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Contents

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Ping Qin, Xiao-Bing Zhang, and Lunyu Xie*

Abstract

There is an ongoing reform in coal taxation in China, from a quantity-based to a price-based approach. While the coal tax could play an important role in resource conservation and air pollution reduction, its distributional effect is not well studied. This paper investigates the distributional effect of China's coal taxes on households before and after the reform. We find that both the quantity-based and price-based coal taxes are regressive for residential consumers in China, that rural poor households are most affected, and that the coal taxation reform slightly reduced the regressivity of the coal tax. By simulation, we also find that the regressivity of the coal tax can be further improved if the tax rate scheme is set appropriately.

Keywords: coal tax, distributional effect, price-based tax, quantity-based tax

JEL Codes: C15; H23; O13

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1. Introduction

As the largest consumer of coal in the world, China accounted for around half of the world's coal consumption in the last decade. In China, coal comprises almost 60 percent of the country's primary energy consumption, far exceeding the 27 percent of the world average (BP, 2018). The energy structure that heavily relies on coal has caused increasingly severe environmental consequences, including air pollution and greenhouse gas emissions. According to the BP Statistical Review of World Energy 2018, around 80 percent of the carbon emissions in China are from coal consumption, while the world average is 40 percent. To reduce air pollution caused by coal consumption and transform China into a low-carbon economy, a nationwide coal taxation reform took effect in 2014. The reform removed various types of pre-existing fees on coal and instead imposed a tax. The tax rate is set between 2 and 10 percent, up to the choice of the provinces. Although a high rate can alleviate the fiscal burdens of local government, most provinces opted for a low tax rate between two and three percent. The possible reasons include protecting local coal businesses and the concern about the distributional effects of the reform. A common argument against a higher tax rate is the potential for regressive consequences, where the poor are hit hardest and bear an unfair tax burden. Does this argument generally hold? The literature on China's coal tax reform is limited, and previous studies on resource or energy taxes in other countries have mixed findings. This study, therefore, investigates the distributional impact of the coal tax reform on residential consumers.

We study the household level, because household coal accounts for a substantial portion of the country's coal consumption and also because of the highly polluting characteristics of household coal. Household coal consumption is estimated at 700 million tons a year, accounting for 17% of total coal combustion in China (Zuo, 2016), while emitting a total amount of air-borne pollutants similar to the total resulting from industrial coal (NRDC 2014).

Coal taxation in China started in 1984, along with taxation of crude oil and natural gas. The goal of the taxes on these fossil resources was to promote efficient levels of extraction and efficient allocation of national resources. The taxes were charged based on quantity extracted (a given number of yuan per ton), for simplicity. Besides the coal tax, firms were also charged several kinds of fees, such as a mineral resources compensation fee, a price adjustment fund, etc.

Effective December 1, 2014, the Ministry of Finance and the State Administration of Taxation released the "Notification of the Coal Resource Taxation Reform," with the stated goals of promoting resource conservation and environmental protection and reducing the tax burden on enterprises. The announcement stated that a price-based coal tax (a given percentage of the price per ton) will replace the quantity-based tax, and that provincial governments are responsible for setting the tax rate within the range of two to ten percent. Firms that sell raw or washed coal are charged at the tax rate set by the provincial government. Firms that produce coal using new technologies or from depleted coal mines enjoy a 30 to 50 percent discount. Meanwhile, all fees related to fossil resources were eliminated.

Most provinces opted for a low tax rate, between two and three percent. Among these, the tax rates in Heilongjiang, Jilin, Liaoning, Beijing, Henan, Hebei, Jiangsu, Anhui, Jiangxi, Fujian, and Hubei are 2%, while the tax rates are set at 2.5% for Guangxi, Gansu, Sichuan and Hunan. The local governments in Chongqing, Shandong, Guizhou and Yunnan set the tax rate at 3%, 4%, 5% and 5.5%, respectively. For coal-rich provinces, the tax rates are relatively higher: the tax rates in Xinjiang, Qinghai and Shaanxi are 6%. The tax rates in Ningxia, Shanxi and Inner Mongolia are 6.5%, 8% and 9%. Given the variations in tax rate and income across provinces, consumers in different provinces are affected differently.

Utilizing a comprehensive dataset on household energy consumption, we investigate the distributional effects of the coal taxes before and after the reform, at household level, which is a much finer level than most previous studies. Households are affected by a coal tax in both direct and indirect ways. For households that directly consume coal, e.g., use coal for cooking or heating, they directly face the price change when a tax is applied, and therefore are directly affected by the reform. Households that do not use coal can also be affected, because coal is an important input for the generation of power and the production of many consumption goods. The tax on coal could be transferred to many sectors through product price adjustment and thereby could indirectly affect the consumers of those goods. In this paper, we focus on the direct (first-order) effect and leave the indirect effect for further research.

We find that nearly 30% of rural households but only 6% of urban households are directly affected by the coal tax. The affected households tend to be poor. We also find that both the quantity-based and price-based coal taxes are regressive, while the reform slightly reduced the regressivity. Furthermore, we find that the coal taxes in Tianjin, Shanghai, Guangdong, Yunnan and Hainan are progressive, while they are regressive for all the other provinces.

The remainder of the paper is organized as follows. Section 2 reviews related literature. Section 3 introduces the data and the methodology. Section 4 presents the findings. Section 5 concludes.

2. Literature Review

There is a large literature on the distributional effects of carbon, resource, and energy taxes, and the findings are mixed. Energy and carbon taxes are found to be regressive in most developed countries, such as the United States (Mathur and Morris 2014), Canada (Hamilton and Cameron, 1994), Australia (Cornwell and Creedy 1996), the Netherlands (Kerkhof et al., 2008) and Denmark (Wier 2005), although they are found to be progressive for the UK and Italy (Tiezzi 2005). Stern (2012) studied the carbon tax in seven European countries and found a very small regressivity of the tax. The author therefore concluded that the carbon tax is approximately proportional. In developing countries, the findings also vary across samples. Brenner et al. (2007) studied the carbon charges on the use of fossil fuels in China and suggested that the charges would be progressive, while Jiang and Shao (2014) found that a carbon tax in China would be significantly regressive. Yusuf and Resosudarmo (2007) analyzed the distributional impact of a carbon tax in Indonesia and suggested that the introduction of such a tax was not necessarily regressive.

The difference in the distributional effects of a resource or a carbon tax is related to the differences in tax base, expenditure patterns, and price elasticity of demand across regions. For example, Barker and Kohler (1998) distinguished energy between household use and transportation use, and found that carbon taxes based on energy for household use were regressive in most EU countries, while those based on transportation use were slightly progressive. Jiang et al. (2015) found that the removal of electricity subsidies has a regressive effect, while the removals of transport fuel and coal subsidies have the strongest and the weakest progressive effects respectively.

The distributional effect of a resource or carbon tax also can be affected by considering the factor price changes caused by the tax and how the tax revenue is recycled back to the economy. Jiang et al. (2015) found that the indirect impact of energy subsidy removal in China is greater than the direct impact. Disso and Siddiqui (2014) found that carbon taxes tend to increase inequality through commodity price changes and decrease inequality through factor price changes. Klenert and Mattauch (2016) analyzed the distributional effects of a carbon tax reform in a two-sector model and found that the reform is progressive if the revenues are recycled as uniform lump-sum transfers and regressive otherwise. In general, empirical studies have found that the method of tax recycling usually determines whether the carbon tax is less regressive (or more progressive); see, e.g., Bureau, 2010; Beck et al., 2015; Gonzalez, 2012.

In this paper, we study the distributional effect of China's coal taxes on households before and after the reform, utilizing detailed coal use data from thousands of households all over the country. Literature on this specific topic is limited. One possible reason is that the heavy use of coal is not a world-wide phenomenon. Brenner et al. (2007) and Jiang and Shao (2014) studied China's carbon tax, which is different from the coal tax we study here. While there is a large Chinese literature on China's resource taxes, these studies mainly focus on the optimal tax rates under different scenarios, the effect of the tax on the whole economy or the industrial departments, or the provincial differences in the effects (e.g. Lin, 2008; Xu et al. 2015; Cao et al. 2011; Guo et al., 2011; Xu 2007). Distributional effects on residential consumers are not considered in this line of literature.

3. Data

The main datasets are from the Chinese Residential Energy Consumption Survey (CRECS) 2013, 2014, and 2015, conducted by the department of Energy Economics at Renmin University of China. CRECS is the first national household energy consumption survey in China. It collects detailed information on (1) household energy prices and consumption, including coal, oil, natural gas, electricity, etc.; (2) the ownership of energy-using appliances and detailed energy consumption habits of a household; (3) household characteristics, including annual household income, age and education of household members, etc.; and (4) characteristics of the residence, including size, age, infrastructure, etc.

In the three years of 2013 through 2015, 8717 households in 31 province-level administrative units were randomly sampled[1]. We exclude Tibet from the analysis, because the income variable is missing in all observations in Tibet. This results in a sample of 7241 households in 30 province-level administrative units. The number of observations in a province ranges from 25 to 759 households, based on the variation on population.

Figure 1 depicts the spatial distribution of household coal consumption. It shows that the coal consumption in the north is much higher than that in the south and the southeast coastal provinces. The average annual household coal consumption of Qinghai, Gansu and Hebei reaches 1588, 1131 and 941 kilograms (kg), respectively. For the southeast coastal areas, such as Guangdong, Zhejiang and Fujian, the household coal consumption is only about one kg, indicating that the majority of households in those areas do not directly consume coal.

[1]Taiwan, Macao, and Hong Kong are not included in the sampling.

Figure 1: Spatial Distribution of Coal Consumption

Most households reported the price they paid for coal in the survey for 2015, but only a small portion of households did so in the surveys for 2013 and 2014. Based on the fact that coal prices within a region are similar, for 2015 we fill in the missing data using the average household-reported coal price in the same province, or the average coal price of the whole sample for the provinces where no price information is available. We then calculate the corresponding prices in 2013 and 2014 based on the prices in 2015, using the Retail Price Indices by Category and Region (2013 and 2014) from the China Price Statistical Yearbook.

Table 1 provides the summary statistics of the variables of coal price, household annual income, and coal consumption. It shows that coal consumption and household income have large variation across households, while coal price variation is relatively small, which is as expected.

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max

Coal consumption (kg)	7,241	265.08	849.54	0	16200
Coal price (yuan/kg)	7,241	0.98	0.27	0.5	1.63
Income (thousand yuan)	7,241	64.47	144.35	0	5000

4. Methodology: Suits Index

We use the Suits Index to measure the progressivity/regressivity of the coal tax. The Suits index is a measurement developed by Daniel B. Suits (1977) and it has been one of the most widely used instruments to assess the progressivity of a tax. The Suits index compares a cumulative frequency distribution of tax liabilities with a similar distribution of household income. One can conclude that the coal tax is regressive (progressive) if the percentage of the total tax burden is always higher (lower) than the corresponding percentage of total income. For a proportional tax, the Lorenz curve would follow a straight 45-degree line.

The Suits index can be calculated as $S = 1 - \left(\frac{L}{K}\right)$, where L is the area under the percentage curve of the total tax burden and K is the area under a straight 45-degree line. The range of Suits index is between -1 (extreme of regressivity) and 1 (extreme of progressivity). For a proportional tax, $L = K$, which implies that the Suits index is zero. For a progressive (regressive) tax, the Suits index takes on positive (negative) values. A larger absolute value of a Suits Index indicates a larger degree of regressivity (if negative) or progressivity (if positive).

5. Findings

5.1 About 30 percent of rural households and six percent of urban households are directly affected by coal taxes.

As shown in Table 2, 1323 out of 4486 surveyed rural households (about 30 percent) and 165 out of 2755 surveyed urban households (about six percent) use coal. This indicates that a larger portion of rural households are directly affected by coal taxes, compared to urban households.

Table 2: Number of Households that Do and Do Not Use Coal

	Households do not use coal	Households use coal	Total
Rural	3163	1323	4486
Urban	2590	165	2755
Total	5753	1488	7241

5.2 Directly affected households tend to be poor.

The average income of rural households is 42.45 thousand yuan, while the average income of urban households is 100.31 thousand yuan, more than twice that of the rural households. Together with Table 1, this shows that coal taxes are more likely to directly affect poor households.

Next, for both the urban and rural households, we compare the characteristics of households that use coal with those that do not. As shown in Table 3, coal users and non-users have different household income, and the differences are statistically significant, for both rural and urban households. On average, the per capita annual income of rural households that do not use coal is 36 percent higher than that of rural households that use coal, while urban households that use coal have about half the income of urban non-coal users. Table 3 also shows differences in the size of the residence: in rural areas, living space is larger for households that do not use coal, while in urban areas, the finding is the opposite. A possible explanation is that, in rural China, wealthier households tend to build larger houses. However, households using coal in urban areas usually live in suburbs or towns and are more likely to live in bungalows than in apartments, where most urban households live. We do not find significant differences in age composition between the households that use and do not use coal, either in urban areas or in rural areas.

Table 3: Comparison between Households that Do and Do Not Use Coal

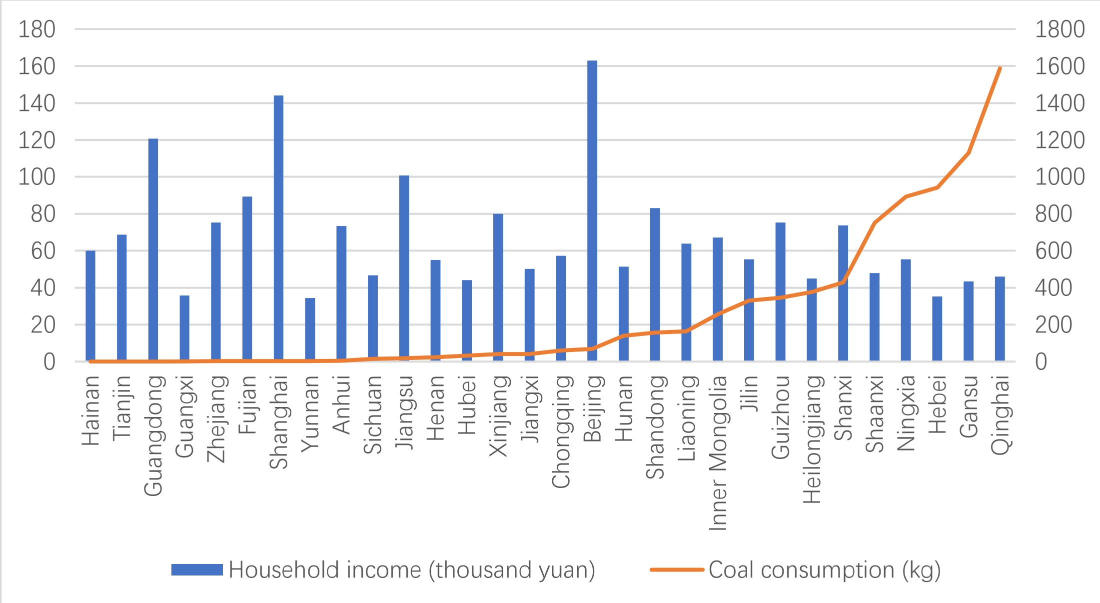
	Rural Households			Urban Households		
	Not use coal	Use coal	Diff.	Not use coal	Use coal	Diff.
No. of ob.	3167	1313		2582	165	
income	18043.91	13277.36	4766.55**	43264.04	20519.35	22744.69***
area	54.43	45.58	8.85***	40.77	50.49	-9.72***
old	0.29	0.29	0.00	0.24	0.28	-0.04
young	0.41	0.42	-0.01	0.29	0.36	-0.07**

Notes: income is household annual income per capita, in units of thousand yuan; *area* is the per capita area of a residence, in units of square meters; *old* is the proportion of household members who are 65 years old or older; young is the proportion of household members who are 18 years old or younger. *** and ** indicate that the difference is statistically significant at the 1% and 5% significance levels.

5.3 Provinces with greater coal consumption, higher coal price, and a higher tax rate are affected to a larger degree, and they tend to have lower household income.

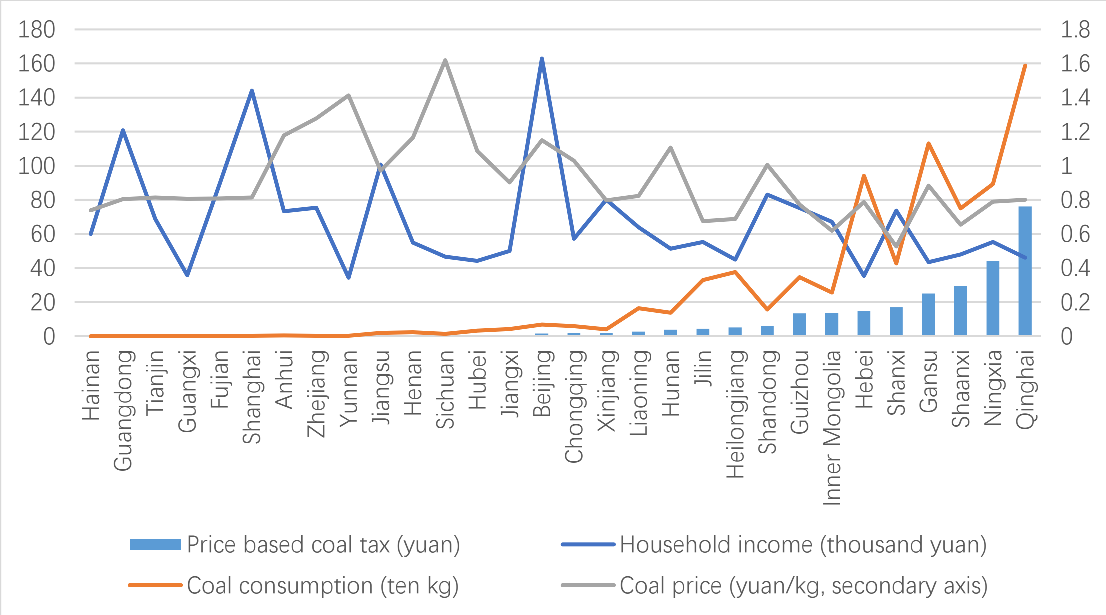
Before the coal tax reform, the amount of tax was determined by the amount of coal consumption. As shown by Figure 2, average household coal consumption and average household income are roughly negatively correlated. The provinces with large coal consumption are those in the north and inner regions, and they tend to have lower average income. The coal consumption of the southeast coastal provinces is much lower than that of the inland areas. The average annual household coal consumption of Qinghai, Gansu and Hebei (northern and inner provinces) reaches 1588, 1131 and 941 kg, respectively. As a result, households in these provinces are affected to a larger degree due to greater consumption of coal. By contrast, for the southeast coastal areas, such as Guangdong, Zhejiang and Fujian, the average annual household coal consumption is only about 1kg, indicating that the majority of households do not directly use coal, so the households in these provinces are almost unaffected by the coal tax.

Figure 2: Average Household Coal Consumption and Household Income of Each Province



Since the reform, the total amount of tax paid by each household also has been affected by the coal price and the tax rate. Figure 3 depicts the average household coal consumption, household income, coal price, and coal tax in each province. It shows that the provinces paying the most coal tax are Qinghai, Ningxia and Shaanxi, which tend to have lower household income. This also shows that there is little correlation between the total amount of coal tax and either average coal price or the provincial tax rate. This indicates that the difference in tax burden mainly comes from the difference in coal consumption, rather than difference in coal price or tax rate. This finding is as expected, since the variation in coal price and coal tax is relatively small across provinces, as shown in Figure 3.

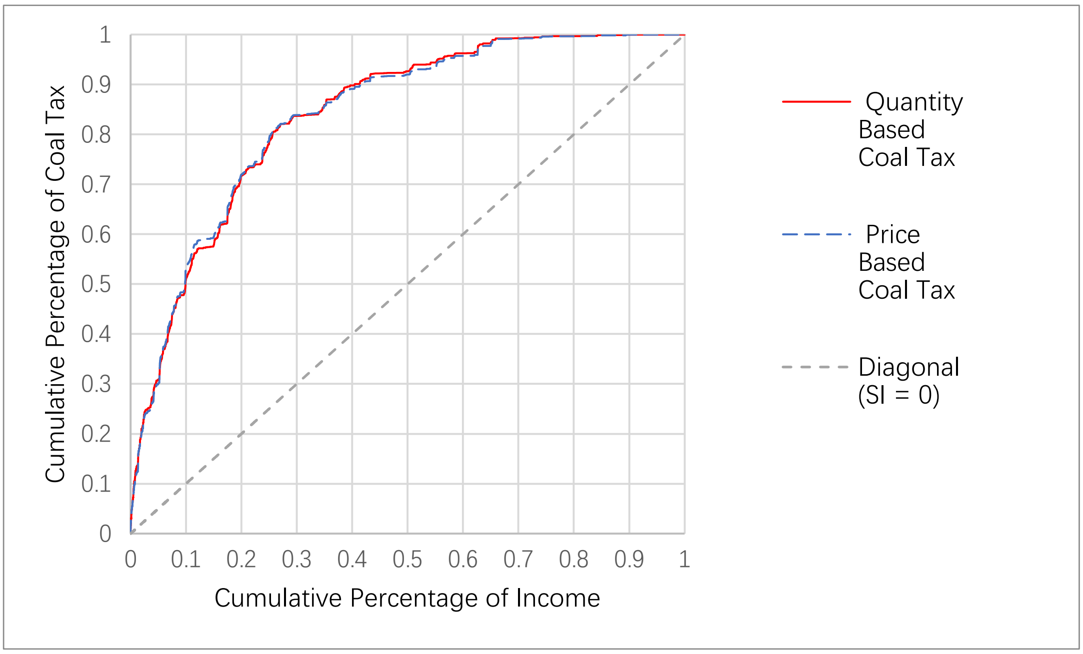
Figure 3: Average Household Coal Consumption, Income, Coal Tax and Coal Price



5.4 The quantity-based tax (the tax before the reform) was regressive

To explore the progressivity of the coal tax before the reform, we plot as the red curve in Figure 4 the cumulative percentage of coal tax paid by households against the cumulative percentage of household income. It shows that the curve lies above the diagonal line. A further calculation shows that the Suits index is -0.6796. This indicates that the previous coal tax was regressive: the poor households faced a relatively higher tax burden compared with their income.

Figure 4: Regressivity Curves for the Quantity-Based Coal Tax and the Price-Based Coal Tax



To assess the regressivity of the tax after the reform, we plot a similar curve for the price-based coal tax. For the five provinces that do not produce coal and therefore do not have reported coal tax rates, we assume their tax rate is the average of the 25 coal producing provinces. The rationale behind this assumption is that households in those provinces which do not produce coal consume coal imported from other provinces, so they are also affected by the tax-induced coal price change in the coal-exporting provinces.

We plot the cumulative percentage curve as light blue in Figure 4. It shows that the coal tax after the reform is still regressive. The Suits Index is found to be -0.6793, slightly smaller in absolute value than the Suits Index of the tax before the reform. This indicates that the price-based coal tax under the current scheme is slightly less regressive than the quantity-based coal tax before the reform.

5.5 The tax reform can further improve regressivity if the tax rate is positively correlated with household income.

Since the tax rate is set by the government and varies across provinces, we experiment with different tax rate scenarios, in order to explore whether changing the current coal tax rate scheme can improve the regressivity of the tax. In scenario one, we set a uniform tax rate which is at the average tax rate of 6%. We find the Suits Index to be -0.6800. In scenario two, we set the tax rate to be positively correlated with the average household income in each province. We first rank the provinces based on the average household income, and then set the tax rate to be $0.02 + 0.002 * (i - 1)$, where i is the ordinal number of the province's rank, which is 1,2...30. We find the Suits Index to be -0.6642. Table 4 summarizes the findings. It shows that there is the potential to improve the regressivity of the coal tax, if the tax rate scheme is set appropriately. However, the room for the improvement is limited, because the negatively correlated relationship between coal consumption and household income dominates in the distributional effect of the tax.

Table 4: Suits Index in Different Situations

Tax Rate	Quantity Based	Price Based		
	0.008 yuan/ton	current scheme	6% for all	tax rate positively correlated to average household income
Suit Index	-0.6796	-0.6793	-0.6800	-0.6642

6. Conclusion

In this paper, we investigate the distributional effect of China's coal tax before and after the change to a price-based tax scheme, utilizing detailed household coal consumption data covering most of the provinces in China. We find that nearly 30% of rural households and 6% of urban households are directly affected as users of coal. They tend to be the households with lower income, compared to the households who do not directly consume coal. We also find that provinces with greater coal consumption, higher coal price, and a higher tax rate are affected to a larger degree and those provinces tend to have lower average income. Therefore, when we use a Suits index to measure the regressivity/progressivity of the coal tax, we find a negative Suits index for both quantity-based and price-based coal taxes; the indices are -0.6796 and -0.6793, respectively. By simulation, we also find that there is room to improve the regressivity of the tax through setting the tax rate at a level that is positively correlated with provincial average income, although the room for improvement is limited due to the negative correlation between coal consumption and household income. Since we assume in this study that coal consumption does not react to the coal price change caused by the taxation reform, a direction for further research could be to investigate how coal consumption responds to price changes and therefore to examine the distributional effect of the coal tax in China in a dynamic framework.

The results from this study have significant implications in related policy arenas in China and other industrializing contexts dealing with similar challenges. First, household energy consumption is usually an important indoor pollution source in developing countries, particularly in areas where coal comprises a significant proportion of household energy use. Given the enormous health burden imposed by indoor pollution, the literature has started to evaluate the effectiveness of various policy tools available to combat air pollution in China and other industrializing countries (such as India). However, the distributional effect of the policy tools has been paid little attention in the literature so far. Second, on a global level, the use of fossil fuels—including the use of coal as a source of household energy—contributes to climate change; appropriate price-based mechanisms are potentially effective parts of the climate policy toolkits available to developing countries. Third and finally, this study is located within the broader context of the ongoing energy transition in developing countries, a significant aspect of which is related to encouraging households to switch away from dirty energy technologies and fuels (such as traditional stoves and coal) towards cleaner, more efficient ones (such as electricity and gas). Economic incentives and price-based mechanisms are thought to be important tools for facilitating this much-needed switch. The distributional consequences of the policies should be assessed when making policy decisions.

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