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Effect of Intergovernmental Fiscal Transfers on Energy Consumption in China

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Abstract: After the 1994 tax-sharing reform, the central government in China used inter-governmental fiscal transfers (IFTs) to improve local governments' fiscal imbalance and to regulate local economic development. Based on China's provincial panel date from 1998 to 2019, we examine the impact of IFTs on energy consumption. The results show that IFTs exert a significant positive effect on energy consumption, a one percentage increase in the IFTs leads to 12.4 percentage increase in energy consumption. Meanwhile, the Mediating Effect model show that IFTs leads to Education Expenditures (EDUEs) expand, which significantly increase energy consumption with the mediating effect 32.59%. Besides, IFTs leads to Pat reduce, which significantly decrease energy consumption with the suppression effect. This indicates that IFTs not only increase energy consumption through education expenditures, but also suppress the science and technology innovation, resulting in a decrease in the positive effect on energy consumption. From the perspective of policy recommendations, this study suggests that the Chinese central government should de-sign a more reasonable distribution model, establish a systematic assessment system that includes green GDP for government officials, and improve the structure of expenditure on education, which help realizing the purpose of decreasing energy consumption.

1. Introduction

In recent years, climate anomalies have been frequent everywhere, constantly re-minding us that environmental issues are a problem that cannot be ignored in this era. The reason is that in China's energy consumption structure, coal consumption once accounted for more than 70% of all fuel use, and a large amount of carbon emissions caused serious environmental pollution and jeopardised the healthy development of the economy [1]. The above issues receive increasing attention in China, and to reduce carbon emissions, the Chinese government proposed several plans to reduce energy consumption.

The IFT system is an important fiscal policy aiming to equalise public services. The central government also relies on this means to achieve a degree of regulation of the provincial economy or

as a tool to help the central government accomplish certain policy goals, including reducing energy consumption and improving environmental quality [2]. However, few studies have focused on IFTs on energy consumption. Liu and Guan [3] analysed the fiscal decentralisation and IFTs that promotes growth in energy consumption by upgrading the industrial structure. In addition, the influence of IFTs on EC distorts local government behaviour, and previous studies have failed to consider the role of local government among them.

The contributions of this study are as follows. First, this study uses provincial panel data for China from 1998 to 2019 and provides an analysis of institutional factors on energy conservation and emphases the importance of IFTs. Second, this study dis-cusses the mechanism of this effect and explore whether IFTs, mainly through local government expenditures, ultimately produce this effect.

The remainder of this paper is organised as follows. Section 2 reviews the existing literature and discusses research hypotheses. Section 3 presents the analysis strategy, variable definition and data interpretation. Section 4 provides the empirical results, and Section 5 summarises the conclusions and policy implications.

2. Literature Review and hypothesis development

2.1. Literature Review

In the extant literature, several articles focused on the impact of transfer payments on environmental pollution including reducing carbon emissions. However, few studies examined the impact of transfers on energy consumption. Cao et al [4] examined the role of ecological transfer payments in China in affecting the governance environment of local governments. They found that ecological transfers have a significantly positive effect on the process of local governments' endeavours to improve environmental quality. However, ecological transfers do not promote ecological improvements. Non-ecological transfers (non-ETPs) are designed to take ecological and environmental considerations into account, but non-ETPs do not work effectively as an incentive role. Syaifudin, Sutrisno, and Setiawan [5] constructed a computable general equilibrium model to examine the effect of fiscal transfers on the implementation of energy policies by local governments in Indonesia. The study found that fiscal transfer can improve the positive energy efficiency effect of economic growth and reduce car-bon emissions. Gong, Zhang, and Liu [6] estimated the effectiveness of ecological fiscal transfers in reducing industrial pollution in China's national priority ecological function areas based on propensity score matching–difference-in-differences methods. Their study found that ecological fiscal transfers can contribute to reducing intensive polluting activities in the national priority ecological function areas. Liu and Guan [3] investigated the changes in energy consumption under the combined effect of fiscal decentralisation and IFTs. They found that IFTs not only show a facilitative role in in-creasing energy consumption but also play a moderating role in the impact of fiscal decentralisation on energy consumption. In addition, their study showed that an up-grade of industrial structure is an intermediate mechanism for a positive impact.

To summarise, the impact of IFTs on EC has not received sufficient attention from scholars. Most importantly, such studies did not explore the mechanism of this impact, which is the changes in local government expenditure behaviour, stimulated by IFTs, and affects energy consumption ultimately. Our present study aims to investigate whether and how IFTs affect energy consumption, and analyse the heterogeneity of this effect across different regions of China.

2.2. Hypotheses

Whether from the perspective of economic indicators or local fiscal revenues and expenditures, local governments are under pressure to develop their economies rapid-ly. In addition, local

governments have a strong incentive to devote financial resources to high energy consumption projects that can develop the regional economy rapidly[7]. Therefore, the study proposes the following hypothesis:

Hypothesis 1. Ceteris paribus, the effect of IFTs on energy consumption is positive.

Hypothesis 2. Ceteris paribus, IFTs increase EDUEs, thereby increasing energy consumption.

Hypothesis 3. Ceteris paribus, IFTs decrease science and technology innovation, thereby diminishing the positive effect of IFTs on energy consumption.of IFTs on energy consumption.

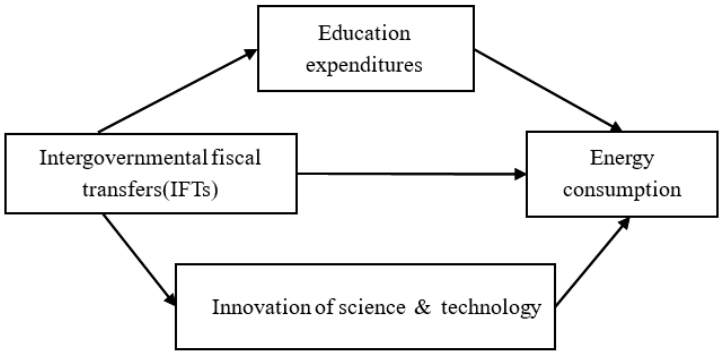

Figure 1: Research model with constructs.

The study depicts the model in Figure 1 based on the proposed theoretical analy-sis and hypothesis to illustrate the relationship between the above variables more clearly. The subsequent empirical analysis of this study will be conducted based on this research model.

3. Empirical strategy and data explanation

3.1. Empirical models

The article uses Fixed Effects Model (FEM) to analyze the effect of IFTs on energy consumption. In the FEM, the Time-fixed effect can solve the Omitting Variables that caused by time varying rather than caused by individual invariant.

Likely, the Region-fixed effect can solve the Omitting Variables that caused by region varying rather than caused by individual invariant.

Based on panel regression model, this study examines the effects of IFTs on energy consumption using stata17. Also, based on the mediation model, the article examines the mechanism of EDUs and PAT on energy consumption.

$$lnEC_{it} = \alpha_o + \alpha_1 lnIFTs_{it} + \alpha_k lnX_{it} + \mu_i + \nu_t + \varepsilon_{it}. \quad (1)$$

$$lnEDUEs_{it} = \beta_0 + \beta_1 lnIFTs_{it} + \beta_k lnX_{it} + \mu_i + \nu_t + \varepsilon_{it}, \quad (2)$$

$$lnEC_{it} = \gamma_0 + \gamma_1 lnIFTs_{it} + \gamma_2 lnEDUEs_{it} + \sigma k lnX_{it} + \mu_i + \nu_t + \varepsilon_{it}. \quad (3)$$

$$lnPAT_{it} = \delta_0 + \delta_1 lnIFTs_{it} + \delta_k lnX_{it} + \mu_i + \nu_t + \varepsilon_{it}, \quad (4)$$

$$lnEC_{it} = \theta_0 + \theta_1 lnIFTs_{it} + \theta_2 lnPAT_{it} + \theta k lnX_{it} + \mu_i + \nu_t + \varepsilon_{it}. \quad (5)$$

3.2. Data

The study shows the descriptive statistics of each variable in Table 1. The tax-sharing reform started in 1994, but the sample period is from 1998 to 2019 (22 years) because the Chinese central government separated Chongqing from Sichuan in 1997. This study covers 30 provinces in China. One reason is that the data for Xizang are severely lacking, and another reason is that Hong Kong,

Macau and Taiwan, China have different IFT systems from other regions of China. Therefore, the scope covers only the remaining 30 provinces. Sources of data include the Statistical Yearbook of China (SYC), the Financial Yearbook of China (FYC) and the China Energy Statistical Yearbook (CESY). PLT data are obtained by collecting resumes of ministers on the Chinese government website. Finally, the study derived a balanced panel of 660 observations. To avoid the effect of heteroskedasticity, the study takes logarithms for all variables except PLT.

Table 1: Statistical description of all the variables.

Symbol	Variable and Units	Observations	Source	Mean	Std.dev.	Min	Max
EC	Energy consumption per capita tons of standard coal / person	660	CESY	0.852	0.599	-0.726	2.367
IFTs	Intergovernmental fiscal transfers yuan($)/person	660	FYC	-0.890	0.541	-2.627	-0.086
IS	Industrial structure % yuan($)	660	SYC	-0.889	0.190	-1.252	-0.180
UR	Urbanization rate % person	660	SYC	-0.762	0.348	-1.963	-0.110
OPEN	Regional openness % yuan($)	660	SYC	-1.742	0.966	-4.477	0.512
FIND	Financial development % yuan($)	660	SYC	-3.097	0.537	-6.131	-1.628
ECS	Energy consumption structure % tons of standard coal	660	CESY	-0.126	0.445	-3.695	0.901
PAT	Number of patents one piece / ten thousand person	660	SYC	0.607	1.468	-2.169	4.097
EDUEs	Education expenditures yuan($)/person	660	SYC	6.427	1.134	4.041	8.555
PLT	Political affiliation (Score)	660	-	2.594	5.300	0.000	29.000

4. Results

First, the study concentrates on verifying whether IFTs have a significant effect on energy consumption according to Eq. 1. Then, the study proceeds to robustness checks of the baseline regression results, including changing the variable definitions, changing the sample size, lagging the explanatory variables by one period and using alternative regression methods. Finally, the study examines the mechanisms of IFTs on energy consumption through EDUEs and innovation of science and technology according to Eqs. (2)–(5).

4.1. Baseline regression results

Table 2 presents the results of the baseline regression estimation. Based on Fixed Effects Model, Year FE means the Time-fixed effect, and the Province FE means Region-fixed effect. As for the constant terms(_CONS), it is common to add the intercept terms in the panel data regression that using Stata17, or the R2 is useless. _CONS rep-resent some other unlisted variables that effect energy consumption.

All six models indicate that IFTs exert a significant positive effect on energy consumption. The first model only contains IFTs as an explanatory variable, and columns (2)–(6) also contain the

remaining control variables. As column 6 contains all control variables and gives the most accurate results, the study uses it as the preferred model.

Table 2: Main estimation results.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
IFTs	0.320***	0.306***	0.192***	0.197***	0.191***	0.124***
	(5.67)	(5.75)	(4.23)	(4.25)	(4.18)	(3.13)
IS		-0.660***	-0.610***	-0.603***	-0.649***	-0.713***
		(-8.77)	(-8.17)	(-8.09)	(-8.84)	(-10.45)
UR			0.434***	0.453***	0.436***	0.335***
			(6.46)	(6.58)	(6.36)	(5.45)
OPEN				-0.0385*	-0.0481**	-0.0452**
				(-1.81)	(-2.39)	(-2.32)
FIND					0.0731***	0.0598***
					(3.70)	(3.24)
ECS						0.255***
						(9.33)
_CONS	1.137***	0.538***	0.812***	0.771***	0.920***	0.723***
	(22.03)	(7.50)	(9.42)	(8.32)	(8.68)	(7.79)
Province FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
R^2	0.9439	0.9496	0.9546	0.9549	0.9555	0.9630
F	32.20	45.20	45.74	33.73	32.39	50.31
Observations	660	660	660	660	660	660

4.2. Robustness checks

This study performs a series of robustness tests based on the preferred research model (column (6) of Table 2) in this section to verify the reliability of the above findings. Table 3 shows the results of the robustness tests. The results for all four models confirm that the baseline regression results are robust.

Table 3: Robustness checks.

	(1)	(2)	(3)	(4)
IFTs	0.151***	0.141***	0.110***	0.560**
	(3.93)	(3.80)	(2.77)	(1.99)
Province FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
R^2	0.9522	0.9670	0.9651	0.9161
F	12.31	54.82	48.44	257.65
Observations	660	572	630	660

The central government may be inclined to increase the corresponding IFTs in a given location to reach its environmental mandate, and thus, energy consumption may in turn affect the IFTs. This possible reverse causal effect biases the previously obtained estimates. Therefore, the study uses a two-stage least squares estimator to deal with the reverse causality and choose PLT as an instrumental variable. PLT of ministers is able to significantly affect energy consumption through the IFTs but does not have other avenues of influence on energy consumption. This result suggests that PLT meets the requirements of correlation and exogeneity. The results (column (4) of Table 3) still confirm the positive impact of IFTs on energy consumption.

Considering that the results of the above robustness tests all support the results in the preferred model, the study can confirm our finding is robust.

5. Mechanism analysis

Based on the previous theoretical hypothesis, the study analyses the influence mechanism of IFTs on energy consumption. From the expenditure perspective, IFTs may affect energy consumption through local government expenditures on education or science and technology. Table 4 shows the mediating effect of IFTs on energy consumption through EDUEs, and Table 5 shows the moderating effect of IFTs on energy consumption through PAT.

Table 4: Mechanism test result (education expenditures)

	(1)	(2)	(3)
	EC	**EDUEs**	**EC**
IFTs	0.124***	0.137***	0.0831**
	(3.13)	(2.70)	(2.42)
EDUEs			0.295***
			(7.25)
Province FE	YES	YES	YES
Year FE	YES	YES	YES
R^2	0.9630	0.9880	0.9667
F	50.31	23.00	59.98
Observations	660	660	660

Firstly, the coefficient of IFTs on EDUEs is significantly positive (β_1 = 0.137***). This finding suggests that IFTs enable local governments to expand EDUEs. However, such a change in expenditures leads to more growth in energy consumption because EDUEs lead to an increase in energy consumption (γ_2 = 0.295***). Therefore, increasing EDUEs increases the growth in energy consumption (from γ_1 = 0.0831** to α_1 = 0.124***). EDUEs are significantly and positively related to energy consumption because of the following. On the one hand, for a long time, Chinese EDUEs focused on providing primary education to citizens, whereas their contribution to improving the quality of higher education is still weak [8]. Many educated individuals have flowed into relatively low-end industries that inevitably consume large amounts of energy for their rapid development of Chinese economic. On the other hand, The Chinese government's investment in education expenditure in the past decades is still focused on expanding infrastructure construction, such as school sites and teaching equipment. However, this way of education capital investment will lead to more energy consumption when the energy consumption structure remains unchanged Thus, EDUEs have increased energy consumption significantly.

The study sees the results of the estimates. All variables are estimated to be significant, Following Baron and Kenny [9], this result indicates that EDUEs play a mediating role in the effect of IFTs on energy consumption. Following Mackinnon, Warsi, and Dwyer [10], the proportion of the mediating effect of EDUEs is 32.59%.($\frac{|\beta_1 * \gamma_2|}{\alpha_1} = |\frac{0.295 * 0.137}{0.124}| = 32.59\%$).

Second, the coefficient of IFTs with PAT is significantly negative, whereas the estimated coefficient of PAT with EC is significantly positive. Such a result indicates that PAT plays a shielding role in the positive effect of IFTs on energy consumption. Following Mackinnon, Krull J L and Lockwood [11], the proportion of the suppression effect of PAT is 14.45% ($\frac{|\delta_1 * \theta_2|}{\alpha_1} = |\frac{0.362 * 0.061}{0.145}| = 14.45\%$).

The PAT decreases with the increase of IFTs, indicating that the government is not inclined to invest in technology that can generate innovation. However, the innovation capacity represented by the number of patents per capita will increase energy consumption. The reason for this phenomenon may be that in the past energy consumption structure, most scientific and technological innovations did not focus on the direction of energy conservation but improved the production capacity without improving the energy utilisation efficiency.

Table 5: Mechanism test result (science and technology expenditures)

	(1)	(2)	(3)
	EC	**PAT**	**EC**
IFTs	0.124***	-0.362***	0.145***
	(3.13)	(-3.76)	(3.84)
PAT			0.0601***
			(3.71)
Province FE	YES	YES	YES
Year FE	YES	YES	YES
R2	0.9630	0.9620	0.9638
F	50.31	7.058	44.44
Observations	660	660	660

6. Conclusions

The Chinese central government established the IFT system because of tax-sharing reform and relied on it to adjust economic development and regulate local government behaviour. However, research on the effects of IFTs on energy consumption is still scarce. In this context, the study conducted an empirical analysis to study the effects of IFTs on energy consumption by using provincial panel data for 30 Chinese provinces from 1998 to 2019. Additionally, the study shows the robustness of the results under four different tests. Moreover, this study explored the mechanism effect of IFTs in influencing energy consumption. The main conclusions obtained in this study are as follows. IFTs facilitate the increase in energy consumption. Second, the study analyses the intermediate mechanisms of the effects of IFTs on energy consumption. The study found that IFTs positively affect energy consumption by increasing local government EDUEs because EDUEs raise the living standards of the population and drive human resources to energy-intensive industries. Moreover, IFTs can further inhibit regional technological innovation of science and technology, but in-creased innovation can contribute to energy emissions in the process of promoting economic development, indicating a masking effect of innovation of science and technology in the effects of IFTs on energy consumption.

Based on the above empirical results, this study proposes the policy implications. First, the IFT system should be further optimised. Moreover, the central government should design a more reasonable distribution model, restrain the behaviour of local officials in the legal aspect and strengthen the surveillance of IFTs to realise the purpose of decreasing energy consumption. Second, The Chinese government should establish a systematic assessment system that includes green GDP for government officials, such as reducing energy consumption as one of the indicators. At present, economic development is a key criterion for evaluating the performance of officials in China, ignoring other indicators such as green GDP. Under the new system, local government officials have an incentive to develop a low-carbon economy and reduce energy consumption. Third, the central-government should improve the structure of expenditure on education. Currently, China's expenditure on education includes funds for education and investment in capital construction. The government should reduce the in-vestment in education infrastructure that causes increasing on energy consumption, and increase the education funds that effectively improve the level of education over-all. Increased EDUEs will increase energy consumption because the Chinese education level has been concentrated at the basic level with a shortage of highly educated personnel.

Moreover, the industrial structure has dominated the secondary industry in the past decades, causing many educated talents to flow to the secondary industry, generally increasing energy consumption. Social planners need to increase awareness of the concept of energy conservation among the citizens and cultivate more highly qualified personnel who can promote the development

of the energy conservation industry. Meanwhile, government officials need to increase the science and technology expenditures for more innovative green technology and consider designing more fiscal tax incentives to promote the development of green industries, which in turn will upgrade the industrial structure to a trend of low energy consumption and encourage the use of cleaner energy to form a high-efficiency energy-consumption structure. Thus, China can ensure the reduction of energy consumption while developing the economy, achieving a balance between economic development and energy reduction as much as possible.

The limitation of this article is that when exploring the impact of local government expenditure on energy consumption, environmental protection expenditure should be considered as the most relevant expenditure. However, environmental protection expenditure has been separately listed in government budgets since 2006, and due to the limitations of its data range, this article did not discuss its impact. In future research, one possible solution is to try using different empirical methods to eliminate the impact of data range on empirical results, thus helping provide more specific and practical policy recommendations for policymakers.

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