designed as follows:

$$edurate_{i,2010} = \begin{cases} 0.04 - education_{i,2010}, & if\, education_{i,2010} < 4\% \\ 0, & if\, education_{i,2010} \geqslant 4\% \end{cases} \tag{2}$$

Where $education_{i,2010}$ is the ratio of educational expenditure to GDP for each city in 2010. If the region *i* has reached the target of 4% of GDP in that year, it is $edurate_{i,2010} = 0$ and otherwise $edurate_{i,2010} = 0.04 - education_{i,2010}$. $education_{i,2010}$ and $edurate_{i,2010}$ may have a negative correlation. That is, when $education_{i,2010}$ is larger, $edurate_{i,2010}$ is smaller. The impact of reform on this place will be smaller and its financial pressure may be fewer.

In addition, there are other variables included in the model. $X$ is a series of control variables that may affect carbon emissions, including economic attribute variables (GDP per capita, investment in fixed assets, scientific expenditure, medical care & family planning expenditure, etc.), industrial attribute variables (proportions of primary and secondary industries, etc.), and enterprise attribute variables (total industrial output, enterprise deposits, etc.). In order to control the regional differences in localities and the time differences in years, the city fixed effect $\delta_i$ and year fixed effect $\rho_t$ are added to the model. $\beta_0$ is a constant term and $\varepsilon_{i,t}$ is a residual term. Since $edurate_{i,t}$ is

captured by city fixed effect in the same area in years, while the dummy variable for $policy_t$ is captured by time fixed effects. So, it is simplified as follows:

$$y_{i,t} = \beta_0 + \beta_1 \times edurate_{i,t} \times policy_t + \gamma X + \delta_i + \rho_t + \varepsilon_{i,t} \quad (3)$$

### *3.2. Variables and Data Description*

The sample period of the city-level data in this paper ranges from 2008 to 2014. The paper explains the financial pressure caused by the proportion of educational expenditure ( $edurate_{i,2010} \times policy_t$ ). The specific structure is as shown above. The continuous variable of the proportion of educational expenditure is calculated based on the proportion of educational expenditure to GDP. The data is from the CEIC database. The main explained variable in this paper is the carbon emission indicator or the carbon emission intensity, that is, the carbon emissions per unit of GDP. The calculation formula is the ratio of carbon emissions to GDP. The carbon emission indicator at city level is from the CEADs database. The control variables include economic attribute variable, industrial attribute variable and enterprise attribute variable. The data are from the CEIC database and the website db.cei.cn. The descriptive statistics of main variables are shown in Table 1.

Table 1. Descriptive Statistics of Main Variables

| Name of variable | Meaning of variable | Number of samples | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|---|---|
| *cgdp* | Carbon emission intensity (carbon emissions per unit of GDP, million tons/RMB 100 million) | 2030 | 2.251 | 1.320 | 0.225 | 8.999 |
| *edurate* | Impact strength variable, continuous variable | 2030 | 0.014 | 0.009 | 0 | 0.319 |
| *policy* | Policy dummy variable | 2030 | 0.571 | 0.495 | 0 | 1 |
| ln*fixed* | Investment in fixed assets (log, RMB 1 million) | 2030 | 11.161 | 0.918 | 7.680 | 14.095 |
| ln*sciexp* | Scientific expenditure (log, RMB 1 million) | 1993 | 5.203 | 1.292 | 1.891 | 10.249 |
| ln*pgdp* | GDP per capita (log, RMB) | 2029 | 10.327 | 0.635 | 8.285 | 12.267 |
| ln*mediexp* | Expenditures on medical care and family planning (log, RMB 1 million) | 1949 | 7.137 | 0.819 | 1.609 | 10.381 |

| Name of variable | Meaning of variable | Number of samples | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|---|---|
| ln*induop* | Gross industrial output value (log, RMB 1 million) | 2023 | 11.821 | 1.230 | 6.728 | 15.041 |
| ln*cordepos* | Corporate deposits (log, RMB 1 million) | 1671 | 10.229 | 1.369 | 7.184 | 15.662 |
| *fgdprate* | Proportion of primary industry | 2026 | 0.134 | 0.083 | 0.001 | 0.499 |
| *sgdprate* | Proportion of secondary industry | 2026 | 0.499 | 0.106 | 0.161 | 0.909 |

## 4. Empirical Analysis

### *4.1. Baseline Regression Results*

Table 2 reports the baseline regression results. Column (1) lists the regression results that control only the fixed effects of cities and years. Column (2) lists the regression results that control both the fixed effects of cities and years and a range of control variables. Column (3) lists the DK standard error results that address the three problems. The advantages of this method are the heterogeneity, sequence correlation and cross-sectional correlation adjustments for standard errors (Yang and Su, 2018). Column (1) of Table 2 shows that the financial pressure brought about by the educational authority reform has a significant positive correlation with carbon intensity and passes through a significance level of 1%. Column (2) shows that after controlling a series of control variables, the financila pressure and carbon intensity are still at a significance level of 1%, and the financial pressure coefficient is 7.334, indicating that when the financial pressure is heavy, and so will the local carbon intensity. DK standard error results in Column (3) also show a positive correlation and are presented at a significance level of 5%. From the regression results in the three columns, it is known that financial pressure will have a significant positive impact on local carbon intensity. The greater the pressure, the greater the carbon intensity. It further indicates that local governments may allow for more carbon emissions to ease financial pressure.

Table 2. Baseline Regression Results

| | *cgdp* (1) | *cgdp* (2) | *cgdp* (3) |
|---|---|---|---|
| $edurate_{i,2010} \times policy_t$ | 8.912*** | 7.334*** | 7.334** |
| | (6.30) | (3.78) | (3.42) |

| | *cgdp* (1) | *cgdp* (2) | *cgdp* (3) |
|---|---|---|---|
| Whether to include control variables | No | Yes | Yes |
| City fixed effects | Control | Control | Control |
| Year fixed effects | Control | Control | Control |
| Sample size | 2030 | 1622 | 1622 |
| $R^2$ | 0.506 | 0.546 | 0.546 |

Note: The *t*-values are in parentheses. ***, ** and * denote *t*-statistic values significant at the 1%, 5%, and 10% levels, respectively. The same below.

### *4.2. Parallel Trend Test*

The important premise of adopting the double differential model is that the treatment and control groups must have the same development trend before the policy is implemented. Or there is no obvious trend difference between the two groups before the implementation. This paper chooses the event study method for parallel trend test. This is done by generating $year_t$ as a dummy variable representing the year. It is 1 when the year is *t*, and otherwise it is 0. It forms an interaction term with $edurate_{i,2010}$. The formula is as follows:

$$y_{i,t} = \beta_0 + \sum_{t=2009}^{2010} \beta \times edurate_{i,2010} \times year_t + \gamma X + \delta_i + \rho_t + \varepsilon_{i,t} \quad (4)$$

The regression results are shown in column (1) of Table 3, where the coefficient exhibits a non-significant positive correlation at the 2008 base period before the policy shock point, i.e., before 2011. Therefore, it can be determined that the treatment and experimental groups have the same trend before the policy shock of educational authority reform.

### *4.3. Placebo Test*

To further observe the differences between the experimental group and the control group at non-policy shock points, the policy time variable is also assumed to be a placebo test in other years, which is performed as follows. First, this paper selects the samples before the policy, i.e., before 2011, for the placebo test. It sets the time of the educational authority reform in 2009 and 2010. The regression results are shown in columns (2) and (3) of Table 3, respectively. Meanwhile, a sample of the time after the educational authority reform was selected for the placebo test. The time of the reform was set in 2013 and 2014. The empirical results are shown in columns (4) and (5) of Table 3.

Table 3. Parallel Trend and Placebo Test

| | *cgdp* (1) Common trend test | *cgdp* (2) 2009 as a policy point | *cgdp* (3) 2010 as a policy point | *cgdp* (4) 2013 as a policy point | *cgdp* (5) 2014 as a policy point |
|---|---|---|---|---|---|
| $edurate_{i,2010} \times policy_t$ | | 2.511 (1.27) | 3.502 (1.28) | 2.938 (1.09) | –1.703 (–0.24) |
| $edurate_{i,2010} \times year_{2009}$ | 1.823 (1.20) | | | | |
| $edurate_{i,2010} \times year_{2010}$ | 1.332 (0.91) | | | | |
| Whether to include control variables | Yes | Yes | Yes | Yes | Yes |
| City fixed effects | Control | Control | Control | Control | Control |
| Year fixed effects | Control | Control | Control | Control | Control |
| Sample size | 1073 | 1327 | 1327 | 1327 | 1327 |
| $R^2$ | 0.464 | 0.545 | 0.644 | 0.643 | 0.643 |

According to the empirical regression results, it can be concluded that whether the hypothetical impact was set before the reform or the hypothetical impact was set after the reform. Neither the experimental group nor the control group showed obvious differences. This partly explains the exogenous nature of the educational authority reform and the robustness of the benchmark regression results.

### *4.4. Robustness Test*

#### 4.4.1. Replacement of Indicators

Traditionally, financial pressure refers to that between fiscal revenue and expenditure or caused by the fiscal gap. Therefore, the main explanatory variable is replaced with the revenue-expenditure gap (ln*gap*), i.e., the expenditure minus the revenue. The explained variable is replaced with carbon emissions (ln*c*). According to the results in columns (1) ~ (3) of Table 4, the relationship between financial pressure and carbon emissions remains significantly positive.

#### 4.4.2. Shortening the Window

Considering that the goal of educational authority reform has a high timeliness, it was presented in July 2010 and the goal was to be achieved in 2012. Therefore, robustness tests are conducted by reducing the original sample to capture the impact of financial pressure on carbon emissions from the short-term goal. Specifically, the

sample time was shortened to the period 2009–2012. The regression results in columns (4) ~ (6) of Table 4 show that the financial pressure still has a significant positive effect on the carbon intensity, which is highly consistent with the baseline regression conclusion and further supports the original conclusion.

Table 4. Robustness Test 1

| | ln*c* (1) 2008–2014 | ln*c* (2) 2008–2014 | ln*c* (3) 2008–2014 | *cgdp* (4) 2009–2012 | *cgdp* (5) 2009–2012 | *cgdp* (6) 2009–2012 |
|---|---|---|---|---|---|---|
| $edurate_{i,2010} \times policy_t$ | | | | 5.320*** (3.54) | 7.379*** (3.24) | 7.379** (3.40) |
| ln*gap* | 0.030*** (3.94) | 0.026*** (3.08) | 0.023*** (4.81) | | | |
| Whether to include control variables | No | Yes | Yes | No | Yes | Yes |
| City fixed effects | Control | Control | Control | Control | Control | Control |
| Year fixed effects | Control | Control | Control | Control | Control | Control |
| Sample size | 2007 | 1622 | 1622 | 1160 | 1030 | 1030 |
| $R^2$ | 0.747 | 0.791 | 0.791 | 0.366 | 0.411 | 0.411 |

4.4.3. Robustness Test for Cross-Section-Related Problems

One of the characteristics of panel data is that there are different degrees of correlation between its cross-sections, which results in correlation between cross-section heterogeneity or regression error items. This affects the unbiasedness, consistency and validity of standard panel data estimates. The interactive fixed-effect model developed by Bai (2009) controls the cross-sectional correlation by introducing common factors that affect cross-sectional units. The model is set as follows:

$$y_{i,t} = \mu + \alpha_i + \theta_t + x_{i,t}^T \beta + v_{i,t} + \varepsilon_{i,t} \tag{5}$$

Where $v_{i,t} = \sum_{l=1}^{d} \lambda_{i,l} f_{l,t}$.

The above panel model differs from the traditional one in that the interaction fixed effect model introduces a random term $v_{i,t}$, where $f_{l,t}$ is a time-varying factor only, $\lambda_{i,l}$ is a factor loading that varies only with individuals, and $l$ is the number of factors. It is the presence of common factors that leads to the significant correlation between cross-sectional units. The regression results are shown in column (1) of Table 5. Financial pressure has a positive effect on carbon emission intensity at the significance

level of 5%, verifying that they do affect local carbon emissions after controlling for cross-sectional correlation.

4.4.4. Excluding Cities with Independent Planning Authority or Sub-Provincial Cities

In considering cities with independent planning authority or sub-provincial cities, it is easy to meet the goal of educational authority reform or have an advantage in carbon emissions. Therefore, this paper adopts the practice of excluding these cities based on the original sample to conduct robustness test. The regression results in columns (2) and (3) of Table 5 show that financial pressure has a positive effect on carbon emission intensity and pass the 1% significance test, which further supports this paper's basic conclusion.

4.4.5. Reclassification of Experimental and Control Groups

In this paper, the core continuous variable $edurate_{i,2010}$ is constructed by using the 2010 data. Considering that there may be deviations in the original processing method, some cities act faster. After receiving the policy, the robustness test is further conducted to construct the financial pressure indicator with the 2009 data and the corresponding policy dummy variable is also changed. When $t \geqslant 2010$, it is $policy_t = 1$ and otherwise 0. The robustness of the regression conclusion is shown in equation (6). Column (4) of Table 5 indicates that financial pressure has a positive effect on carbon emission intensity and pass the significance test of 5%.

$$y_{i,t} = \beta_0 + \beta_1 \times edurate_{i,2009} \times policy_t + \gamma X + \delta_i + \rho_t + \varepsilon_{i,t} \tag{6}$$

Table 5. Robustness Test 2

| | Control cross-sectional correlation *cgdp* (1) | Excluding cities with independent planning authority *cgdp* (2) | Excluding sub-provincial cities *cgdp* (3) | Replacement of main explanatory variables *cgdp* (4) |
|---|---|---|---|---|
| $edurate_{i,2010} \times policy_t$ | 5.490** (2.50) | 7.088*** (3.58) | 7.303*** (3.74) | |
| $edurate_{i,2009} \times policy_t$ | | | | 4.237** (2.51) |
| Whether to include control variables | Yes | Yes | Yes | Yes |
| City fixed effects | Control | Control | Control | Control |
| Year fixed effects | Control | Control | Control | Control |
| Sample size | 1622 | 1374 | 1407 | 1622 |
| $R^2$ | 0.993 | 0.547 | 0.546 | 0.545 |

## 5. Path Analysis

The above baseline regression and robustness test regression results show that financial pressure significantly affects the intensity of local carbon emissions. When local governments face financial pressure, it is the way they choose to address it, and how this affects local carbon emissions, that this paper needs to explore further.

Main emitters are mostly micro-entities like residents and enterprises. Residents who burn more coal for heating will generate a large amount of carbon dioxide, but this part is not taken into consideration. First, due to the increasing importance of environmental protection in recent years, residents use less fuel. Second, due to the comprehensive coverage of central heating, residents are less likely to emit carbon dioxide. Third, burning fuel for heating is a rigid need. The magnitude of financial pressure will not have a significant impact on carbon dioxide emissions or cause a significant change in carbon emissions by them. As such, local governments under financial pressure tend to govern micro-enterprises, especially those with high energy consumption, which emit large amounts of carbon dioxide. Further analysis of why governance is focused on micro-enterprises, especially high energy consuming ones. This paper attributes this to the fact that high energy-consuming enterprises generally have higher output and tax-generating capacity. When local governments are under financial pressure, they tend to relax energy regulation or energy consumption control on such enterprises and prompt them to expand their production capacity and output to create more tax base for them.

First, according to the *Notice on Energy Efficiency Benchmark and Baseline in Key Areas of High Energy Consuming Industries (2021)* issued by China's National Development and Reform Commission, this paper defines high energy-consuming industries. Second, this study summarizes according to the carbon market-covered industries in each pilot region in 2019. Then, the paper takes the intersection of industries and lists those with higher carbon emissions and higher energy consumption. Finally, the summarized industries are matched in the database of Chinese industrial enterprises to obtain over 470000 enterprises from 2008 to 2013. The data at the enterprise level are aggregated at city level.[1]

This section verifies whether local governments are under financial pressure through their governance over existing enterprises (i.e., existing enterprises with high energy consumption and high carbon emissions) or through the introduction of such enterprises, or both. By referring to the research of Acemoglu *et al*. (2013) and Fang and Zhang (2013), the identification method of channel analysis is back-extrapolated and distinguished

[1] Ideally, municipal-level industry summaries should be used because industrial enterprises above the designated size do not fully include all high energy-consuming ones. However, the industry data of cities are generally summarized and calculated according to the first-level indicators in the National Economic Industry Classification. The classification level is high, so it is impossible to accurately separate high energy-consuming industries. Therefore, this paper uses the data from industrial enterprises above designated size and sum them up to those of prefecture-level cities for empirical analysis.

by introducing the incremental channel of enterprises with high energy consumption and carbon emissions. Through the aforementioned method, a matching summary is made in the database of Chinese industrial enterprises to find out those with high carbon emissions and high energy consumption each year. According to the change in their number each year, the growth rate is calculated and included in the regression analysis (see equation (7)). As shown in column (1) of Table 6, it can be seen that the financial pressure has no significant impact on the growth rate of high energy-consuming enterprises. As such, local governments under financial pressure may not introduce enterprises with high energy consumption and high carbon emissions as an incremental channel. Regarding the reason, this paper argues that the incremental channel of attracting investment is lees effective in giving full play to the timing of increasing fiscal revenue. The newly introduced enterprises may also enjoy a package of preferential policies, such as tax preferential policy in previous years. On the contrary, the governance over the existing high energy-consuming enterprises can get the immediate effect. They pay a large amount of tax to ease financial pressure while emitting more carbon dioxide.

This paper further verifies the relationship between local government's financial pressure and enterprise with high carbon emissions and high energy consumption. In selecting existing enterprises, the paper adopts the method of excluding the enterprises whose establishment time is later than that year to keep the sample of existing enterprises. First, the correlation between local governments' financial pressure and operating incomes of existing enterprises with high carbon emissions and high energy consumption is verified to determine whether micro enterprises will obtain more incomes when local governments are under financial pressure and thus pay more taxes to relieve the pressure. Therefore, the operating incomes of enterprises with high carbon emissions and high energy consumption matched with the data of Chinese industrial enterprises are summed up to the prefecture level to obtain the prefecture-level revenue data (ln*rev*), which are included in the regression of equation (7). To verify the tax relationship more intuitively between financial pressure and enterprises with high carbon emissions and high energy consumption, this paper also adds their main business taxes and surcharges to the prefecture-level data to obtain their main business taxes and surcharges (ln*maintax*) and incorporate them into the regression of equation (7). In addition, the business taxes and surcharges of such enterprises that are matched with the data of Chinese industrial enterprises are summed up to the prefecture-level data to obtain the prefecture-level business taxes and surcharges (ln*satax*), which are included in the regression of equation (7). The above results are shown in columns (2) ~ (4) of Table 6. The financial pressure is positively correlated with operating incomes, taxes and surcharges of such enterprises. Their taxes and surcharges are all at a significant level of 1%. Therefore, it is verified that local governments will govern the micro enterprises with high carbon emissions and high energy consumption when they are under financial pressure, thus obtaining more tax revenues to relieve financial pressure.

$$y_{i,t} = \beta_0 + \beta_1 \times edurate_{i,t} \times policy_t + X\gamma + \delta_i + \rho_t + \varepsilon_{i,t} \quad (7)$$

In equation 7, $y_{i,t}$ represent the growth rate of the enterprise number (*increase*), operating income (ln*rev*), taxes and surcharges on main business (ln*maintax*), and taxes and surcharges (ln*satax*), respectively.

Table 6. Path Analysis 1

| | *increase* (1) | ln*rev* (2) | ln*maintax* (3) | ln*satax* (4) |
|---|---|---|---|---|
| $edurate_{i,2010} \times policy_t$ | 248.723 (1.51) | 29.767*** (4.34) | 23.700*** (3.10) | 34.762*** (4.50) |
| Whether to include control variables | Yes | Yes | Yes | Yes |
| Year fixed effects | Control | Control | Control | Control |
| City fixed effects | Control | Control | Control | Control |
| Sample size | 926 | 1206 | 1206 | 1206 |
| $R^2$ | 0.035 | 0.991 | 0.973 | 0.978 |

Finished products of enterprises with high carbon emissions and high energy consumption are considered the most direct channel linking local governments' financial pressure with carbon emissions. To further verify the carbon emission pathway of micro enterprises, especially those with high carbon emissions and high energy consumption, the products of the enterprises that are matched with the data of Chinese industrial enterprises are summed up to the prefecture-level data. The prefecture-level finished product data (ln*figd*) are included as the intermediary channel in the following three equations to verify the path of financial pressure and carbon emissions and obtain the regression results in Table 7.

$$y_{i,t} = \beta_0 + \beta_1 \times edurate_{i,t} \times policy_t + X\gamma + \delta_i + \rho_t + \varepsilon_{i,t} \quad (8)$$

$$\ln figd_{i,t} = \beta_0 + \beta_1 \times edurate_{i,t} \times policy_{t+} + X\gamma + \delta_i + \rho_t + \varepsilon_{i,t} \quad (9)$$

$$y_{i,t} = \beta_0 + \beta_1 \times edurate_{i,t} \times policy_t + \beta_3 \ln figd_{i,t} + X\gamma + \delta_i + \rho_t + \varepsilon_{i,t} \quad (10)$$

Table 7. Path Analysis 2

| | Equation (8) | Equation (9) | Equation (10) |
|---|---|---|---|
| | *cgdp* (1) | *lnfigd* (2) | *cgdp* (3) |
| $edurate_{i,2010} \times policy_t$ | 7.551*** (3.72) | 17.113*** (2.59) | 3.275** (1.90) |

| | Equation (8) *cgdp* (1) | Equation (9) *lnfigd* (2) | Equation (10) *cgdp* (3) |
|---|---|---|---|
| ln*figd* | | | 0.021** (2.06) |
| Whether to include control variables | Yes | Yes | Yes |
| Year fixed effects | Control | Control | Control |
| City fixed effects | Control | Control | Control |
| Sample size | 1206 | 1206 | 1206 |
| $R^2$ | 0.523 | 0.982 | 0.763 |

Column (1) of Table 7 is the paper's baseline regression. Due to data feasibility limitations, its time is changed to 2008–2013. The results show that financial pressure has a positive effect on local carbon emissions. The regression coefficient is 7.551, and it is significant at the 1% level. Column (2) regresses financial pressure as an independent variable using the ln*figd* data as the dependent variable. The result shows that the financial pressure is positively correlated with the 1% significance level of finished products of high energy-consuming enterprises. Column (3) incorporates the indicator of high energy-consuming enterprises' finished products into the baseline regression model. It is found that the indicator exhibits a positive correlation with carbon emissions and passes the 5% significance test. To put it differently, the higher the carbon emissions of the enterprises, the higher the carbon intensity. However, financial pressure has a positive impact on local carbon intensity at a significance level of 5%. The coefficient is 3.275, which is 4.276 lower than the coefficient listed in column (1) of Table 7. This proves the path role of high energy-consuming enterprises in producing finished products. Therefore, the above conclusion is verified. When local governments are under financial pressure, high energy-consuming enterprises with high output and strong tax-generating ability expand their production capacity and output, thus creating more tax bases for local governments. However, their increased output may cause a large amount of carbon emissions. Therefore, hypotheses 2 and 3 are verified.

## 6. Conclusions and Recommendations

How can local governments relieve financial pressure when faced with the imbalance of revenue and expenditure or with the hard task of meeting policy targets? Does this affect carbon emissions? How does it affect carbon emissions? The exploration of this set of issues not only provides lessons for local governments to relieve financial pressure, but also helps them to achieve a win-win situation between achieving the goals of fiscal sustainability and carbon neutrality. This paper uses the educational authority reform to capture exogenous changes in financial pressure and examines the impact of financial pressure on carbon emissions.

Empirical studies have found that financial pressure can significantly affect local carbon emissions in a positive way, meaning that local governments can solve financial pressure through other methods. But the methods generate large amounts of carbon dioxide. Further research has found that when local governments are under financial pressure, they govern high energy-consuming enterprises with high output and strong tax-generating capacity (easing energy-saving regulation or energy-consumption control) to increase their output and create more tax bases. The output increase may cause large amounts of carbon emissions.

The research in this paper supplements the existing literature on the relationship between financial pressure and carbon emissions, enriches the understanding of the ways in which financial pressure is relieved, and helps us gain a deeper understanding of local government behaviors. Based on this study, the following policy recommendations are made.

First, we need to find a way to resolve financial pressure. This study demonstrates that local governments may create more tax bases by increasing the output of enterprises with high energy consumption and high carbon emissions to ease their financial pressure. This way of relieving financial pressure is not science-based or even runs counter to the goals of carbon neutrality and carbon peaking. It is impossible to achieve win-win results. Therefore, we should face up to financial pressure, and adopt a proper approach to resolving it. It is important to pay attention to the following two points: firstly, the modern fiscal and tax system should be improved to establish a fiscal system that matches the power and expenditure responsibility and rationally divide the expenditure responsibility among governments at all levels based on the sound division of power; secondly, the budgetary system should be refined to make adequate planning in advance, respond in a timely manner and learn from experience afterwards. In addition, it is possible to relieve financial pressure by improving management efficiency.

Second, we, in achieving the goal of carbon neutrality and carbon peaking, should focus on mitigating the negative effects of financial pressure from local governments. The research suggests that the current excessive carbon emissions are largely due to the behavior of local governments governing micro-enterprises in order to relieve financial pressure. This method can indeed relieve financial pressure in the short term and give high energy-consuming enterprises a certain development space. But in the long run, this method may cause more carbon emissions and environmental pollution. Reducing carbon emissions for subsequent environmental control will exacerbate financial pressure, adversely affect the development of Chinese enterprises and the upgrading of the industrial structure, and ultimately form a vicious circle. Therefore, we need to take a long-term view on the path of carbon neutrality and carbon peaking and focus on mitigating the negative effects of financial pressure.

Third, we need to accelerate innovation among enterprises and refine and upgrade industrial structure. Local governments can defuse financial pressure by acting on high energy-consuming micro-enterprises, which imposes higher requirements on enterprises. They not only meets local governments' requirements for more output and taxes but also satisfies human needs for less pollution and carbon emissions. It is

necessary to expedite enterprise innovation and refine and upgrade industrial structure by adopting internal and external methods. Externally, local governments need to provide a better environment for enterprise innovation, adopt fiscal incentives, and put in place fiscal and tax policy for innovation, with a focus on rewarding innovation-oriented enterprises. Internally, enterprises need to raise their innovation awareness, increase investment in innovation research, and attract more high-quality talents, ultimately realizing the transformation and upgrading of the entire industry.

Fourth, all actions will be taken to promote full coverage of the pilot program on carbon emissions trading. Meeting the goal of carbon peaking and carbon neutrality requires national, industry-wide and community-wide efforts. Firstly, the state should cut carbon emissions through various combination policies, such as meeting the standard for carbon emissions. Secondly, various industries should increase investment in and development of low-carbon environmental technologies, strengthen innovation in such technologies, and strengthen pollution remediation efforts. Thirdly, residents should enhance their environmental awareness by starting with waste sorting, energy conservation and consumption reduction. Finally, we need to implement carbon emissions trading pilots, summarize the experience of pilot regions, and constantly improve carbon emissions trading process and methods to achieve full coverage.

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