Is Fuel Taxation Progressive or Regressive in China?

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ABSTRACT

Fuel taxation is often viewed as unfavorable instrument compared to traffic restrictions. First, people appear to believe that gasoline demand is not quite price elastic given the impression there is little flexibility in demand in the short-run. Second, political resistances often arise when debating on the tax incidences of fuel tax reform, since most western studies suggest that gasoline tax is very likely to be regressive. In this paper, we first estimated the short-run and long-run fuel demand elasticities in China and other Asian countries, then we estimates distribution effects of the current fuel tax reform initiated on January 1, 2009, by working out a spreadsheet analysis using a micro-level household survey data with the estimated elasticity results. Our results show that the direct effect is strongly progressive, and even if indirect use through public transport is included it is still progressive. Therefore, we can conclude that the new fuel tax policy in China is a desirable progressive policy.

Key Words: fuel taxation, regressivity, progressivity, distribution effects
JEL Classification: Q48, Q52, Q53

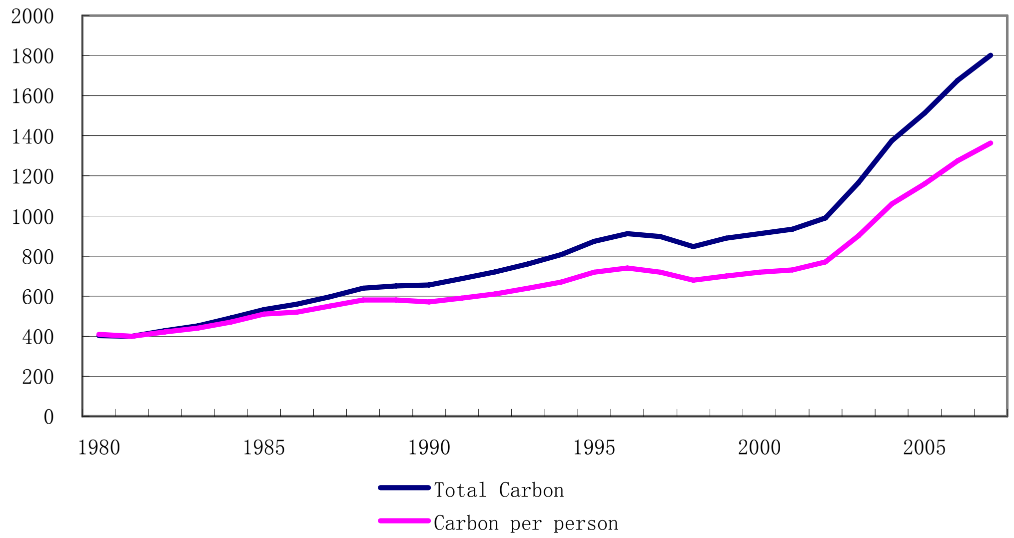
1. Introduction

The magnitude of the air pollution problem in China is alarming. While rapid economic development and urbanization over the last three decades have kept an average 8-10% GDP growth, and lifted hundreds of millions of Chinese people out of poverty, it also created tremendous pressures on the environment and sustainable development. Escalating urban environmental threats to human health afflicted many cities of China. According to SEPA, roughly 39.7% of Chinese cities are facing either medium or serious air pollution, and China has 16 to 20 most polluted cities in the world. In addition, with the energy and carbon spike after year 2002, China has top the list of carbon emitter countries, exceeding the United States. Figure 1 shows the rise in total carbon emissions and carbon per capita from the fossil fuel combustion since economic reform thirty years ago. Though the trend is somewhat flatten during 1995-2002, it increase dramatically after 2002.

Recently, though China has made significant progress in terms of promoting energy saving in heavy manufacture industries and controlling coal-combusted air pollution in urban area. However new challenges arise from the increasing number of automobile vehicles (figure 2) and vehicle emissions, posing new challenges in urban air pollution control. For example, daily and hourly NO_x and Ozone concentrations have exceeded national air quality standards (NAAQS); high concentrations of CO, HC and SO_2 are along roadside; potential threats of photochemical smog exist for many large cities. Vehicle emission has become the main source of air pollution in some big cities including Beijing.

To stabilize the future carbon emissions and vehicle emissions, there is one class of economic-based instrument, that has been proven to be very effective and efficient, and that is simply to impose a tax on transport fuels such as gasoline. Fuel/gasoline tax may be imposed first for non-environmental reasons, such as energy security. However, it has been proven to produce remarkable environmental effects as well. To simply put, a higher gasoline price will encourage people to drive less, and also provide incentives for producers to produce more efficient car, so that can change people's incentive from both demand and supply side. The question is, how large are these effects? Is this policy progressive or regressive?

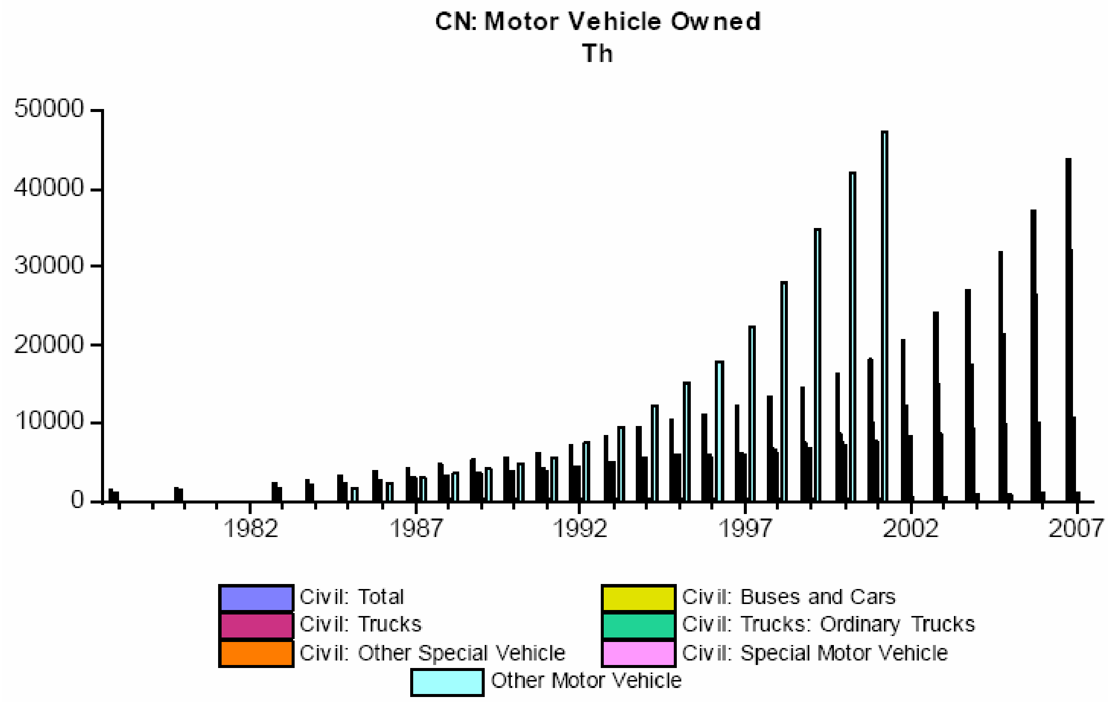
Figure 1 Total Fossil Fuel Carbon Emissions and Carbon Per Capita, 1980-2007

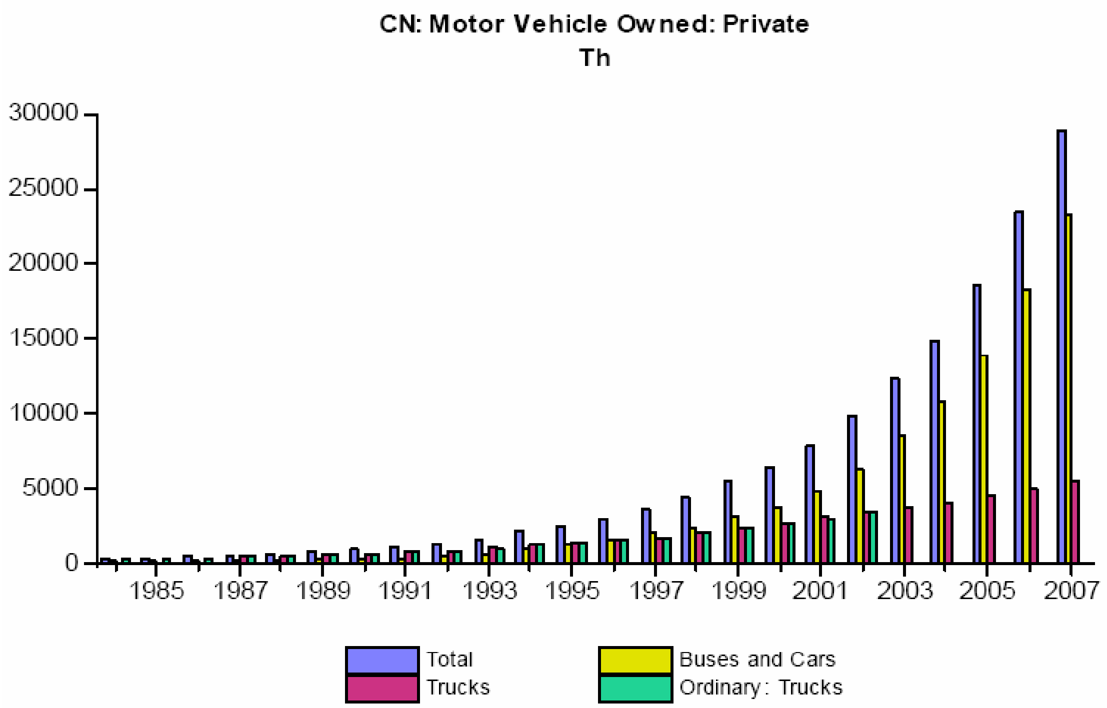


Many policy makers and academics are concerned that the gasoline tax will have regressive properties. They say that lower income people will be hit because they will not be able to afford the tax. We believe, however that this matter should be studied empirically in a careful manner. It is not obvious that fuel taxes are regressive in developing countries. Since only rich people can afford buying automobiles in the developing countries, so many developing countries may actually have progressive fuel taxes rather than regressive ones. Sterner (2008) have shown that, gas tax in South Africa and India are likely to be progressive.

Even for developed countries, some portion of gasoline tax may be progressive as well. For example, West (2004) concludes that, the gasoline tax is more progressive between the low and middle-income distributions, and less regressive between middle and high income distributions. In addition, the progressive or regressive results depend a lot on how the gas tax revenue is used, for example, West and Williams (2004) suggest that, one can easily make the gas tax highly progressive by using the revenue to finance cuts in really regressive taxes. Thus, the tax incidences are actually an empirical matter and depend fully on the gas tax reform design, and interactions with other pre-existing taxes.

Figure 2 Trends of Vehicle amount in China (Civil and Private Vehicles)





Source: CEIC database.

This paper is organized as follows. We start with an overview of the background of China's fuel tax reform in section 2. In section 3 we estimate the price and income elasticities of fuel use in China, then we combined the China data with other Asian countries to get larger data set for cross-sectional analysis. Sector 4 we explored China's fuel use distribution effects across different expenditure and income deciles, using a simple spreadsheet analysis combining our household survey data and estimated elasticities, which shed some light on pointing out the distribution effects of current fuel taxation regime in China. Section 5 concludes.

2. Fuel Tax Reform in China: Background

Since January 1, 2009, China has started a modest reform on fuel tax, initiated under the nation's top economic planner, the National Development and Reform Commission (NDRC), together with the Ministry of Finance and Ministry of Transport. This is a big breakthrough after 15 years' discussion and debates on fuel tax reform in China. Last year, the record low world oil prices offered a rare opportunity for China to push ahead its fuel taxation reform. In addition, it also provides some channels to revising the current fuel prices mechanism, and forthcoming resource tax reform. Though the fuel tax reform maybe kicked start with the concerns on energy security, it will in the long-run give the market a larger role in pushing for better environment and energy efficiency.

The scheme of the current fuel tax, now annuals six types of fees on road and waterway maintenance and management, instead raise the fuel consumption tax from 0.2 yuan per liter to 1.0 yuan per liter for gasoline, and 0.8 yuan per liter for kerosene. With the remarkable fall of gasoline price in the last year, an increase on gasoline price only come out very ignorable effects initially on consumers, and then it gradually increase when the world oil price steadily increase, it will ultimately push Chinese consumers shifting their demand on fuel use.

However, compared to European fuel tax reform, most of the fuel tax in China is simply replacing the pre-existing road maintenance fees. In addition, the tax revenue is spent on compensating the losses in Ministry of Transportation, and other petro users who previously waived the road tolls, such as airlines, army and etc. Therefore, the tax rates are very modest, in some sense not sufficient enough to substantially reduce carbon and other vehicle emissions, thus raising the issue whether China needs to deepen its fuel tax reform or not? However, such a reform often faces resistance for political reasons on regressivity. Thus, we need to answer such a question, is fuel taxation policy in China regressive, as most studies in the western countries suggests?

In order to understand this, in the following sections we conduct an empirical study estimating the fuel demand elasticity in China and other Asian countries, then we combined the household survey data, to examine the distribution effects of current fuel tax regime in China.

3. Fuel Demand Elasticity Estimation

3.1 Data

In this paper, we conduct a comparative study of fuel demand elasticity in China, other Asia countries, US and European countries. Here we rely on aggregate fuel price, fuel use data combined with income data from the Chinese Statistical yearbook to estimate China's own price and income elasticity on fuel use. Besides, we also pool Hongkong, Japan, Korea and other Asia countries together, as a backup to proxy for China's elasticities estimation if China's data is not very reliable. The data for other Asian countries is retrieved from the CEIC database[1]. We can obtain the time series data on fuel price, quantity, and income for Hong Kong, India, Indonesia, Japan, Korea, Philippines, Thailand, Vietnam from the CEIC database. The sample period that we examined is from 1991-2007.

3.2 The Model

Like all products, we can assume that the demand for fuel G is a function of income Y, and price P. A simple model that can capture this dynamic behavior is presented as follows:

$$Q_{it} = a \cdot P_{it}^{\alpha} \cdot Y_{it}^{\beta} \cdot Q_{it-1}^{\delta} e^{\mu_{it}} \quad (1)$$

Q_{it} -Quantity of gasoline demand of country i in period t

P_{it} -Real price of gasoline country i in period t

Y_{it} -Real income in country i period t

Q_{it-1} -Quantity of gasoline demand country i in period (t-1)

This formulation is called the lagged endogenous model, and the lagged quantity of gasoline demand (Q_{t-1}) represents the inertia of economic behavior. In the formulation, α, β and δ are three parameters to be estimated. α represents the price elasticity, β represents the income elasticity, and δ is the discount rate. The price and income elasticity in short run and long run can be formulated as follows:

[1] http://www.ceicdata.com/

Table 1. Relationship between Short-run and Long-run Price Elasticity and Income Elasticity

	Price Elasticity	Income Elasticity
Short Run	α	β
Long Run	$\frac{\alpha}{1-\delta}$	$\frac{\beta}{1-\delta}$

3.3 China's Gasoline Demand Elasticity Estimation

Though extensive studies have been conducted in OECD, US and other countries, the empirical study on China's fuel demand elasticities is still very limited, partly due to the data availability and quality of China's fuel price data, which is actually planned by the Chinese government and not frequently affected by the world fuel price. However in statistics, if we don't observe data variation it is unlikely to do any empirical estimation on demand elasticities. In recent years, the plan price variation is larger than previous years, NDRC steady revise the fuel price, to follow up the world price, though still in an imperfect way. So we try to use China's own data first to estimate the short-run and long-run price and income elasticities. We collected a time-series data set on China's per capita GDP, gasoline price, and gasoline use in transportation sector, and estimated the above equation (1). The results are shown in table 2.

Table 2. China's Gasoline Demand Elasticity Estimation Results

α	β	δ	$\alpha/(1-\delta)$	$\beta/(1-\delta)$
-0.1245 （-0.31）	0.1187 （0.03）	0.9531 （1.04）	-2.6546	2.5309

Our estimates above do not pass the statistical test, this is mainly due to the small variance in the price data, and we only have very limited years time-series data. To solve this issue, next we use other Asian countries' data as proxy to estimate the gasoline demand elasticities, considering that Asian countries have similar life-style and consumption patterns, so the bias will be smaller than using western countries data.

3.4 Demand Elasticity Estimation in Asian Countries

Since China's data has quality issues, we try to pool China and other similar Asian countries together to mitigate the statistical problem. The other Asian countries we selected are India, Indonesia, Japan, Korea, Philippines, and Thailand. Then we converted the per capita GDP data in all the countries with the PPP adjustments. Our data sample for estimation is 1991-2007. The estimation results are summarized in

Table 3.

Since we have more data, the results based on the whole sample or sub-sample are much better than the China data alone. We can see that the short-run price elasticity for the whole Asian sample is -0.16, short-run income elasticity is 0.27. The long-run elasticity is roughly four times of the short-run elasticities, for instance long-run price elasticity is -0.69, and long-run income elasticity is 1.14. .

Table 3. Gasoline Demand Elasticity Estimation Results for Asian Countries

Cases	α	β	δ	$\alpha/(1-\delta)$	$\beta/(1-\delta)$
All Asian Countries	-0.1620 （-3.04）	0.2672 （4.10）	0.7655 （14.23）	-0.6908	1.1394
Asian Developing Countries (China,India,Indonesia, Philippines, Thailand)	-0.2057 （-2.56）	0.3575 （2.83）	0.7259 （8.75）	-0.7504	1.3043
Asian Developed Countries (Japan+Korea)	-0.1841 （-4.96）	0.2327 （5.69）	-0.1841 （-4.96）	-0.5929	0.7494

We also divide the whole sample into two: one group is Asian developing countries including China, India, Indonesia, Philippines and Thailand, the other group is Asian developed countries including Japan and Korea. We can see that Asian developing countries have higher price and income elasticities than Asian developed countries.

3.5 Demand Elasticity Estimation in Western Countries

There are a large number of gasoline demand studies in the western world, see for instance ((Dahl and Sterner, 1991a, 1991b; Goodwin, 1992 Goodwin et al 2004, Hanley et al 2002, Graham and Gleister 2002, 2004). These studies show that short-run elasticity is usually -0.22~ -0.31, the long-run elasticity is quite high around -0.80~ -1.01 (Dahl and Sterner, 1991a, 1991b; Goodwin, 1992 Goodwin et al 2004, Hanley et al 2002, Graham and Gleister 2002, 2004). Table 4 is a summary table from Graham and Gleister (2002), we can see that our results in sub-sample of Asian developing countries are consistent with the elasticity estimates in the western countries.

Table 4. Summary of Price Elasticities of Gasoline Consumption

	Short Run	Long run
Time series data	-0.27	-0.71
Cross section data	-0.28	-0.84

Adapted from Graham and Gleister (2002).

Though people appear to believe that gasoline demand is not very price elastic, the reason behind this may only reflect the lower estimate of short-run price elasticities, giving people the impression that there is very little flexibility in changing demand. However, the truth is opposite, in fact in the long-run the price elasticities are very high, thus an effective gasoline tax can potentially reduce carbon emissions and vehicle pollutions substantially in the long-run.

4 The Distributional Effect of Fuel Tax in China

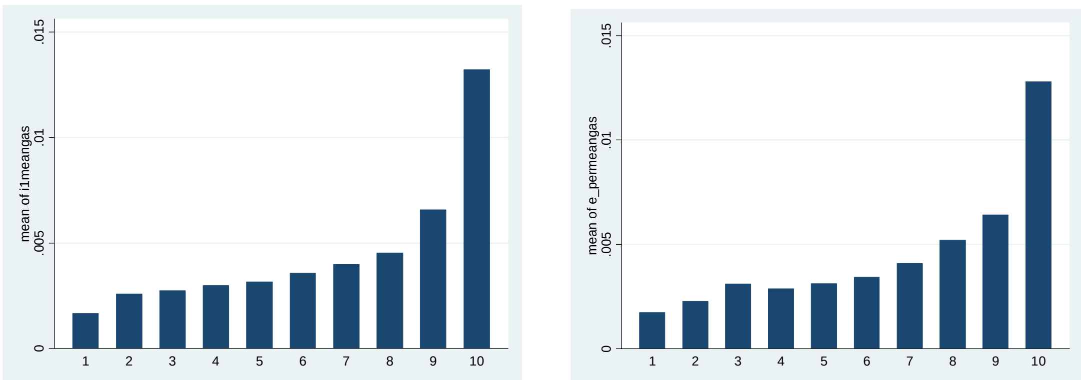
Currently, though fuel tax is proved to be cost-effective, in terms of distribution effects the government policy makers are mostly concern one question: are they regressive? Worrying that fuel tax reform might worsen the current increasing domestic inequality might be another political barrier to use this instrument. The literature in this field suggest mixed evidence for many industrialized countries, but very limited evidence for developing countries, and actually no evidence ever for China yet. For many developing and poor countries, most poor households do not own cars, so it could be possible for the fuel tax reform to be progressive in some sense.

The relationship between fuel use and income may have various function forms: it can increase with income with linear or nonlinear trend, it can also presents an inverted-U shape relationship as so-called “Environmental Kuznets Curve”. One way to check how people with different income respond to price change is simply comparing whether the budget shares for the consumption of fuel use are higher or lower among high and low income earners (Sterner, 2009). For instance, if poor people spend more share on the fuel consumption then the rich people, a fuel tax will hit the poor relatively harder even though the rich consume larger physical quantities.

In this paper, we use the urban household expenditure/income survey data set from the National Bureau of Statistics in China to calculate average direct and indirect expenditures on fuel by both income and expenditure deciles. The Chinese NBS household expenditure/income surveys have a dramatic change in 2002. Before 2002, the survey only includes number of household owned automobiles (value and quantities), fuel cost, transport expenditure which includes taxi bills and other transportation expenditure. After 2002, the survey is more complicated, including fuel use (quantity and value), transportation expenditure which can be further divided into: 1) transportation fee: by flight, by train, by long-distance bus, by public transportation, by taxi, and others (in both value and quantities); 2) transport service fee, including vehicle maintenance fee, user fees and etc. This data set also has very detail questions on household incomes, which may be useful to conduct some simple spreadsheet simulations of the effect of fuel taxes on expenditures as well. But the limitation of this dataset is that, the fuel use in the survey includes all the gasoline, diesel and other fuels, and there is no data for the sub-categories uses. So we cannot examine the different policy implications on gasoline and diesel.

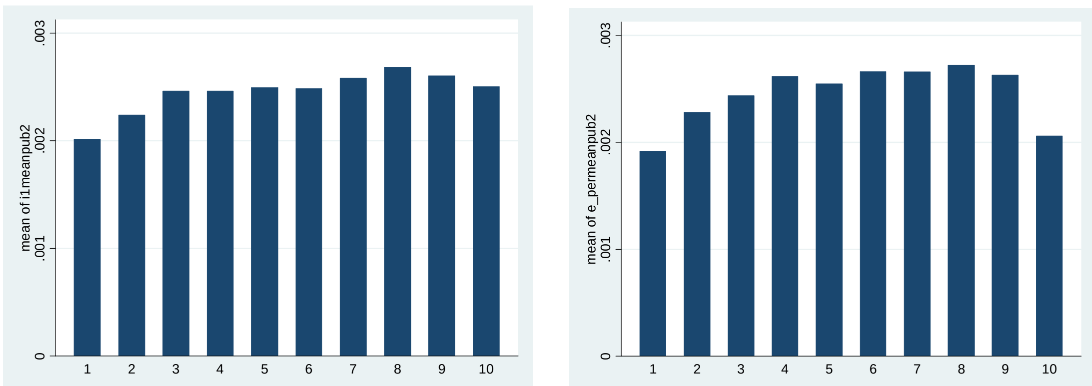
In the micro level household survey, we divide the sample into quintiles based on both income and expenditures. Similar with West and Williams III (2004), we adopt an equivalence scale to adjust total expenditures on gasoline and other goods for different family sizes. The argument is, given the same total household income, household with fewer members clearly have a higher standard of living. We use the same parameter that West and William III used to weight adults and children equally but allows for economies of scale in consumption. More specifically, we divide total expenditure by $(\text{adults} + \text{children})^{0.5}$, we than pool all the households, rank then together by equivalence-scale adjusted total expenditure on gasoline and other goods, and then divide them into expenditure quantiles. We then constructed income quantiles similarly just for comparison.

Figure 3 Private Fuel Costs as Share of Total Household Expenditures (2006)



(by income decile) (by expenditure decile)

Figure 4 Public Fuel Costs as Share of Total Household Expenditures (2006)



(by income decile) (by expenditure decile)

Note: Public transport here include public bus and long distance bus, here we don't have data to estimate how much share of the bus fees are fuel costs, so we take the number of 21% from Alpizar, Blackman, Osakwe (2008) study in Costa Rica.

Figure 3 and 4 give the budget share of private and public fuel costs[2] as share of total household expenditures in year 2006. The results are intuitive. In China, only very rich people can afford private cars therefore in the figure 3 the share of private fuel costs over total household expenditure is increasing with income, and the slope become much steeper in the 10th income and expenditure decile. On the other hand, when we look at public fuel costs as share of total household expenditure, we find that the budget share tends to follow an inverted U-shape, with low share in the poorest decile and richest decile for the poorest people cannot even afford bus fees while the richest people tend to use private vehicles more frequently. We also tried sample periods from 2002 to 2005, and we got the same progressive results as figure 3 and 4.

Now let us try a very simple spreadsheet simulation to examine the impact of fuel tax in China.

$$G = PQ \tag{2}$$

where G is expenditure on fuel use, P is price of fuel, and Q is quantity of fuel use. Based on the definition of price elasticity, we have

$$\varepsilon = \frac{dQ/Q}{dP/P} = \frac{dQ}{dP}\cdot\frac{P}{Q} \tag{3}$$

Now differentiating equation (2), we can derive

$$dG = PdQ + QdP \tag{4}$$

Therefore, rearranging terms in equation (4), we can derive a relationship between changes in expenditure in fuel and short-run or long-run price elasticity.

$$dG = G(dP/P)(1+\varepsilon) \tag{5}$$

where dP/P is the fuel tax rate, now let us take the price elasticity based on our Asian developing country sub-sample estimation results, that is, picking short-run price elasticity as -0.21, and long-run price elasticity as -0.75 for our simple spreadsheet simulation. In China we use unit fuel tax on gasoline use, that is 1 yuan/liter for gasoline and 0.8 yuan/liter for kerosene. Since we cannot separate gasoline and kerosene, here we ignore the small tax differences and assume aggregate tax is 0.8 yuan/liter for all fuel. Now the gasoline price in China is roughly 6.5 yuan/liter, so the ad-valorem tax rate[3] is roughly 12.3%. Now let's assume all the population have the same price elasticities, then the impacts of changes on fuel use budget share is shown in figure 5. Here we only use the distribution by income decile, since the figures are quite similar between income decile graph and expenditure decile

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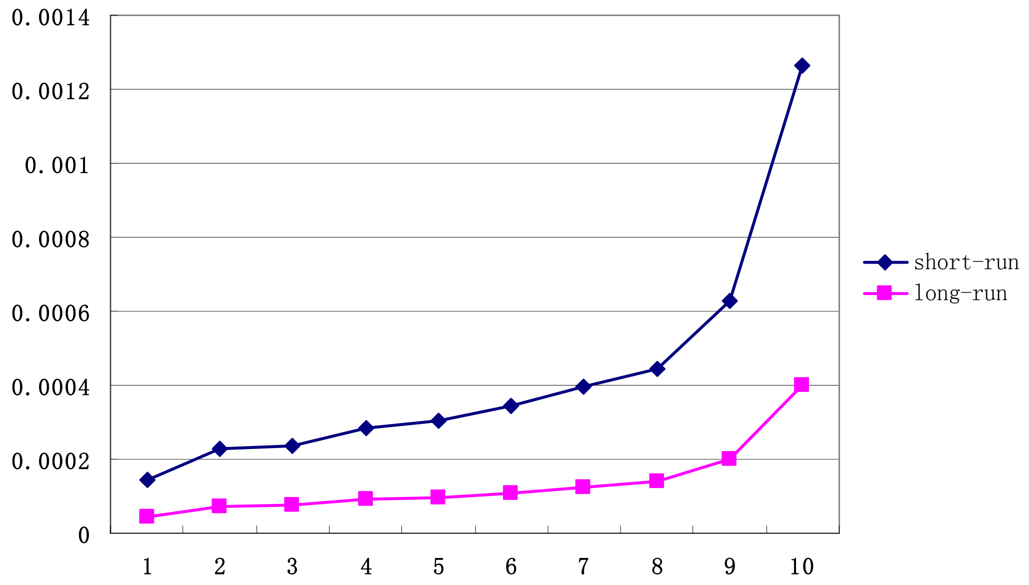
3 There is a pre-existing gasoline consumption tax at 0.2 yuan/L, so the incremental part is 0.8 yuan/L for gasoline.

graph, so we should have similar results for the expenditure decile case.

Our results shows that with a unit tax incrementally increased at 0.8 yuan/L, the richest decile has the biggest impact, therefore the fuel tax reform is progressive at all levels, though the progressivity is smaller in the long-run case than in the short-run case.

In this preliminary paper, we only calculate the direct gasoline consumption, while leaving the indirect effects to impact of fuel tax on public transport. However, figure 4 shows that for the richest decile they only slightly consume less than other deciles. So our results in figure 5 still hold even when taking into these indirect effects.

Figure 5. Changes in Expenditure Share Due to the Current Fuel Tax Regime



(by income decile)

5 Conclusion

Fuel taxes have been proven to be very effective for combating with vehicle pollutions and mitigating global warming. However, political resistances usually arise from a couple of reasons. First, people appear to believe that gasoline demand is not price elastic given the impression there is little flexibility in demand, even local government also favors command-and-control type of traffic restriction policies, for example the ones implemented in Beijing and Mexico city. Second, many western studies show that fuel tax reform is very likely to be regressive, so poor people might be hit harder. Our studies suggest this hypothesis is not supported in the China case. Rather, we find the current fuel tax reform is very progressive. Even indirect use through public transport is included here; it is still unlikely to reverse the progressivity result. With the rare opportunity early this year with the lowest world oil price, China kick start a new fuel tax which we find is progressive and desirable, thus it should clear up the concerns on distribution effects of fuel tax reform, and push forward a deepening reform to phase out current traffic restriction policies in China.

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