The Distributional Effects of a China Carbon Tax: A Rural–Urban Assessment

Wenjun Sun

Graduate School of Economics, Kyoto University, Japan
E-mail: wenjunsunny@gmail.com

Kazuhiro Ueta

Professor, Graduate School of Economics, Kyoto University, Japan
E-mail: ueta@econ.kyoto-u.ac.jp

ABSTRACT

In September 2009, the National Development and Reform Commission and the Ministry of Finance of China—the country that emits the most greenhouse gases—issued a report on the necessity and feasibility of imposing carbon taxes in the country. The Commission also explored a tax design. In this study, we use input–output analysis to examine the scenario presented in that report, and attempt to measure the potential distributional impact of carbon taxes on Chinese residents. The results suggest that a carbon tax in China would be regressive in urban areas but progressive in rural ones, and that rural areas are more heavily burdened than urban areas. In addition, given that most policy options with regard to revenue-recycling—as implemented in industrialized countries—are not feasible in China, we show that lowering the electricity prices for households would be a practical approach that would lighten the burden on poor urban households and narrow the rural–urban disparity in tax burden. This would offset the adverse distributional effects of the carbon tax.

Keywords: China, carbon tax, distributional effects, rural-urban, input–output approach
JEL Classification Numbers: Q58, H23

1 Introduction

In September 2009, a research group of the Research Institute for Fiscal Science of China's Ministry of Finance and the National Development and Reform Commission issued a joint special report, *Research on Levying Carbon Tax in China* (hereafter, the *Report*). That *Report* proposes the possibility of initiating the collection of carbon taxes within the following five years, and puts forward an implementation framework for a carbon tax system. This proposal marks the first announcement of a plan to introduce carbon taxes in China.

Although carbon taxes are recognized as an effective policy tool in reducing carbon dioxide (CO_2) emissions, they can have undesirable effects on various aspects of a national economy. The OECD (1994) points out that carbon taxes themselves are regressive—that is, the carbon substantial tax burden will fall disproportionately on the poor. The distributional effects of carbon taxes have been widely studied since the 1990s, and the consensus of the literature is that carbon charges are regressive.[1] The OECD (2006) points out that although most environmental taxes, including carbon taxes, may have only a very limited impact on the final disposable income of most households, pushing for the introduction of taxes perceived to be unfair would be extremely difficult. Therefore, even if a carbon tax were widely recognized as a cost-effective instrument, the distribution of its cost would remain a fundamental factor determining acceptability. Indeed, some countries—like France and Spain—have announced the introduction of carbon taxes, but ultimately they were not realized.

OECD countries treat income distribution as an important issue in the introduction of carbon taxes, because it is highly concerned about the fairness of, or people's receptivity to, such policies. However, since China has a serious problem with absolute poverty, income distribution is not merely a problem that relates to the extent to which people will support and accept relevant policies; it is also a potential life-or-death problem that is very real and extremely imminent. Most developing countries face similar issues. Therefore, in introducing a new tax system, China and similar developing countries must be more careful than advanced countries with regard to the distributional effects of any tax burden—in particular, the impact on the lowest-income earners. In addition, China differs from advanced countries in terms of its significant urban–rural disparities. Since the actual conditions of these regional gaps are not reflected in any analysis that treats the country as a single entity, urban and rural areas need to be studied separately.

Compared to advanced countries, developing countries possibly have different distributional effects with respect to carbon taxes, given their different consumption patterns or energy mixes. As Baranzini and Zhang (2000) imply, however, most of the earlier studies on carbon taxes focus on advanced countries, and there have been only a few studies to analyze developing countries or countries with in-transition economies. Of those few, Shah and Larsen (1992) find that the distributional effect of the introduction of a carbon tax in Pakistan can exhibit progressivity at a tax rate of USD10 per ton of carbon. Yusuf (2008) examines the case for carbon taxes with a tax rate of USD32.60 per ton, concluding that the introduction of a carbon tax in Indonesia would be strongly progressive in rural areas and either neutral or slightly progressive in urban areas, with an overall progressive distributional effect nationwide.

Studies on China have centered mainly on emission-reduction effects and the economic effects of carbon taxes, but lack analysis on welfare effects. Of those few studies, Brenner et al. (2007) use data captured during a survey of nationally representative household income and expenditure conducted for the year 1995, and examine the distributional impact of a CNY300 per ton carbon tax introduced in China. Nationwide, the lowest decile pays 2.1% of its total expenditures toward the charge, while the highest decile pays 3.2%. They interpret this as a reflection

[1] See OECD (1994), Baranzini et al. (2000), Zhang and Baranzini (2004), and Boccanfuso et al. (2008) for literature reviews.

of the fact that of the mix of products available in China, relatively wealthy people buy more carbon-intensive ones than relatively poor people. Within rural and urban regions, the size of the charge is roughly proportional to expenditure: every decile in the urban areas pays between 3.2% and 3.5% of its expenditures toward the charge, while every decile in the rural areas pays between 1.8% and 2.1%. Moreover, Brenner et al. (2007) propose revenue-recycling in China through a "sky trust" option: a lump-sum redistribution to all households on an equal, per-capita basis. It is thought that this would enhance a progressive distributional effect, producing net gains for most of the income groups in the rural areas and improving the pre-tax situations of the lowest-income earners in the urban areas.

Based on the settings of the tax system proposed in the *Report*, this study aims to calculate the short-term tax burden on various income groups in urban and rural areas, at the initial stage of the introduction of a carbon tax in China. Our results show that the carbon tax in China is regressive in urban areas and progressive in rural areas, and that rural areas are more heavily burdened than urban ones. In addition, given that most policy options of revenue-recycling, as implemented by industrialized countries, are not feasible in China, we consider an alternative revenue-recycling option: lowering the electricity prices for households. We then show that it would be practical to lighten the burden of poor urban households and narrow the rural–urban disparity in tax burden, thereby offsetting the adverse distributional effects of the carbon tax.

Compared to previous studies, this study makes a contribution in several ways. First, the scenario used in the current analysis is based on the proposal made by the *Report*, which will most likely be adopted when China actually introduces carbon taxes. Second, we illustrate how consumption differences across income groups and between rural–urban areas drive the distributional effects of the policy; such information can assist in garnering a better understanding of some of the special features of a developing China.

2 Scenario and Method

Fullerton (2008) discusses six ways in which environmental policies may have distributional impacts; the current study focuses on the most prevalent one: forward cost-shifting, wherein a carbon tax increases the cost of production, thus also increasing the equilibrium price of output and affecting consumers in terms of product expenditures. Under China's method laid out by the *Report* of collecting carbon taxes on upstream industries, the impact will at the beginning rely on the sectors where primary fuels are mined, extracted, or imported; the impact will then propagate throughout the entire economy, given the net of interactions among sectors on which an economic system is based. Thus, the carbon tax produces effects both directly and indirectly on each sector. The input–output (IO) model has been widely recognized as the best economic model by which to study and evaluate both direct and indirect effects among sectors in a great degree of detail. Moreover, through the series expansion of the Leontief inverse, it is possible to evaluate how much each level of interaction contributes to final price increases (Treloar, 1997, quoted in Mongelli, et al. 2009).

This property of the IO model has been leveraged widely in studies of the price effects of carbon taxes.[2] However, it should be noted that the use of an IO model does not directly allow for substitution possibilities in production. Carbon taxes on the production or use of fossil fuels can be fully forward-shifted in the short term only if the firms in the industry have full market power, if the demand for the taxed commodity is perfectly inelastic, or if the supply is perfectly elastic. Thus, the results presented within this study must be regarded as having derived from a short-term model where substitutability in production is limited.

This study estimates the distributional effect of a carbon tax as follows. The tax collection framework proposed in the *Report* is applied to 42 sectors in the 2007 Input–Output Table of China, and the coal, petroleum, and natural gas industries are considered to constitute the sectors subject to direct taxation.[3] Since the quantity of output in the Input–Output Table is expressed in terms of yuan (CNY), data from the China Statistical Yearbook (2008) are used instead. Once the taxation route and a tax rate are determined, the incidence of a carbon tax on the sector subject to direct taxation can be calculated. An increase in production costs within a sector is considered here a manifestation of the incidence of tax on the sector. Since the carbon tax is set as a tax levied per ton of CO_2, it is converted for each type of fossil fuel to a tax per unit of fossil fuel; the corresponding *ad valorem* tax rate is calculated as in equation (1).

$$t_i^{dir} = Te_i y_i / Y_i \tag{1}$$

In this equation, t_i^{dir} is the rate of the direct *ad valorem* tax borne by industry i, which produces fossil fuel of type i. T is the tax per unit of CO_2 emitted, which is set here at CNY10 per ton of CO_2, based on the proposal made by the *Report*. Additionally, e_i denotes the emission coefficient—that is, the amount of CO_2 emitted per ton of fossil fuel produced in industry i. Y_i/y_i denotes the price of fossil fuel of type i, expressed as the amount of total production value in CNY Y_i, divided by the quantity produced y_i.

The carbon tax levied on the production or import of coal, petroleum, and natural gas has shifted to the entire industrial sector, through price changes. The IO model measures these price changes and shows how changes in costs in some indus-

[2]Among many examples are Symons et al. (1994), Cornwell and Creedy (1996), Labandeira and Labeaga (1999), Brannlund and Nordstrom (2004), Wier et al. (2005), and Feng et al. (2010).

[3]Since the sector-based categorization in the 2007 Input–Output Table treats the petroleum and natural gas sectors as a single sector, the current study combines the amount of taxes levied on both sectors' total output.

tries affect other industries and the economy as a whole. According to the tax collection route set in the *Report*, as well as the limitation of the IO model, two conditions are assumed in the present analysis: one is that the tax levied on the industrial sector is completely shifted to products, and the other is that price elasticities or substitution effects in production are not considered. These assumptions are not thought to adversely affect results since, as mentioned, this paper analyzes the short-term effects of a carbon tax, with the initial tax rate set low at CNY10 per ton.

$$t_g^{ind} = \sum_i m_{g,i} t_i^{dir} \tag{2}$$

Here, t_g^{ind} denotes the rate of indirect carbon tax borne by sector g, which is calculated through equation (2). This indirect carbon tax rate is the sum of the carbon tax on the three fossil fuel industries (indexed with i), all of which are subject to direct taxation. The share of intermediate input from industry i in output produced by sector g is denoted by $m_{g,i}$.

Through the use of a bridge matrix, we match the sectors of the Input–Output Table to the categories of household consumption goods used in the household survey of the China Statistical Yearbook (2008). Price increases for different consumption goods are estimated, based on equation (3).

$$\Delta P = t^{ind}(I - A)^{-1} B \tag{3}$$

In equation (3), ΔP is a 1×8 vector of rates of price increase in consumption goods, and t^{ind} is a 1×42 vector of rates of indirect carbon tax in industrial sectors obtained through equation (2). $(1 - A)^{-1}$ is the well-known Leontief inverse matrix, and its size here is 42×42. B is a 42×8 bridge matrix used to convert 42 sectors in the 2007 Input–Output Table to eight consumption goods categories used for per-capita annual consumption expenditure in the China Statistical Yearbook (2008).[4] The bridge matrix shows how much output from different sectors is contained within each consumption goods category.

$$V_k = \sum_j \Delta p_j c_{j,k} \tag{4}$$

The amount of carbon tax borne by income group k is denoted by V_k and is calculated via equation (4). Here, Δp_j is the price change of consumption category j, $c_{j,k}$ is the expenditure of income group k on consumption category j, and V_k is the sum of the expenditure change in each consumption category.

[4] Here, the bridge matrix is based on the matching table in Chen et al. (2010).

The production-related data used in this study are drawn from the China Energy Statistical Yearbook (2008), the China Statistical Yearbook (2008), or the 42-sector data of the Input–Output Table for the year 2007. The consumption-related data are from the China Statistical Yearbook (2008), which cites eight income groups of urban residents and five income groups of rural residents.[5]

This study evaluates tax incidence based on consumption expenditure, but not on income. This kind of approach is not rare. Poterba (1989) argues that in measuring the share of goods subject to taxation in a household budget, it is desirable to use current annual household expenditure for the denominator, rather than current annual household income. One reason is that an important factor in measuring the regressivity of such taxes is lifetime income, not short-term (e.g., annual) income, and that annual household expenditure relates more to lifetime income than annual household income and more accurately reflects a household's ability to pay. Measurements of distributional incidence based on short-term income are likely to overestimate a regressive tendency; studies that discuss and compare annual income, annual consumption expenditure, and lifetime income include those of Metcalf (1999) and Hassett et al. (2009). Another reason concerns data problems arising from China's unique circumstances. *Net income*, used as rural residents' income in the China Statistical Yearbook, is an indicator from which investments in agricultural reproduction are not subtracted.[6] Moreover, the *disposable income* of urban residents includes medical care and residence compensation, but not the indirect benefits that urban residents would typically receive;[7] it therefore differs from the definition of "disposable income" that is generally

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[5] Income and expenditure data from the National Bureau of Statistics pertain to life in urban and rural households, respectively. Data on urban residents come from a sample survey on urban households conducted by the Department of Urban Social and Economic Surveys of the NBS, and it includes 59,000 households at the end of 2007. The urban household survey was organized by the Department of Urban Social and Economic Surveys, NBS; in total, 68,000 households were selected from 7,100 villages across China.

[6] "Net income" refers to the total income of rural households from all sources, minus all corresponding expenses. The formula for its calculation is as follows:

Net income = total income – taxes and fees paid – household operation expenses – taxes and fees – depreciation of fixed assets for production – gifts to nonrural relatives

Net income is mainly used as input for reinvestment in production and as consumption expenditure for the year; it is also used for savings and noncompulsory expenses of various forms. "Per capita net income of farmers" is the level of net income averaged by population, reflecting the average income level of rural households in a given area.

[7] "Disposable income of urban households" refers to the actual income at the disposal of members of the households; it can be used for final consumption, other noncompulsory expenditure, and savings. This equals to total income minus income tax, personal contribution to social security, and a subsidy for keeping diaries a part of being a sample household. The following formula is used:

Disposable income = total household income—income tax—personal contribution to social security—subsidy for keeping diaries for a sampled household used. It is considered that in order to compare urban areas and rural areas on an equal footing, the same indicator should be used in both cases.

3 Results

Table 1 lists the top 10 sectors of the 42 sectors, in terms of scale of impact of a carbon tax. According to the calculation results, under the scenario used in the present analysis, the introduction of a carbon tax would lead to tax revenues of CNY54.7 billion, or approximately 1% of China's total annual fiscal revenue.

Price changes for the consumption categories are shown in Table 2. Due to price increases in electricity, fuel, and real estate, residence expenditure—which includes electricity and gas charges and rent—increases at the highest rate, followed by household facilities, articles and services, miscellaneous goods and services, health care and medical services, and transportation and communications. Since direct impacts on agriculture are small, the price of food increases is at the lowest rate among the eight categories.

This result is unique in comparison to those of previous studies. According to Kerkhof et al. (2007), for example, among five categories—food, house, clothing and footwear, hygiene and medical care, and development, leisure, and traffic—the rate of price increase (resulting from a carbon tax) for food is greater than that for hygiene and medical care and clothing and footwear, and

Table 1. Tax Rate Borne by Sectors.

Sector	Rate of indirect carbon tax
Coal mining	0.062855
Petroleum and natural gas mining	0.012534
Electricity, gas, and water production and supply	0.012076
Petroleum processing; coke and nuclear fuel	0.011759
Gas production and supply	0.011589
Nonmetal mineral products	0.006848
Metal smelting and rolling processing	0.005329
Chemical engineering	0.005193
Metal mining	0.004387
Metal products	0.004074

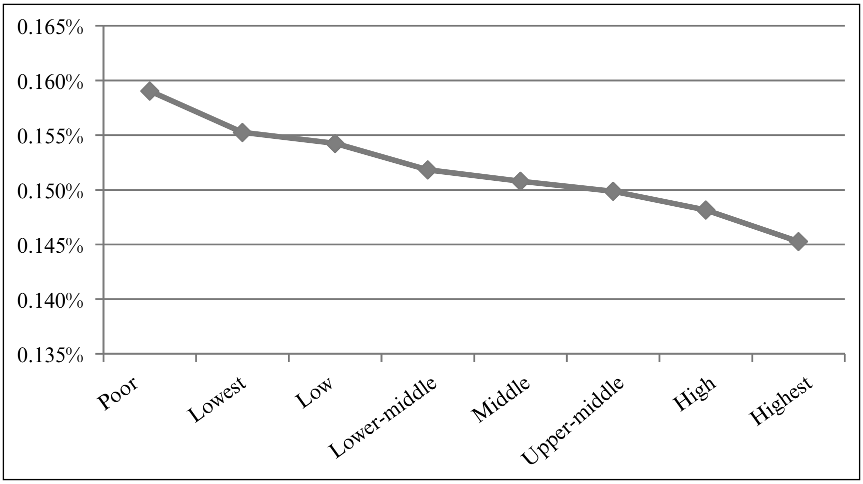
Table 2. Rate of Price Change for Consumption Goods.	
Consumption goods	**Rate of price change**
Food	0.140%
Clothing	0.211%
Residence	0.515%
Household facilities, articles, and services	0.377%
Health care and medical services	0.296%
Transportation and communications	0.268%
Education, cultural, and recreation services	0.179%
Miscellaneous goods and services	0.320%

is ranked third. In the study by Grainger and Kolstad (2010) that analyzes the case of the United States, consumption goods are divided into 13 categories, and the amount of carbon emission associated with households' consumption of each category is estimated. The amount of emission associated with food and alcohol consumption is ranked third, followed by electricity and gasoline, and accounted for approximately one-sixth of total emissions. Under China's method of levying a carbon tax on fossil fuel at the early production stage, the extent of indirect tax-shifting to food would be small. Since this is consistent with the recognition that lowered tax rates, or certain levels of refund, for food are generally effective in reducing regressivity, this Chinese method of taxation can be considered rational.

Figures 1 and 2 illustrate the incidence of a carbon tax (as a percentage of expenditure) on different income groups in urban and rural areas, respectively. As seen in the graphs, the incidence of a carbon tax in China exhibits regressivity, with two characteristics: one is the regressivity of the tax in urban areas, and the other is the difference in tax incidence between urban and rural areas. Contrary to most experiential views, the tax appears to be progressive in rural areas. However, this does not imply that the tax incidence in rural areas is ideal. An in-depth examination of the incidence of the tax on income groups shows that the highest percentage in urban areas is 0.16%; compare this to the much higher value of 0.24% in rural areas. Additionally, the lowest percentage for rural areas exceeds the highest percentage for urban areas. To shed light on the reasons for this finding, the components of consumption among urban and rural residents are compared and interpreted.

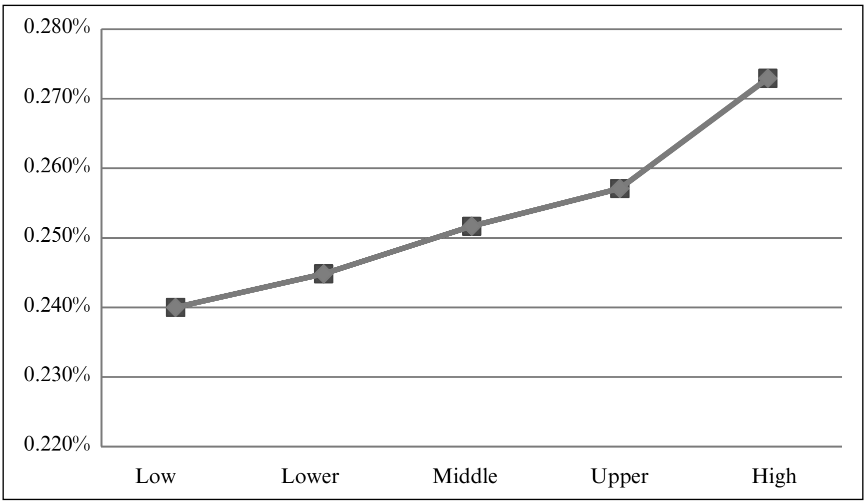
Figures 3 and 4, respectively, break down household expenditure in rural and urban areas, thus providing an overview of household expenditure patterns by income group. As Figure 3 shows, two categories—namely, residence and

Figure 1. Distribution of Burden: Urban Areas.



Source: Authors' calculations based on NBS data, and authors' assumptions.

Figure 2: Distribution of Burden: Rural Areas.

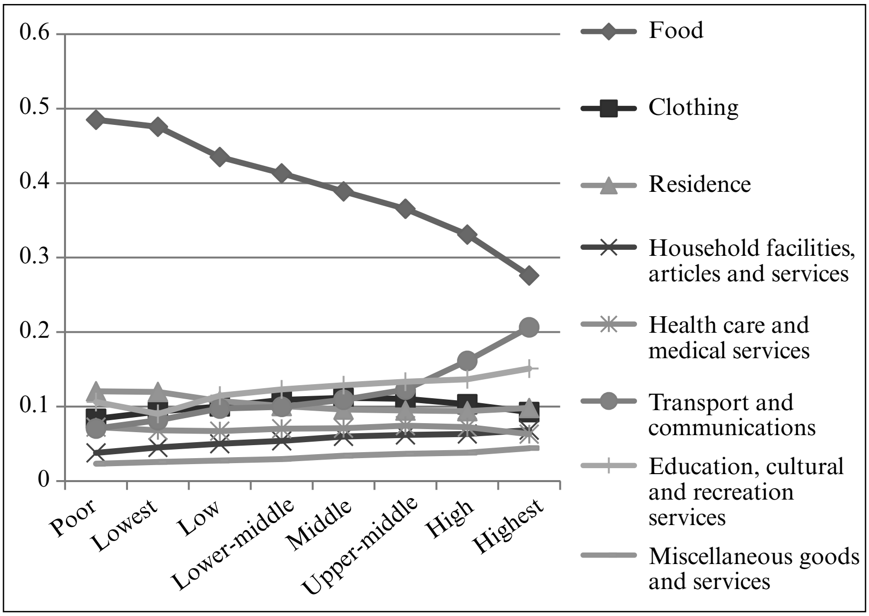


Source: Authors' calculations based on NBS data, and authors' assumptions.

food—play a significant role as factors of the regressive incidence of a carbon tax against urban residents' consumption. The price of residence is affected most by the collection of a carbon tax. Since the share of residence expenditure would be small for high-income earners, the incidence of the tax on low-income earners would be relatively high. The extent of tax-shifting to food is smallest. Since the share of food consumption in total expenditure drastically declines as income rises, an overall regressive tendency is observed. This phenomenon is also consistent with the findings of Golley et al. (2008), who calculate the demand of urban residents for energy, and the amount of CO_2 emissions expended for goods and services consumed by different income groups in China; they conclude that although the amount of emissions related to relatively low-income residents is clearly small, their emission intensity per unit of consumption is conversely high.

Unlike in urban areas, the incidence of a carbon tax is progressive for rural areas. Figure 4 shows that as income increases in rural areas, there are upward tendencies in most consumption categories, except food. Food consumption as a proportion of consumption expenditure—that is, Engel's coefficient—shows a downward tendency. However, this does not become a decisive factor in the

Figure 3. Urban Residents' Consumption Patterns.



Source: Derived from National Bureau of Statistics (NBS), 2008. *Urban Household Income and Expenditure Survey*, China Statistical Yearbook, China Statistics Press, Beijing.

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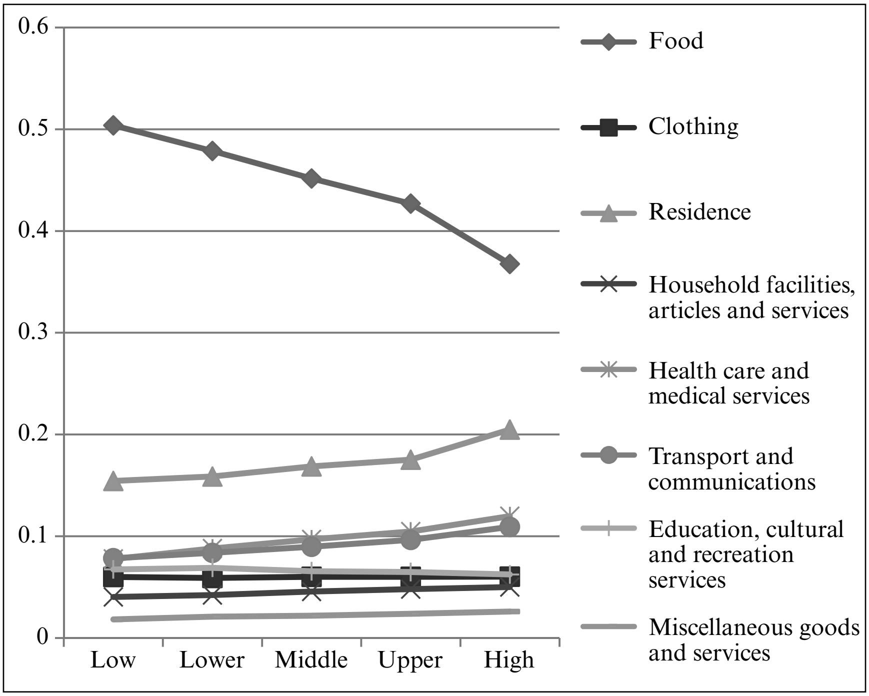


Source: Derived from National Bureau of Statistics (NBS), 2008. *Rural Household Income and Expenditure Survey*, China Statistical Yearbook, China Statistics Press, Beijing.

incidence of a carbon tax, because the effect of the tax on food prices is relatively small.

A comparison of Figures 3 and 4 reveals two categories in which the consumption pattern of urban residents differs significantly from that of rural residents. The first is residence. As income increases, the share of residence as a proportion of urban residents' total expenditure tends to decline, but the share of residence in rural residents' expenditure uniformly rises. Brenner et al. (2007) also examines consumption patterns, but finds upward tendencies for both urban and rural areas, because data for 1995 are used. A possible reason for the downward tendency for urban residents and the upward tendency for rural residents is that while urban areas have rapidly developed as the economy has grown, rural areas have lagged behind; this has resulted in the emergence of gaps in terms of lifestyle and improvements in the equipment needed to fulfill daily life activities. Take residential buildings, as an example: China has taken three steps to improve energy efficiency. The first step requires a 30% cut in energy use relative to typical Chinese residential buildings designed in 1980–1981. Second, China requires that new buildings be 50% more efficient by 2010. Third, the energy-saving goal is to be increased to 65% for new buildings by 2020 (Zhang 2010). These plans for energy-saving houses, however, are largely implemented in urban areas, and no consistent guidelines or regulations have been established for residential constructions in rural areas. With regard to energy expenses for residential heating, most residences in urban areas in northern China are equipped with a steam-heat system. The system is connected to a district-wide network of hot water pipes that provides heating uniformly to each household. This is far more efficient and economical than households individually generating heat for themselves. In contrast, such benefits are still not enjoyed in rural areas, partly because only a limited number of multi-unit residential buildings have been constructed.

Attention should also be paid to transportation and communications. Expenses related to transportation and communications for both urban and rural residents tend to increase as income increases. However, while the increase for rural areas is gradual, the increase for urban areas jumps in the upper-middle-income group. One reason might be that an increasing number of middle or high-income earners own a car in urban areas, and affluent classes have tended to buy luxury automobiles in recent years. Owing to expenses related to the purchase of a vehicle and gas, the share of consumption related to transportation and communication in total consumption has increased significantly. In contrast, since low-income earners use public transportation systems, their share of expenditure within this category is modest. Aasness et al. (2002) obtained a similar result in their analysis of a Norwegian case.

Another finding that cannot be ignored is the phenomenon where the amount of expenditure on education, cultural, and recreational services is much lower in rural areas than in urban areas. The reason for this is the low income levels of rural residents, which points to the reality that they can seldom afford to enjoy the consumption of services that extend beyond basic living necessities. The tax incidence passed to these consumption categories is relatively small, and this contributes to the gap in tax incidence between urban and rural areas.

4 Discussion

The distributional effect of a carbon tax depends on how tax revenues are used. There are mainly two ways of reducing the regressive impacts of a carbon tax through the use of tax revenues (Zhang and Baranzini, 2004). One is the *ex post* lump-sum redistribution of carbon tax revenues to the population. Under this scheme, the amount redistributed to low-income earners exceeds what they pay, resulting in mitigated regressivity. For example, in the analysis of Brenner et al. (2007) of China, the recycling of carbon tax revenues through a “sky trust” brings benefits to low-income groups and imposes a heavier burden on high-income groups. This can be considered an extremely effective method of reducing the regressive impacts of the tax. In fact, Switzerland has already implemented a similar method in which part of the tax revenues is used to reduce the people's health insurance premiums uniformly nationwide through insurance companies. However, two issues must be addressed, before this type of method can be undertaken in China. The first is the administrative cost. Brenner et al. (2007) assumes the administrative cost associated with revenue-recycling through a sky trust to be 1% of the entire revenue. China would face difficulties in managing its residents: China, unlike Switzerland, has no system that covers the entire population, and the people's movements are active due to undertaking migrant work. If enormous administrative costs are considered essential to the returning of tax revenues uniformly to 1.3 billion people, we would see problems concerning whether the exogenously given administrative cost is appropriately set. As to the second issue, even if the setting of the administrative costs is appropriate, the *Report* sets the rate of a carbon tax at CNY10 per ton, whereas Brenner et al. (2007) set it at CNY300 per ton. The specific amount to be recycled has little impact on administrative costs. However, as tax revenues clearly shrink, the share of costs increases, which leads to a question regarding the efficiency of implementing such a method.

Another option is to use the generated fiscal revenues to decrease income taxation or adjust the social security system, such as an increase in residence benefits and social benefits based on means-tested benefits. For example, Finland and Sweden each use carbon tax revenues to reduce income tax, and Germany and Denmark each use revenues to lower social security contributions; these moves are generally regarded as regressive and are also expected to increase employment. However, it is difficult at present for China to take such approaches, because the country has not yet developed social systems like those seen in advanced countries. In the case of income tax, for example, personal income tax in China is imposed on urban sector incomes only; thus, decreasing income taxation there can hardly benefit rural residents, and will possibly exacerbate rural–urban income disparities. Moreover, with regard to lowering social security contributions, the precondition is the existence of a welfare or social security system that focuses on guaranteeing a level of lifestyle seen in advanced countries. However, as China is still a developing country, it cannot meet this precondition.

The *Report* proposes the use in China of revenues derived from carbon taxes. It suggests that such revenues be used to cover costs associated with developing and utilizing energy-saving technologies, new energies, and renewable energies. In other words, the use of revenues for specific purposes, or environmental purposes, is proposed. However, the *Report* also points out that specified or fixed revenue uses would reduce flexibility in revenues and expenditures.

Since a method by which the current "unfair" burden of carbon tax in this unique circumstance can be ameliorated and the carbon tax introduced more smoothly, we consider another alternative political option: recycling the tax revenue through electricity supply facilities by reducing the electricity charges levied to households. The losses taken by each electricity supply company can be calculated, based on its electricity supply to residences; part of the carbon tax revenues is returned to the people in the form of an electricity subsidy. The electricity supply in China is categorized into several types (e.g., industrial, agricultural, commercial, and residential), and a different price is set for each type. Such a system allows for the easy estimation of the impact of a price change on households, since it is easy to control for electricity charges. Unlike other options, as discussed, that can only lighten the burden of a limited proportion of China's population, this method ensures that revenue-recycling benefits every household that uses electricity, while exacting a relatively low implementation cost.

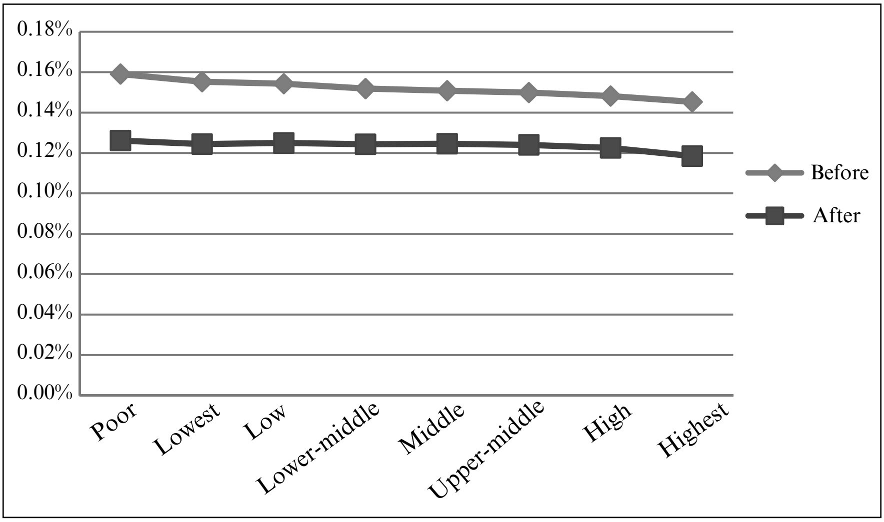
Here is one scenario that provides a rough calculation and thus shows the process and effect of this political option. Since the expenditure on electricity is included in the residence category, and residence is the most important element to bring about a difference in carbon tax burden between the rural and urban areas, how much an electricity price reduction would change the expenditure on the residence category can be calculated. If the average electricity charge is reduced by 1.112%—the level that barely offsets the carbon tax burden on residence—then the loss to the electricity supply companies (i.e., the amount of subsidy as a compensation for the relevant facilities) is CNY2.67 billion; this amount is less than 5% of the total annual tax revenue of CNY54.7 billion. Figures 5 and 6 illustrate the results of implementing this policy.

As shown in Figures 5 and 6, an adjustment to the electricity charges for households would have a large effect on the urban middle and low-income groups—in which the current study has the greatest interest—and regressivity would be mitigated. The initial upward trend observed for rural areas would weaken slightly, and the reduction in the overall burden of the tax would be larger than the reduction in urban areas. The initial gap in the incidence of the carbon tax between urban and rural areas would decline from 0.081–0.128% to 0.034–0.049%, reflecting a rational adjustment. Several rationales can be considered for the possibility and rationality of implementing in China this method of adjusting the incidence of a carbon tax, by changing electricity charges.

First, in 2008, residential consumption of energy in China accounted for 10.8% of total energy consumption, while residential consumption of electricity accounted for 12.7% of total electricity consumption.[8] Currently, in China, increased energy efficiency in terms of electricity could be substantially achieved by making improvements at the electricity generation stage and in industrial production processes. Even if carbon tax revenues were used to reduce electricity charges for households, a carbon tax would maintain the incentive levels of

[8] Source: author's calculations, using data from the China Energy Statistical Yearbook (2010).

Figure 5. Effect of an Electricity Price Adjustment on the Incidence of a Carbon Tax in Urban Areas.



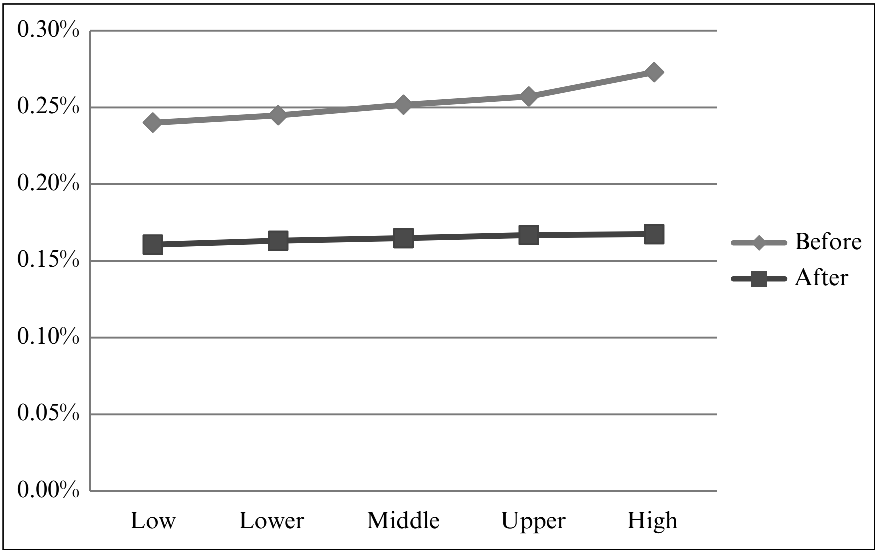
Source: Authors' calculations based on NBS data, and authors' assumptions.

power plants and the industrial sector. Therefore, few inconsistencies vis-à-vis reductions in greenhouse gas emissions would arise.

Second, the tax rate would be set low at the initial phase of introducing a carbon tax in China. Under this condition, only small changes in electricity charges would be needed to adjust the overall incidence of a carbon tax effectively. Even if the price elasticity of electricity for households were taken into account, such small changes in electricity charges would have little effect on the pattern of electricity consumption by the middle, upper, and high-income classes. In addition, even if the use of electricity by low-income households were to rise to some extent, it would undoubtedly lead to increased quality of life rather than to a substantial change in consumption.

Third, in developing countries such as China, from the standpoint of energy conversion, increased use of electricity does not necessarily result in serious global warming. People in the poor regions of China use coal, biomass (wood and livestock/agricultural waste), and other types of solid fuel as energy for use in cooking and the heating of the home and its water, but those energy sources can have adverse health effects, owing to the toxic substances generated during their combustion; a large amount of greenhouse gas is also emitted due to inefficient combustion. If logging causes the destruction of forests, losses can be further exacerbated; therefore, if reduced electricity charges encourage the

Figure 6. Effect of an Electricity Price Adjustment on the Incidence of a Carbon Tax in Rural Areas.



Source: Authors' calculations based on NBS data, and authors' assumptions.

use of electricity by poor households, there is a potential for overall positive environmental results.

Fourth, the use of carbon tax revenues for the electricity supply sector would be easy to realize, and the associated costs would be small. Carbon tax revenues of about CNY50 billion that remain following revenue-recycling can be used in the development and utilization of energy-saving technologies, new energies, and renewable energies, as proposed by the *Report*. However, it should be noted that even if such adjustments were made, special treatments would be needed for residents living below the poverty line. There would still be poor residents in China who do not use electricity.[9] These people would be unable to avoid the incidence of a carbon tax, but would not be covered by the aforementioned general guarantees. Therefore, the use of tax revenues for poor residents following the introduction of a carbon tax becomes a significant issue.

[9] As of 2010, the number is said to be 4.5 million. More details are available at http://www.ce.cn/xwzx/gnsz/zg/201007/14/t20100714_21612636.shtml.

5 Conclusions

In this study, we calculated the incidence of a carbon tax (as a percentage of expenditure) across various income groups in urban and rural areas, based on the establishment of a carbon tax levied on production in the early stage at CNY10 per ton of CO_2; this approach is discussed in the *Report* issued by a research team with China's Ministry of Finance, using IO analysis. The analytical results are as follows.

First, if a carbon tax were introduced under the scenario of the *Report*, the incidence of the tax on various income groups in urban areas would exhibit a regressive tendency, but a progressive tendency would be observed in rural areas. However, the incidence of the tax on rural residents would be much higher than that on urban residents.

Second, the above result warrants further examination, vis-à-vis the use of tax revenues beyond expenditure on the development of energies and energy-saving technologies, which is proposed by the *Report*. This study makes a single proposal: that the incidence of a carbon tax be adjusted with a reduction in electricity charges for households; this study also shows that the scheme would mitigate the regressive nature of the tax incidence in urban areas, and that the gap in tax incidence between urban and rural areas could be narrowed.

The adjustment of the distributional effect of a carbon tax through electricity charges, however, is a short-term measure that could not be used repeatedly. The low tax rate discussed here is appropriate to the initial stage of implementing a carbon tax in China; it would need to be raised gradually, following an initial implementation period. Therefore, when introducing carbon taxes in a developing country like China—a country that is facing numerous serious issues, such as extreme poverty and social disparities—seeking an optimal policy design with full consideration of the circumstances unique to China is still open to further examination and research.

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