A Chinese Sky Trust?
Distributional Impacts of Carbon Charges and Revenue Recycling in China

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Abstract

The introduction of carbon charges on the use of fossil fuels in China would have a progressive impact on income distribution. This outcome, which contrasts to the regressive distributional impact found in most studies of carbon charges in industrialized countries, is driven primarily by differences between urban and rural expenditure patterns. If carbon revenues were recycled on an equal per capita basis via a 'sky trust,' the progressive impact would be further enhanced: low-income (mainly rural) households would receive more in sky-trust dividends than they pay in carbon charges, and high-income (mainly urban) households would pay more than they receive in dividends. Thus a Chinese sky trust would contribute to both lower fossil fuel consumption and greater income equality.

1. Introduction

This paper examines the scope for addressing two problems in the Chinese economy with one policy. The problems are rising fossil fuel consumption and rising income inequality. The policy is a 'sky trust': a system of carbon charges in which the revenues are recycled to the public on an equal per capita basis.

The choice of China as a setting for this analysis is motivated by three considerations. First, China's rising use of fossil fuels is widely seen as jeopardizing both the sustainability of the country's rapid economic growth and the prospects for redressing global climate change. Second, China's rising income inequality, particularly urban-rural inequality, is a source of concern from the standpoints of both human development and potential social unrest. Third, as a developing country, China's pattern of fossil fuel use is

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likely to differ from that in the industrialized countries where most prior studies of the distributional impacts of carbon charges have been undertaken.

The paper is organized as follows. Section 2 provides a brief overview of China's role in the global carbon economy. Section 3 surveys the literature on the distributional effects of carbon charges. Section 4 describes how a sky trust would work. Section 5 discusses the data sources and methodology used in the study. Section 6 presents the results, and Section 7 offers concluding observations.

2. China and the Global Carbon Economy

China is the world's second-largest emitter of carbon dioxide (CO_2), the most important 'greenhouse gas' implicated in global climate change. In 2002, China's CO_2 releases from the consumption and flaring of fossil fuels amounted to 906 million metric tons of carbon (mtC), 13.5% of worldwide emissions; the United States, the world's largest consumer of fossil fuels, emitted 1568 million mtC, or 23.4% of the total (see Figure 1a).

In per capita terms, China's carbon emissions are only about one-eighth of those in the United States (see Figure 1b). In recent years, however, the absolute volume of China's emissions has risen substantially, propelled by the country's rapid economic growth. Roughly 70% of the country's total energy supply comes from coal. China's fossil fuel consumption grew at an annual rate of 3.8% from 1980 to 2002, according to official figures. Given that the country's GDP grew at a 9.1% rate in the same period, this implies a rather low income elasticity of fossil fuel consumption (0.4) compared to other low-income economies (Zhang 2000, 745).[1] Even so, extrapolation from current trends implies that China's carbon emissions will double by the year 2025.

A comprehensive picture of China's role in the global carbon economy would include other sources of CO_2 releases, notably from the burning of wood and other biomass resources, as well as the reabsorption of CO_2 by terrestrial and marine plant life. Apart from the additional data needed for such an analysis, this would require grappling with the thorny question of how the carbon reabsorptive capacity of the biosphere – including that of the oceans, which accounts for about half the total – ought to be allocated across countries.[2] In this paper we avoid these complications by focusing solely on CO_2 emissions from the burning of fossil fuels.

As a developing country, China is not subject to the mandatory emission-reduction targets specified in the 1997 Kyoto Protocol. No international agreement limiting the carbon emissions of developing countries is imminent. Even in the absence of such an agreement, however, it is possible that China will choose at some point to act unilaterally to curb its use of fossil fuels. Several considerations could bring this about. First, China is not well-endowed with fossil fuel resources (World Bank 1997, 49); as a result, the country is now importing coal from Australia, in addition to being the world's fastest-growing importer of oil.[3] Second, China may be more vulnerable to climate change than are the industrialized countries, due to the much higher share of agriculture, an especially climate-sensitive sector, in its GDP (Zhang 2000, 749).[4] Third, the health and environmental benefits of reduced use of fossil fuels (or slower growth in their use) by virtue of lower emissions of pollutants with localized effects – sulfur dioxide, nitrogen oxides, and particulates – would reduce, or perhaps even offset, the net social cost of emission reductions.[5] Fourth, China faces mounting international pressure on this issue, particularly from the United States government; the Bush administration cited the absence of emission reduction targets for China and other developing countries in rejecting the Kyoto agreement as 'fatally flawed' (Bush 2001). Finally, China already has introduced a system of pollution charges to curb sulfur dioxide emissions (Sterner 2003, 321), a precedent that may lower the administrative and institutional barriers the introduction of carbon charges.

To assess the prospects for measures to limit fossil fuel consumption in China, and the potential economic and social effects of such measures, it is important to assess the likely distributional impacts of such policies. Income inequality in China has grown rapidly in recent years, with the Gini coefficient rising from .382 in 1988 to .452 in 1995 (Khan and Riskin 2001, 41). Rural-urban disparities are a major component of this inequality, with the average income per capita in urban areas (5706 yuan or US$683 in 1995) being 2.5 times higher than that in rural China (2307 yuan or US$276).[6] Accordingly, 17% of the rural population was living in poverty in 1995, as compared with 4% of the urban population.[7]

To a substantial extent, carbon emissions are driven by household expenditure.[8] Yet to the best of our knowledge, prior studies of China's carbon economy have not disaggregated across households on the basis of income and the rural-urban divide. Our paper in an initial attempt to address this lacuna.

3. Distributional Incidence of Carbon Charges

One way to reduce carbon emissions is to establish a system of carbon charges that curtail demand for fossil fuels by raising their price.[9] The distributional incidence of carbon charges is important in assessing both their welfare effects and the political economy of their introduction. Two questions arise: First, how will higher prices for fossil fuels (and for goods and services whose production uses fossil fuels) affect different households? Second, how will the revenues generated by carbon charges be used and the resulting benefits distributed? This section reviews the available evidence on the first question; section 4 considers the second.

Several European countries have introduced carbon charges, starting with Finland in 1990 and followed by Norway, Sweden, Denmark, the Netherlands, and Italy (Baranzini *et al.,* 2000). A European Union-wide carbon tax was proposed, but not implemented, in the 1990s (Smulders and Vollebergh 2001). Studies in these and other industrialized countries generally have concluded that carbon charges are regressive – taking a bigger slice in percentage terms from low-income households than from high-income households – or in some cases distributionally neutral or mixed. For example, a simulation analysis by Symons *et al.* (1994) found that a carbon tax in the United Kingdom would be 'severely regressive.' In Canada, according to Hamilton and Cameron (1994), a carbon tax would be 'moderately regressive.' Cornwell and Creedy (1996) likewise found that a carbon tax in Australia would be regressive. Symons *et al.* (2000) reported regressive effects in Germany, France, and Spain, a mixed effect in the UK, and a neutral effect in Italy. Klinge Jacobsen *et al.* (2003) and Wier *et al.* (2005) find that Denmark's carbon taxes are regressive, and Brännlund and Nordström report that increases in carbon taxes in Sweden would be regressive. Summarizing the results of studies from various OECD countries, Cramton and Kerr (1999, p. 261) conclude: 'The weak regressivity of carbon regulation appears to hold across countries and modeling techniques.'[10]

In assessing distributional impacts, studies often have stratified households on the basis of expenditure rather than income, on the grounds that expenditure provides a better proxy for lifetime income and is less subject to transitory shocks. If distributional incidence instead is calculated on an income basis, carbon charges look even more regressive, because expenditure-to-income ratios generally decline as household incomes rise (for discussion, see Metcalf 1999).

The methodologies used in these studies have ranged from relatively simple computations based on the shares of energy products in household expenditure to computable general equilibrium (CGE) models. Most studies assume that carbon charges are fully shifted forward to consumers, altering the relative prices of goods and services in proportion to their carbon content. The regressive incidence of carbon charges thus reflects the fact that the expenditure patterns of low-income households tend to be more carbon-intensive than those of high-income households.[11]

Whether these findings can be generalized to the developing countries of Asia, Africa, and Latin America is an open question. Patterns of household expenditure and energy use in developing countries are likely to differ from those in industrialized countries. For example, ownership and use of automobiles is less prevalent in developing countries, and more concentrated in high-income households. Less fuel is used for home heating in tropical and subtropical climates. And biofuels, such as wood and crop residues, are widely used for cooking, particularly in poor rural households.[12] Given these differences, it is not evident that higher prices for fossil fuels would have a regressive impact in developing countries. It has been speculated that 'the net effect of adding a carbon tax in developing countries may well be proportional to income, or even progressive' (OECD 1995, p. 25).

A handful of empirical studies have investigated the distributional impact of carbon charges in developing countries, with mixed results. Shah and Larsen (1992) found that with full forward shifting to consumers, a carbon tax in Pakistan would be regressive (but that with only partial shifting it could be progressive). In a study of Iran, Jensen and Tarr (2002) similarly report that the withdrawal of subsidies on domestic energy products would have a regressive effect, although if this were accompanied by lump-sum redistribution of the savings the net effect would be progressive. On the other hand, in studies of Ghana and Madagascar, respectively, Younger (1996) and Younger *et al.* (1999) conclude that taxes on petroleum products, other than kerosene, are progressive.[13]

4. The 'Sky Trust' Option for Lump-sum Revenue Recycling

The net distributional effect of a carbon-charge system depends not only on the impacts of price changes on households, but also on the uses of the revenues generated by the charges. If carbon-charge revenues flow to government as a 'carbon tax,' and are used to increase public expenditure and/or reduce other taxes, the net effect depends on the incidence of these policies. In this paper we consider an alternative revenue-recycling option: lump-sum redistribution to all households on an equal per capita basis. Such a system has been dubbed a 'sky trust' (Barnes 2001).[14]

A sky trust would be an autonomous institution established by government action but operating outside the government budget, akin to social security trust funds. It would receive the revenues from carbon charges, and redistribute them to households after a small deduction for administrative costs. Revenues would be most easily, and inexpensively, collected 'upstream': at the coal mines, oil refineries, natural gas facilities, and ports where fossil fuels first enter the economy.[15]

The sky trust option has three attractive features. First, it asserts the principle of common ownership of nature's wealth: rights to benefit from the carbon-absorptive capacities of the biosphere are allocated equally to all. Second, it yields a progressive redistribution of income, the scale of which depends on the level of the carbon charges and on how the carbon intensity of household expenditure varies with income. Third, unlike tax shifting and increased public expenditure, the distributional outcome of the sky trust does not depend on the willingness and ability of government to do 'the right thing' – however defined – with present and future carbon revenues; in other words, once it is established, the sky trust is insulated from the vagaries of fiscal politics.[16]

Several studies have analyzed the distributional impact of a hypothetical sky trust in the United States. Recognizing that 'the amount of wealth that a U.S. carbon trading policy would redistribute could reach into the tens or hundreds of billions of dollars,' the U.S. Congressional Budget Office (2000) compared two methods of allocating carbon emission allowances – selling them (i.e., carbon charges), or giving them away to fossil fuel producers and importers free of charge – and two methods of revenue recycling: reducing corporate taxes, or rebating an identical lump-sum to each household.[17] The only scenario that was found to have a progressive distributional effect was the combination of allowance sales with lump-sum redistribution: in this case, the regressive effect of price increases (arising from an inverse relation between income and the share of income spent on carbon-intensive goods) was outweighed by the progressive effect of equal payments. With a carbon charge of $100/ton, the CBO estimated that after-tax incomes in the lowest quintile of the income distribution would rise by 1.8%, while those of the top quintile would decrease by 0.9%. In an extension of the CBO analysis, Dinan and Rogers (2002), reported even stronger redistributive impacts: a 3.5% rise in incomes for the lowest quintile, coupled with a 1.6% decline for the top quintile.[18]

Both of these studies assumed that carbon charges are distortionary, creating 'deadweight losses' by reducing fossil fuel consumption (and also, in the Dinan and Rogers study, by lowering real returns to labor and capital and thereby reducing factor supplies). For example, when consumers curtail fuel consumption in response to higher prices, they suffer welfare losses in the form of 'the discomfort associated with keeping their house cooler in the winter or the loss in satisfaction that would result from canceling a vacation because of high gasoline prices' (U.S. Congressional Budget Office 2003, p. 3). By placing a monetary value on the foregone consumer surplus and distributing these losses across households, the studies diminish the sky trust's positive effect on incomes of low-income households, and augment its negative effect on those of high-income households. It can be argued, however, that the true distortion is the subsidy currently implicit in the failure to charge for use of the limited carbon absorptive capacities of the biosphere. If so, appropriately calibrated carbon charges would *remove* a distortion rather than creating one.

Neither study attempts to estimate the welfare gains that would result from reductions in carbon emissions, via the mitigation of climate change and associated reductions in emissions of other pollutants. Yet these gains are the prime rationale for introducing carbon charges. A comprehensive analysis of the distributional impacts of carbon charges would allocate them across households, too. In the absence of this accounting, the incorporation of 'deadweight losses' from carbon charges gives a misleading picture of net welfare effects: in effect, this procedure counts the cost of correcting for the welfare losses from excessive carbon emissions, without counting the benefits. In this paper, we adopt the simpler – and, in our view, more appropriate – procedure of estimating the distributional impacts of the carbon charges and revenue recycling alone, without attempting to incorporate other welfare effects.

Barnes and Breslow (2003) follow this procedure in a third analysis of the distributional impact of a United States sky trust, using a higher carbon price of $191/ton. They find that the bottom decile would receive a net benefit equal to 5.1% of income, while the top decile would bear a net loss of 0.9%, and that seven deciles would see net gains. That is, the majority of the population would receive more in rebates than they paid as a result of higher fuel prices.[19] Insofar as public policy follows the principle of majority rule, this result suggests that the establishment of a sky trust would be politically feasible.

While these studies find that a sky trust generally would benefit low-income households, they acknowledge that some, whose livelihoods are tied to production or use of fossil fuels – coal miners and truck drivers, for example – could bear net losses. One way to compensate for these is to allocate some percentage of the sky trust's revenues to transitional adjustment assistance that assists displaced workers in moving into new jobs. For example, Barnes (2001) proposes a transition fund that initially would recycle 25% of the sky trust revenue and be phased out over a ten-year period. We do not include transitional adjustment assistance in our analysis of the distributional effects of a Chinese sky trust, but such a component could be readily added.

5. Data Sources and Methodology

In order to examine the distributional implications of a carbon tax in mainland China this study draws on a nationally representative household income and expenditure survey conducted for the year 1995. The survey was designed and overseen by scholars at the Chinese Academy of Social Sciences' Institute of Economics (CASS), and provides the only publicly available, nationally representative household data from mainland China in the reform era.[20] Households in the CASS sample are drawn from the Chinese State Statistical Bureau's (SSB) annual income and expenditure survey, and SSB enumerators were contracted to administer the CASS questionnaires.

Because the CASS survey is drawn from the SSB's parent sample, it inherits many of its features. For example urban and rural households are sampled separately, and must be appropriately weighted when combined to produce estimates representative of the population.[21] This CASS survey also inherits many of the problems associated with the SSB's parent sample, discussed thoroughly in Chen and Ravallion (1996). Perhaps the most striking of these is the fact that the SSB sample frame is constructed on the basis of households' residence of record. As such, so-called floating migrants are not enumerated in either their village of origin or their current place of residence. Finally, it bears note that the CASS surveys also follow the SSB's method for sample selection, using a procedure known as the 'equidistant selection method' (*duichen dengju chouyang fangshi*), which roughly corresponds to systematic sampling.[22]

The survey instrument used for 1995 was developed by CASS, in collaboration with an international team of scholars. It was based on a 1988 household income and expenditure survey conducted by CASS (see Griffin and Zhao 1993), with some minor changes. Surveys were administered in the selected counties by the SSB survey teams between March and June 1996 for the reference year 1995. Data for the CASS survey were compiled largely from the daily diaries and cash and goods transaction books maintained for the SSB's annual household income and expenditure survey.[23] However, the CASS survey made substantial improvements over the survey instrument currently in use by the SSB, particularly with regard to the measurement of household income.[24]

Before reviewing the major assumptions involved in estimating household carbon usage, Table 1 provides an overview of the expenditure patterns for households by expenditure decile (each of which represents 10% of the population).[25] Considering the all-China data presented in Panel A, several features stand out. First, the top two expenditure deciles account for more than half of all household expenditures. Second, in the lowest decile, food expenditures comprise more than three-quarters of total spending. This share falls to less than 40% for the highest decile. A corollary is that the share of non-food items rises as we move up the expenditure distribution. Finally, we see that carbon-intensive categories of household spending – items such as fuel, electricity, and transportation – account for a small share of average household expenditures, but that this share rises with household expenditure. Separate results for rural and urban China (presented in panels B and C, respectively) are broadly similar, the main difference being that the share of spending on fuels and electricity falls as we move up the expenditure distribution; the opposite finding at the all-China level is driven by rural-urban differences.

Measuring Household Carbon Usage

In this study we measure carbon usage at the household level in two steps. First, we separate household spending into six categories: (i) food, including the value of self-produced agricultural products; (ii) industrial goods, including clothing, daily use consumption goods, and durable goods; (iii) housing, specifically new construction and repair costs;[26] (iv) household fuels and electricity; (v) transportation and communication; and (vi) other expenditures, including education, medical expenditures, and other miscellaneous spending.

Second, we apply a carbon loading factor to each of these six expenditure categories, in order to estimate the carbon usage embodied in these different types of household consumption. This provides us with a metric to evaluate the distributional implications of a carbon charge.

We derive loading factors by matching the six expenditure categories from our survey data to corresponding categories in the Chinese system of national accounts. Table 2 depicts the basic steps. In the first column we report the total energy consumption of each major economic sector, measured in millions of tons of Standard Coal Equivalent (SCE).[27] In the second column we report the total value of Gross Domestic Product in each of the same major economic sectors, in billions of *yuan*.[28] The third column presents the tons of SCE per 10,000 *yuan* of final demand (i.e. the quotient of columns one and two), while the last column presents our loading factors in terms of tons of carbon per 10,000 *yuan* of final demand.[29] We convert tons of SCE to tons of carbon using as a conversion factor the total tons of carbon emitted in China in 1995 divided by the total tons of SCE utilized in that year.[30]

We then estimate the per capita carbon consumption using the following formula:

$$C = 0.03{*}EXP_F + 0.24{*}EXP_I + 0.02{*}EXP_H + 1.20{*}EXP_E + 0.11{*}EXP_T + 0.03{*}EXP_O$$

where C = total carbon consumption (in kilograms); EXP = expenditure (in *yuan)*; and subscripts F, I, H, E, T, and O refer to food, industrial goods, housing, fuels and electricity, transportation and communication, and other expenditures, respectively.

The Carbon Charge

To assess the distributional implications of a carbon charge and sky trust revenue-recycling scheme in China, we assume a charge of 300 *yuan* per metric ton of carbon.

A charge of this magnitude is squarely within the range of hypothetical carbon charges used in prior research on China. For example, Zhang (1998) evaluates the degree to which a carbon charge would reduce CO2 emissions in China under two scenarios: a charge of 205 *yuan*/tC, and another set at 400 *yuan*/tC. Zhang estimates that the first scenario would lead to a 20% reduction in projected carbon emissions in 20 years (between 1990 and 2010), while under the second scenario emissions would fall by 30%. In a study of the impact of a carbon charge on emissions in Shanghai, Gielen and Chen (2001) use a charge of 100 *yuan*/tCO2 (equivalent to 367 *yuan*/tC); they estimate that this would result in an 11% reduction in carbon emissions between 2000 and 2010, along with a substantial shift in types of abatement technology deployed.

The charge of 300 *yuan*/tC is also comparable with existing carbon charges in other countries. For example, five European countries had coal taxes in place in 1999, ranging from $14/tCO2 in Finland to $67/tCO2 in Demark (Baranzini, Goldemberg, and Speck, 2000). This range is equivalent to 103 *yuan*/tC to 491 *yuan*/tC.[31]

For simplicity, we calculate the distributional impact of carbon charges on the basis of the 1995 consumption patterns, without estimating changes in demand in response to higher fossil fuel prices.[32] Equivalently, we could use a higher carbon charge coupled with commensurately lower demand. For example, a 400 *yuan*/tC charge that reduces carbon demand to 75% of the 1995 level would yield the same results.

In calculating the distributional impact of recycling carbon revenues through a sky trust, we deduct 1% from total revenues to cover administrative costs. As noted in section 4, administrative costs would be minimized by revenue collection at mine mouths, refineries, and ports where fossil fuels enter the economy. We regard this as a conservative assumption (that is, a high-end estimate of the administrative costs); by way of comparison, administrative costs for petroleum taxes and excise duties typically range from 0.12 to 0.25% of revenue (Smulders and Vollebergh, 2001, p. 116).

6. Results

Our main results are presented in Tables 3 and 4. Table 3 shows the distributional incidence of a carbon charge on its own, without taking into account the use of the proceeds. Table 4 shows the effect of a sky trust, with the carbon revenue recycled to the Chinese people on an equal per capita basis. The incidence of the charge on each household is calculated by multiplying per capita carbon consumption by 300 *yuan* per ton of carbon. The tax/expenditure column is the average of the tax incidence to expenditure ratios for each person in the decile.[33]

Distributional Effects of Carbon Charges

Table 3 shows that even without an egalitarian redistribution of the revenues, the effect of the carbon charge would be progressive. The lowest decile pays 2.1% of their total expenditures into the charge, and the highest decile pays 3.2%. This reflects the fact that the mix of products that relatively rich people buy is, on average, more carbon intensive than what relatively poor people buy. This contrasts with results from studies in other countries, reviewed in section 3, which generally have found a carbon charge to be either regressive or neutral. Our results call into question the generality of this conclusion.

A closer look at what lies behind this progressive incidence is useful. The breakdown into urban and rural areas shows that the incidence of the charge in urban areas is higher than in rural areas. As we saw in Table 1, urban areas have more carbon-intensive expenditure patterns, spending significantly more than rural households on household energy and industrial goods, the two most carbon-intensive sectors in China. The rural population, on the other hand, devotes a larger share of its expenditure to food, which is much less carbon-intensive. The result is that urban areas would pay an average of 3.3% of their expenditure into the sky trust, while rural areas would only pay 2.0%. Since the average income in urban areas is considerably higher than in rural areas, this makes the overall incidence of the charge progressive.

A similar pattern may exist in other developing countries – particularly where rural areas are relatively poor, consume few industrial products and obtain much of their direct energy use from firewood and other biomass that would not be subject to carbon charges. In contrast to the pattern often reported for industrial countries, carbon charges may turn out to be progressive in many developing countries.

It is the difference between China's rural and urban areas that makes the overall effects of the carbon charge progressive. Within each region, the size of the charge is roughly proportional to expenditures. Every decile in the urban areas pays between 3.2% and 3.5% of their expenditures into the charge, while every decile in rural areas pays between 1.8% and 2.1%. Behind these results are offsetting trends in the different expenditure categories: the most energy-intensive category, fuels and electricity, accounts for a larger share of expenditures for the poorer households in each region, but the other two energy-intensive categories, transportation and industrial goods, form a larger part of the expenditures of the richer households.

Distributional Effects of a Chinese Sky Trust

Table 4 shows the incidence of a sky trust scheme, in which the money from the carbon charge is redistributed to households on an equal per capita basis. The size of the dividend payout, which comes to 69 *yuan* per person, is found simply by dividing the total revenue by the number of people in China (after deducting 1% for administrative costs). The net benefit of the sky trust is the payout minus the per capita incidence of the charge shown in Table 3. The last three columns of Table 4 show the charge, dividend, and net benefit as a percentage of household expenditures.

Clearly, the combined effect of the carbon charge and dividend redistribution is strongly progressive. Nationwide, the bottom seven expenditure deciles would benefit from the sky trust, while the top three deciles would pay more into the fund than they would get back in dividends. As noted in section 4, even in the US, where a carbon charge alone would be regressive, the equal per capita payout via a sky trust would yield a progressive net effect. This occurs as long as *total carbon use* by rich households is higher than carbon use by poor households, even if the carbon *intensity* of consumption is higher for poor people. In China, where the carbon intensity of consumption is lower for poor people, the progressive effect is that much stronger.

The majority of China's population (about 70%) would be net beneficiaries from the sky trust in purely financial terms, not counting any benefits associated with improvements in environmental quality. Moreover, as a percentage of household expenditure, the net benefits to the lower deciles are greater than the net losses to the higher deciles.[34]

The magnitude of redistribution depends on the size of the carbon charge. At 300 *yuan* per ton of carbon, the households in China's poorest decile would see their incomes rise by the equivalent of 10.3% of total expenditure. A higher charge would redistribute more from top to lower deciles, and a smaller charge would redistribute less, but there would be no change in which deciles would gain and lose, nor in the relative sizes of their benefits and losses.

The breakdown between rural and urban households again shows striking differences. In urban China the top nine deciles would incur net losses of income and only the bottom decile would benefit, while in rural China the bottom nine deciles would benefit and the top decile would break even. This reflects the fact that rural areas have both lower total expenditures and a less carbon-intensive pattern of expenditure than urban areas.

Our results do not change substantially when households are ranked by per capita income rather than per capita expenditure. Appendix II shows the net effect of the sky trust on households ranked by per capita income. The most noteworthy difference is that the charge, on its own, is no longer clearly progressive when taken as a percentage of income. Urban households still pay a higher portion of their income than rural households, but within each region the incidence is regressive, leading to mixed results when the two regions are combined. This is consistent with observations from other studies that find that consumption-based taxes look relatively more regressive when income is used as the denominator and basis of stratification.[35] However, it is worth noting that even when households are ranked by income, the charge is progressive when measured as a percentage of expenditures.[36]

While the choice between the income and expenditure lenses affects how progressive a carbon charge appears on its own, there is not much difference in the results once the sky trust dividend payments are entered into the picture. Regardless of whether expenditure or income is used as the basis for comparisons, the net effect of a Chinese sky trust is strongly progressive, with the bottom seven deciles nationwide registering gains and the top three registering losses.

Effects of a Sky Trust on Poverty

A Chinese sky trust would substantially reduce poverty, especially in rural China. Table 5 shows the effect it would have on poverty rates, using a poverty line of 810 *yuan* for rural China and 1604 *yuan* for urban China.[37] Before implementing a sky trust, 14.7% of our sample had expenditures below this poverty line: 19.1% in rural areas and 3.8% in urban areas. The net effect of a sky trust, with the carbon charge set at 300 *yuan*/tC, is a 21% reduction in the headcount poverty rate, from 14.7% to 11.6%. A total of 36.4 million rural people and 292,000 urban people would be lifted out of poverty as a result.

Table 5 also reports two additional poverty measures, the Foster-Greer-Thorbecke 'P1' and 'P2' measures. The first, also known as the 'poverty gap,' measures not only the number of people below the poverty line but also the depth of their poverty, that is, how far the poor are below the poverty line. Implementing a sky trust of the magnitude examined here would reduce the poverty gap nationwide by 28%. The final poverty measure, known as the 'squared poverty gap,' puts greater weight on the gaps of the poorest. By this measure, the impact of the sky trust is even stronger, reducing poverty by 34%, with the strongest impact in rural China.

7. Conclusions

In China, the introduction of carbon charges on fossil fuels would have a progressive distributional effect: high-income households would pay a larger percentage of their income than low-income households. This is in contrast to the regressive impact found in most studies of industrialized countries. Our results suggest that findings on the incidence of carbon charges in industrialized countries cannot be readily generalized to developing countries, due to differences in patterns of expenditure on personal transportation, home heating, industrial goods, and the use of bio-fuels.

If the revenues from carbon charges were recycled to the populace on an equal per capita basis through a sky trust, the progressive impact would be further enhanced. With a charge set at 300 *yuan* per ton of carbon, the poorest decile would receive a net income gain equivalent to 10.3% of total expenditure, while the richest decile would see a 2.3% decline. Countrywide, roughly 70% of China's population would emerge as net 'winners' from the sky trust, with more money in their pockets after the policy than before. Poverty would be reduced by more than 20% by the simple headcount measure, and even more substantially by measures that take into account the depth of poverty as well as its breadth.

China's wide and growing urban-rural disparities play a key role in these results. While 90% of rural people would be net winners, 90% of urban households would be net losers. Given the size of China's urban-rural income gap, the negative net impact on most urban households may be regarded as acceptable from an equity standpoint. Politically, however, this may prove to be a liability. One strategy to address this concern is to modify the policy so as to ease or reverse adverse impacts on the lower deciles in urban areas. In a similar fashion, Holland's tax on energy use exempts certain small consumers (Zhang and Baranzini 2004, p. 511).

We have made no attempt to measure the welfare gains that would accrue to the Chinese people from the environmental benefits of reduced use of fossil fuels, including lower greenhouse gas emissions and lower emissions of other pollutants such as sulfur dioxide. These could be substantial, however, and they would add to the attractions of a Chinese sky trust.

The policy relevance of the results presented here extends beyond China. In other developing countries, too, carbon consumption patterns may more closely resemble those of China than those of the industrialized countries. In addition, there may be scope for the international community to encourage adoption of carbon-charge systems in China and elsewhere. Under the Clean Development Mechanism established by the Kyoto protocol, for example, industrialized-country signatories could reimburse developing countries for implementing measures to cut carbon emissions, using these reductions to fulfill part of their Kyoto obligations. This would provide additional resources that could be used to offset income losses (for example, to China's urban lower and middle deciles), invest in renewable energy, and provide transitional adjustment assistance to coal-mining regions (Gielen and Changhong, 2001). Aid donors also could use 'green conditionality' to encourage developing country governments to introduce sky trust policies (D'Arista and Boyce, 2002). Funds from the Global Environment Facility (GEF) could be used to underwrite the initial costs of establishing sky trusts.[38]

As noted in Section 2, there are several reasons why Chinese policy makers may decide to take institute measures to reduce the country's use of fossil fuels: shortfalls in domestic supplies; the country's vulnerability to climate change; the health and environmental benefits of reduced pollution; the weight of international opinion; and the fact that the country already is developing the capacity to administer pollution charges. This paper suggests that an appropriately designed policy can provide an additional reason to act: steps to reduce fossil fuel consumption can, at the same time, help to counteract widening economic disparities between rich and poor, and between urban and rural areas.

Endnotes

[1] Growth in carbon dioxide emissions from consumption and flaring of fossil fuels calculated from data reported by the US Energy Information Administration (2004); GDP growth calculated from data reported by the World Bank's *World Development Indicators* (based on constant 1990 yuan). The official figures may understate the rise in China's use of fossil fuels, since some local governments apparently responded to central directives to shut down small low-grade coal mines and heavily polluting power plants simply by ceasing to report their operations to the central government (Bradsher 2003; see also Sinton 2001).

[2] Oceanic sinks and terrestrial sinks each absorb roughly 1900 million mtC/year; but land-use changes (especially deforestation) release roughly 1700 mtC/year; in net terms, oceanic sinks therefore account for close to 90% of annual carbon sequestration (Sarmiento and Gruber 2002). Agarwal and Narain (1991) argue that the Earth's reabsorptive capacities should be allocated on an equal per capita basis. Using this formula, the contributions of populous nations like China and India to the world's net carbon emissions is reduced relative to that of the United States and other industrialized economies.

[3] See Bradsher (2003). In an effort to limit China's growing dependence on imported oil, in 2004 the government introduced new fuel-economy standards for automobiles that are more stringent than those in the United States (Bradsher, 2004).

[4] A study of regional differences in global warming damages found that damages in China would be equivalent to 6.1% of GNP, versus a world average of 1.5% (Fankhauser and Pearce 1994, p. 76, cited by OECD 1995, p. 34).

[5] In the case of Pakistan, for example, Shah and Larsen (1992) estimated that the benefits of reductions in local environmental externalities would more than offset the output losses from a carbon tax. The World Bank (1997, p. 54) estimates that inclusion of the health costs of coal use in Beijing would double its price.

[6] Khan and Riskin (2001, pp. 17 and 20). In a subsequent paper, Khan (2003) reports that in 2002 the urban-rural average income gap had widened to a 3:1 ratio. The national-level Gini coefficient remained unchanged, however, as widening urban-rural inequality was offset by greater equality within both sectors.

[7] Khan and Riskin (2001, pp. 66 and 71). The authors estimate headcount poverty for three different poverty lines in both rural and urban China. We report poverty rates for what they term the 'Unadjusted Intermediate Poverty Threshold.' For further discussion of rural-urban disparities, see Knight, Shi, and Song (1994).

[8] In 1995, the year to which the data reported in this paper pertain, total household consumption in China (estimated from the survey data presented below) amounted to 3,301.4 billion yuan, equivalent to 57.6% of GNP as reported in the national income accounts (Khan and Riskin 2000, p. 25). While carbon emissions per yuan may differ somewhat between the household and non-household sectors, this gives a rough approximation of the household sector's importance in the carbon economy.

[9] We call these 'charges' rather than 'taxes,' because their effect is to reduce or eliminate a *de facto* subsidy: free use of the limited carbon absorptive capacity of the biosphere.

[10] A recent study of Italy's carbon tax (Tiezzi 2005) finds that it has a progressive incidence, however, by virtue of the fact that it hits transport fuels harder than domestic fuel use and that higher-income households reduced their consumption less in response to higher prices.

[11] If it is assumed that carbon charges are not fully passed on to consumers, but instead are partly absorbed by producers via reduced profit margins, the result is less regressive since capital ownership is concentrated in upper-income households (see Dinan and Rogers 2002; Parry 2004). For further discussion of methodologies for assessing the distributional incidence of carbon taxes, see Speck (1999).

[12] In the case of China, for example, Wang and Feng (1999, p. 97) report that biomass accounts for 60-90% of rural household energy consumption.

[13] Addison and Osei (2001) question the conclusion that petroleum taxes are progressive in Ghana, however, arguing that adverse spillover effects via higher transport costs adversely affect the rural poor.

[14] The sky trust is an extension of the 'feebate' concept, whereby fees are paid according to the extent of individual resource use, and the proceeds rebated equally to all use-rights holders. This idea that has been applied to a variety of environmental problems; see, for example, Puig-Ventosa (2004). For an early application to gasoline taxes, see Shepard (1976).

[15] In the United States, this would translate into roughly 2000 collection points (Kopp *et al.* 1999; U.S. Congressional Budget Office 2001). Smulders and Vollebergh (2001, p. 116) report that the administrative costs of petroleum taxes and excise duties range from 0.12 to 0.25% of revenue, lower than most other taxes; see also Fisher *et al.* (1998). As the CBO (2001, p. 19) notes, administrative costs would increase if charges were levied not only on fossil fuels, but also on imports of carbon-intensive products (such as aluminum) so as to avoid placing domestic producers at a disadvantage in the absence of similar carbon policies in the exporting countries.

[16] In theory, one can design alternative uses of carbon-charge revenues that are superior to lump-sum redistribution on efficiency or distributional grounds, as Zhang and Baranzini (2004, pp. 511-2) discuss. In practice, these alternatives arguably would be more open to political manipulation than would a sky trust. Moreover, they would not share the first advantage identified here: affirmation of the principle of equal rights to nature's common wealth.

[17] The give-away allocation option, sometimes referred to as 'grandfathering,' was the main method adopted in the U.S. when sulfur dioxide emissions permits were introduced in the 1990s. Insofar as permit rents are taxed, this method does generate some government revenue. Parry (2004) analyzes the impact of grandfathered carbon emissions permits in the U.S. with rents taxed at the rate of 35%; even when coupled with lump-sum redistribution of the proceeds, he finds that the distributional impact is regressive due to the highly skewed distribution of profit income.

[18] The stronger distributional effects in the Dinan and Rogers study arise mainly from (i) incorporation of an estimated 'deadweight loss' in factor markets due to the impact of higher carbon prices on real returns to capital and labor; and (ii) use of a lower value for average income in the lowest quintile.

[19] The incorporation of deadweight losses (without the attendant welfare gains) reduces the percentages of households who receive net benefits. Thus the CBO (2000) and Dinan & Rogers (2002) estimated that the bottom two quintiles would come out ahead, while the top three quintiles would be net losers.

[20] These data are available through the Inter-University Consortium for Political and Social Research (ICPSR), holding number 3012. See Riskin, Zhao and Li (2000) for more details. A similar survey was also conducted for the year 1988 and is available through the ICPSR, holding number 9836. See Griffin and Zhao (1993) for more details.

[21] The 1995 urban sample contains 21,694 individual records, while the rural sample contains 34,739. In order to create a pooled sample that is representative of the country as a whole, the rural observations should be weighted by a factor of 24,741 (equal to the total rural population in 1995 divided by the number of individual observations in the rural sample). Likewise, observations in the urban sample must be weighted by a factor of 16,214.

[22] See Eichen and Zhang (1993) for a complete discussion of the sample selection methods used in the 1988 survey data (which were also followed in 1995). Briefly, the 'equidistant selection method' is applied to the selection of counties within the province, as well as villages within the county and households within the village. The unit to be selected is ranked, usually by per capita income, and selection is made at fixed intervals after a random start. Generally for counties with a population over 450,000, 80 households are selected, and for those under 450,000, that number is 60. Since 10 households are usually surveyed from each village, this implies that either 8 or 6 villages are surveyed depending on whether the county is above or below 450,000 in population. See Chen and Ravallion (1996) for more details.

[23] Participants in the SSB's rural survey keep these logs for the entire reference year, the data from which are transferred to summary worksheets every two weeks, and then compiled by county level survey teams, where they are coded and checked for errors. Afterwards, they are sent to the provincial team, where they are cleaned and checked again, then they are sent to the national office in Beijing.

[24] For details, see Griffin and Zhao (1993) and Riskin, Zhao and Li (2001).

[25] In examining the expenditure distribution from the CASS survey, we eliminated those households with extraordinarily low reported expenditure. Specifically we deleted all households where reported total expenditure fell below one quarter of the median expenditure for the lowest decile of either the rural or urban sample, respectively.

[26] Our urban survey does not contain information on repair and construction costs, so these costs were estimated for each household. From our rural survey we calculated that repair and construction costs were approximately 3.5 percent of the market purchase price of housing. We then applied this ratio to the market purchase price of urban housing to arrive at urban repair and construction costs.

[27] These data are drawn from the State Statistical Bureau's China Statistical Yearbook (1996), Tables XXX. They exclude bio-energy, solar, and nuclear energy use. All fuels are converted into standard coal equivalent (SCE) with thermal equivalent of 7,000 kilocalorie per kilogram. The conversion is as follows (figures in brackets refer to thermal equivalent): 1 kg of coal (5,000 kcal)=.714kg of SCE; 1 kg of crude oil (10,000 kcal)=1.43 kg of SCE; 1 cubic meter of natural gas (9,310 kcal)=1.33kg of SCE. The conversion of hydropower into SCE is calculated on the basis of the consumption quota of standard coal for thermal power generation of the given year.

[28] The other expenditure categories from our household data do not match identically with national accounts categories. We used the following bridge between household expenditures and national accounts categories: household transport and communication spending was matched to transportation, postal and telecommunication services; household spending on food was matched to the farming, forestry, animal husbandry, fishery and water conservancy national accounts category; household industrial goods expenditures were matched to the national accounts category of industry; household spending on housing new construction and repair was matched with construction; and we used the non-material production sector for other household spending. For the expenditure category of household fuels and electricity, there is no corresponding national account entry capturing final demand. Instead we used an estimate of total national expenditure on household fuels and electricity derived from data provided in the *China Statistical Yearbook*. In the urban areas we started with figures reported in the *China Statistical Yearbook* on per capita spending on water, electricity, fuels and services. Using data from the 1988 CASS urban household survey (which were more detailed than the 1995 data) we estimated that 82.5 percent of this spending was on electricity and fuels alone. Similarly, in the rural areas we started with total per capita 'residential' expenditures reported in the *China Statistical Yearbook*, and using data from the 1988 CASS household survey we estimated that 23.4 percent of these expenditures were on fuel.

[29] The carbon loading factors reported in Table 2 represent only the 'first-order' carbon usage; carbon expended in the production or consumption of intermediate goods is not captured.

[30] According to data from the U.S. Department of Energy's Energy Information Administration, China emitted 2,888.3 million metric tons of CO_2 in 1995 (equivalent to 787.7 million metric tons of carbon). According to the State Statistical Bureau, China utilized 1,311.8 million metric tons of Standard Coal Equivalent (SCE) that same year. Using these figures, we convert tons SCE to tons of carbon using a factor of .601.

[31] Purchasing power parity-adjusted exchange rates are used for these calculations.

[32] Of course, one aim of carbon charges is precisely to shift expenditure toward less carbon-intensive goods and services. If the price elasticity of demand for carbon varies across deciles, this would affect the incidence of carbon charges. Because we do not have the data needed to incorporate this effect, we assume the price elasticity of demand to be constant across deciles. West and Williams (2002), using data from the United States, find that price responsiveness to gasoline taxes is inversely related to income; that is, in response to a higher price, lower-income households reduce consumption more than upper-income households, and hence 'studies that do not consider demand responses will substantially overstate the regressivity of the gas tax' (p. 6). A similar finding is reported for Italy by Tiezzi (2005). If this pattern were to apply to carbon charges in China, their progressivity would be even stronger than reported here.

[33] Note that this is slightly different from taking the average tax for the decile and dividing it by the average expenditure for the decile, so the third column will not be exactly equal to the 2nd column divided by the 3rd column. We chose to take the average of the ratios rather than the ratio of the averages in order to weigh the effect on each individual evenly when calculating the averages, rather than giving people with higher expenditures a higher weight. The choice of method does not have a significant effect on the results, as can be seen in Appendix I.

[34] This reflects the simple fact that any lump-sum redistribution from rich to poor increases the incomes of the poor by a greater percentage than it decreases the incomes of the rich.

[35] See, for example, Poterba (1989), Bruce *et al.* (1996, pp. 419-421) and Shah and Larsen (1992, pp. 8-10).

[36] Although it is more common to use only income or expenditure as the denominator and basis for stratification into deciles, rather than mixing the two, a reasonable case can be made for looking at tax incidence as a proportion of expenditure even when ranking households by income. For discussion, see Joint Committee on Taxation (1993).

[37] These poverty lines are adapted from the intermediate poverty thresholds used by Khan & Riskin (2000). In their work Khan and Riskin examine income poverty, whereas we are focused on expenditure poverty. To shift from income to expenditure poverty thresholds, we calculated the average per capita expenditures of all individuals who were within 5 percent of the per capita income poverty threshold defined by Khan and Riskin.

[38] This would be consistent with the guidelines for use of GEF resources recommended by Johnson *et al.* (1996).

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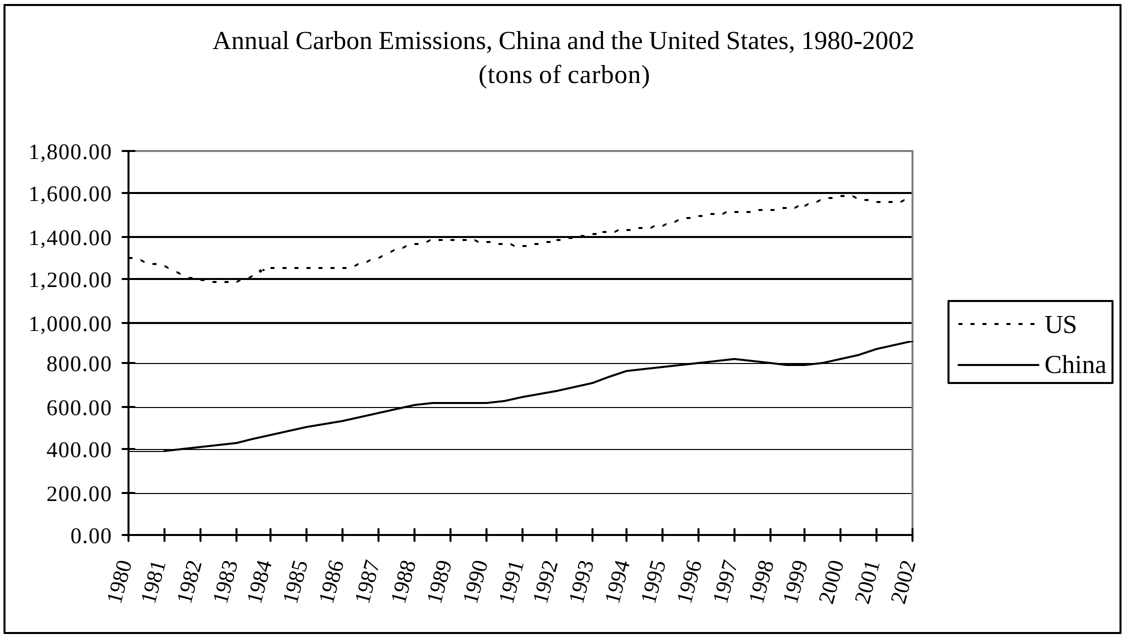
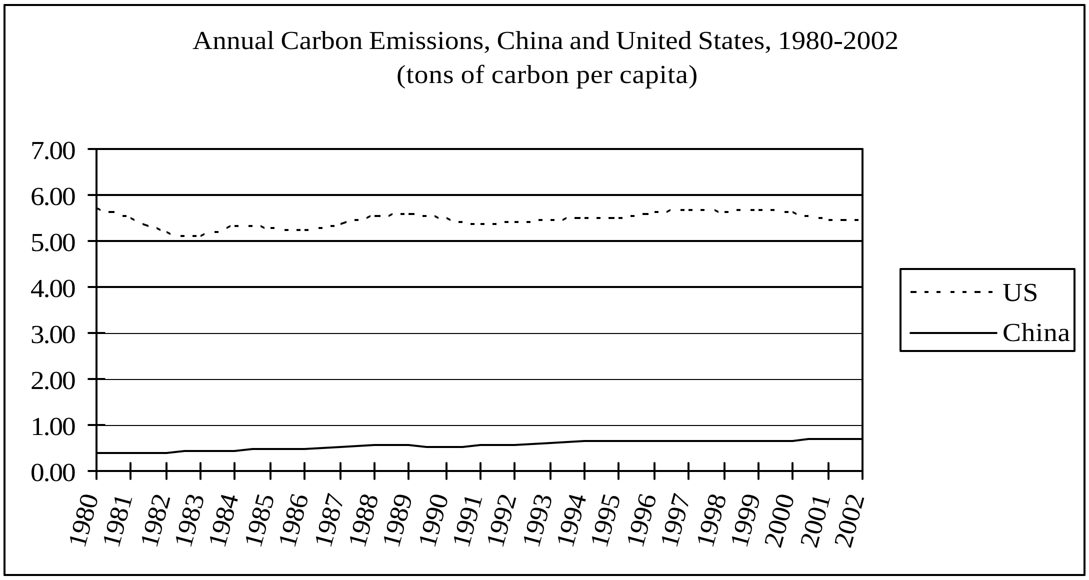
Figure 1a: Annual Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, China and the United States, 1980-2002 (metric tons of carbon)



Date source: Energy Information Administration, *International Energy Annual 2002*, http://www.eia.doe.gov/emeu/international/total.html#IntlCarbon.

Figure 1a: Annual Carbon Dioxide Emissions per capita from the Consumption and Flaring of Fossil Fuels, China and the United States, 1980-2002 (metric tons of carbon per capita)



Data source: U.S. Energy Information Administration, *International Energy Annual 2002*, http://www.eia.doe.gov/emeu/international/total.html#IntlCarbon.

Table I: Breakdown of Household Expenditures in China, 1995

All households

Per capita Expenditure Decile	Per capita expenditure (yuan)	Share of total expenditure	Food	Industrial goods	Housing	Household fuels and electricity	Transport and comm-unication	Other[a]
1	591	2.3%	77.4%	11.2%	1.1%	1.4%	0.9%	8.0%
2	840	3.3%	76.2%	11.0%	1.3%	1.2%	1.5%	8.7%
3	1,022	4.0%	76.6%	10.6%	1.6%	1.2%	1.3%	8.6%
4	1,218	4.8%	74.8%	10.7%	2.5%	1.2%	1.5%	9.5%
5	1,451	5.7%	73.2%	10.8%	2.6%	1.1%	1.4%	11.0%
6	1,771	6.9%	70.0%	11.5%	3.3%	1.4%	1.7%	12.0%
7	2,258	8.8%	63.6%	14.0%	4.5%	1.8%	1.8%	14.2%
8	3,097	12.1%	55.2%	16.3%	6.2%	2.6%	2.1%	17.5%
9	4,414	17.3%	48.2%	19.9%	7.0%	2.7%	2.5%	19.7%
10	8,866	34.7%	38.7%	24.7%	9.0%	2.3%	2.5%	22.8%
Total	2,553	100.0%	65.4%	14.1%	3.9%	1.7%	1.7%	13.2%

Rural households

Per capita Expenditure Decile	Per capita expenditure (yuan)	Share of total expenditure	Food	Industrial goods	Housing	Household fuels and electricity	Transport and comm-unication	Other[a]
1	542	3.5%	77.0%	11.4%	0.9%	1.5%	0.9%	8.2%
2	756	4.9%	77.4%	11.0%	1.2%	1.3%	1.2%	8.0%
3	894	5.8%	76.6%	10.6%	1.4%	1.1%	1.5%	8.8%
4	1,021	6.6%	76.1%	10.8%	1.6%	1.2%	1.4%	8.9%
5	1,161	7.5%	75.6%	10.6%	2.5%	1.1%	1.5%	8.7%
6	1,315	8.5%	74.9%	10.5%	2.3%	0.9%	1.4%	9.9%
7	1,505	9.7%	73.2%	10.5%	2.8%	1.0%	1.6%	11.1%
8	1,760	11.4%	71.5%	10.9%	3.3%	1.1%	1.9%	11.3%
9	2,154	13.9%	67.2%	12.0%	4.2%	1.0%	2.3%	13.2%
10	4,353	28.2%	56.5%	12.7%	9.4%	1.0%	4.7%	15.7%
Total	1,546	100.0%	72.6%	11.1%	3.0%	1.1%	1.8%	10.4%

Urban households

Per capita Expenditure Decile	Per capita expenditure (yuan)	Share of total expenditure	Food	Industrial goods	Housing	Household fuels and electricity	Transport and comm-unication	Other[a]
1	1,657	3.3%	60.2%	16.5%	3.8%	4.0%	0.7%	14.8%
2	2,437	4.9%	55.9%	18.3%	4.9%	3.7%	0.9%	16.3%
3	2,973	5.9%	53.6%	19.1%	5.5%	3.4%	1.1%	17.3%
4	3,438	6.9%	51.4%	18.7%	5.5%	3.5%	1.5%	19.3%
5	3,907	7.8%	49.5%	20.1%	6.4%	3.2%	1.6%	19.4%
6	4,468	8.9%	47.4%	21.6%	5.9%	3.0%	1.6%	20.5%
7	5,151	10.3%	46.1%	21.4%	6.4%	3.0%	1.8%	21.3%
8	6,046	12.1%	42.0%	22.8%	7.2%	2.7%	2.0%	23.4%
9	7,506	15.0%	39.9%	24.0%	8.3%	2.5%	1.8%	23.5%
10	12,530	25.0%	31.4%	31.0%	8.4%	1.9%	2.1%	25.1%
Total	5,013	100.0%	47.7%	21.4%	6.2%	3.1%	1.5%	20.1%

Source: Authors' calculations from 1995 CASS survey data.

[a] 'Other' includes education, medical expenditures, and miscellaneous expenses.

Table II: Carbon Loading Factors, 1995

	Energy (million tons SCE[a])	GDP[b] (billion yuan)	Tons SCE / 10,000 yuan	Tons carbon / 10,000 yuan
Food	55.1	1199.3	0.46	0.28
Industrial Goods	961.9	2435.4	3.95	2.37
Housing	13.4	382.0	0.35	0.21
Household fuels and electricity	157.5	79.1	19.91	11.95
Transport and Communication	58.6	323.7	1.81	1.09
Other	45.2	976.3	0.46	0.28

Source: Authors' calculations based on data drawn from the 1996 State Statistical Yearbook.

[a]SCE = Standard coal equivalent.

[b]Total spending on household fuels and electricity is calculated from household survey data.

Table III: Distributional Incidence of a Carbon Charge, 1995

All households

Per capita Expenditure Decile	Per capita expenditure (yuan)	Charge per capita (yuan)	Charge / expenditure[a]
1	591	12	2.1%
2	840	17	2.0%
3	1,022	20	2.0%
4	1,218	24	1.9%
5	1,451	28	1.9%
6	1,771	37	2.1%
7	2,258	54	2.4%
8	3,097	87	2.8%
9	4,414	136	3.1%
10	8,866	282	3.2%

Rural households

Per capita Expenditure Decile	Per capita expenditure (yuan)	Charge per capita (yuan)	Charge / expenditure[a]
1	542	11	2.1%
2	756	15	2.0%
3	894	17	1.9%
4	1,021	20	2.0%
5	1,161	22	1.9%
6	1,315	24	1.8%
7	1,505	28	1.9%
8	1,760	34	2.0%
9	2,154	43	2.0%
10	4,353	86	2.1%

Urban households

Per capita Expenditure Decile	Per capita expenditure (yuan)	Charge per capita (yuan)	Charge / expenditure[a]
1	1,657	55	3.3%
2	2,437	80	3.3%
3	2,973	96	3.2%
4	3,438	112	3.3%
5	3,907	126	3.2%
6	4,468	146	3.3%
7	5,151	168	3.3%
8	6,046	195	3.2%
9	7,506	244	3.3%
10	12,530	440	3.5%

Source: Authors' calculations based on data reported in Table I and II.
[a] This column represents the average charge/expenditure ratio for each household in the decile. This differs slightly from the ratio of the decile averages reported in preceding columns. For discussion see note 30 and Appendix I.

Table IV: Distributional Incidence of a Chinese Sky Trust

All households

Per capita expenditure decile	Per capita expenditure (yuan)	Household size	net benefit per capita (yuan)	% of expenditures		
				charge	dividend	net benefit
1	591	5.3	57	2.1%	12.4%	10.3%
2	840	4.9	52	2.0%	8.2%	6.3%
3	1,022	4.8	49	2.0%	6.8%	4.8%
4	1,218	4.8	45	1.9%	5.7%	3.7%
5	1,451	4.6	41	1.9%	4.8%	2.8%
6	1,771	4.5	32	2.1%	3.9%	1.8%
7	2,258	4.1	15	2.4%	3.1%	0.7%
8	3,097	3.7	-18	2.8%	2.2%	-0.6%
9	4,414	3.4	-67	3.1%	1.6%	-1.5%
10	8,866	3.2	-213	3.2%	0.9%	-2.3%

Rural households

Per capita expenditure decile	Per capita expenditure (yuan)	Household size	net benefit per capita (yuan)	% of expenditures		
				charge	dividend	net benefit
1	542	5.4	58	2.1%	13.4%	11.3%
2	756	5.0	54	2.0%	9.1%	7.2%
3	894	4.9	52	1.9%	7.7%	5.8%
4	1,021	4.8	49	2.0%	6.8%	4.8%
5	1,161	4.8	47	1.9%	5.9%	4.0%
6	1,315	4.7	45	1.8%	5.2%	3.4%
7	1,505	4.7	41	1.9%	4.6%	2.7%
8	1,760	4.6	34	2.0%	3.9%	2.0%
9	2,154	4.3	26	2.0%	3.2%	1.2%
10	4,353	4.1	-17	2.1%	2.0%	0.0%

Urban households

Per capita expenditure decile	Per capita expenditure (yuan)	Household size	net benefit per capita (yuan)	% of expenditures		
				charge	dividend	net benefit
1	1,657	3.9	14	3.3%	4.5%	1.2%
2	2,437	3.6	-11	3.3%	2.8%	-0.4%
3	2,973	3.5	-27	3.2%	2.3%	-0.9%
4	3,438	3.4	-43	3.3%	2.0%	-1.3%
5	3,907	3.4	-57	3.2%	1.8%	-1.5%
6	4,468	3.3	-77	3.3%	1.5%	-1.7%
7	5,151	3.2	-99	3.3%	1.3%	-1.9%
8	6,046	3.2	-127	3.2%	1.1%	-2.1%
9	7,506	3.1	-175	3.3%	0.9%	-2.3%
10	12,530	3.0	-371	3.5%	0.6%	-2.9%

Based on a carbon tax of 300 yuan/tC, which yields a dividend of 69 yuan per person.

Source: Authors' calculations (see text for details).

Table V: Distributional Effect on Poverty of a Chinese Sky Trust, 1995

	All Households	Rural Households	Urban Households
Headcount Poverty Rate: Before	14.67	19.11	3.84
Headcount Poverty Rate: After	11.65	14.88	3.75
Difference	3.03	4.23	0.08
Poverty Gap: Before	3.06	3.99	0.78
Poverty Gap: After	2.20	2.81	0.72
Difference	0.85	1.18	0.06
Squared Poverty Gap: Before	1.02	1.34	0.26
Squared Poverty Gap: After	0.67	0.85	0.23
Difference	0.35	0.48	0.03

Source: Authors' calculations from 1995 CASS survey data.

Appendix I: Average of Ratios vs. Ratio of Averages

All households

Per capita expenditure Decile	Per capita expenditure (yuan)	Charge per capita (yuan)	net benefit per capita (yuan)	with average of ratios		with ratio of averages	
				Charge / expenditure	Net benefit / expenditure	Charge / expenditure	Net benefit / expenditure
1	591	12	57	2.1%	10.3%	2.0%	9.6%
2	840	17	52	2.0%	6.3%	2.0%	6.2%
3	1,022	20	49	2.0%	4.8%	2.0%	4.8%
4	1,218	24	45	1.9%	3.7%	1.9%	3.7%
5	1,451	28	41	1.9%	2.8%	1.9%	2.8%
6	1,771	37	32	2.1%	1.8%	2.1%	1.8%
7	2,258	54	15	2.4%	0.7%	2.4%	0.7%
8	3,097	87	-18	2.8%	-0.6%	2.8%	-0.6%
9	4,414	136	-67	3.1%	-1.5%	3.1%	-1.5%
10	8,866	282	-213	3.2%	-2.3%	3.2%	-2.4%

Rural households

Per capita expenditure Decile	Per capita expenditure (yuan)	Charge per capita (yuan)	net benefit per capita (yuan)	with average of ratios		with ratio of averages	
				Charge / expenditure	Net benefit / expenditure	Charge / expenditure	Net benefit / expenditure
1	542	11	58	2.1%	11.3%	2.1%	10.7%
2	756	15	54	2.0%	7.2%	2.0%	7.1%
3	894	17	52	1.9%	5.8%	1.9%	5.8%
4	1,021	20	49	2.0%	4.8%	2.0%	4.8%
5	1,161	22	47	1.9%	4.0%	1.9%	4.0%
6	1,315	24	45	1.8%	3.4%	1.8%	3.4%
7	1,505	28	41	1.9%	2.7%	1.9%	2.7%
8	1,760	34	34	2.0%	2.0%	2.0%	2.0%
9	2,154	43	26	2.0%	1.2%	2.0%	1.2%
10	4,353	86	-17	2.1%	0.0%	2.0%	-0.4%

Urban households

Per capita expenditure Decile	Per capita expenditure (yuan)	Charge per capita (yuan)	net benefit per capita (yuan)	with average of ratios		with ratio of averages	
				Charge / expenditure	Net benefit / expenditure	Charge / expenditure	Net benefit / expenditure
1	1,657	55	14	3.3%	1.2%	3.3%	0.9%
2	2,437	80	-11	3.3%	-0.4%	3.3%	-0.4%
3	2,973	96	-27	3.2%	-0.9%	3.2%	-0.9%
4	3,438	112	-43	3.3%	-1.3%	3.3%	-1.3%
5	3,907	126	-57	3.2%	-1.5%	3.2%	-1.5%
6	4,468	146	-77	3.3%	-1.7%	3.3%	-1.7%
7	5,151	168	-99	3.3%	-1.9%	3.3%	-1.9%
8	6,046	195	-127	3.2%	-2.1%	3.2%	-2.1%
9	7,506	244	-175	3.3%	-2.3%	3.3%	-2.3%
10	12,530	440	-371	3.5%	-2.9%	3.5%	-3.0%

Source: Authors’ calculations from 1995 CASS survey data.

Appendix II: Distributional Incidence of Carbon Charge and Sky Trust on Income Basis

All households

Per capita income decile	Per capita income (yuan)	Per capita expenditure (yuan)	Charge per Capita (yuan)	Charge / expenditure	Charge / income	Net benefit / expenditure	Net benefit / income
1	645	1,037	17	1.8%	3.0%	6.8%	8.6%
2	1,008	1,115	20	1.9%	2.0%	5.5%	4.9%
3	1,297	1,240	23	1.9%	1.8%	4.8%	3.6%
4	1,610	1,393	28	2.0%	1.7%	4.1%	2.6%
5	1,989	1,502	32	2.1%	1.6%	3.5%	1.9%
6	2,492	2,033	46	2.4%	1.8%	2.6%	0.9%
7	3,156	2,500	69	2.6%	2.2%	1.2%	0.0%
8	4,109	3,422	101	2.9%	2.5%	-0.2%	-0.8%
9	5,555	4,466	138	3.0%	2.5%	-0.8%	-1.2%
10	11,168	6,820	221	3.0%	2.2%	-1.4%	-1.5%

Rural households

Per capita income decile	Per capita income (yuan)	Per capita expenditure (yuan)	Charge per capita (yuan)	Charge / expenditure	Charge / income	Net benefit / expenditure	Net benefit / income
1	577	1,035	17	1.8%	3.4%	6.9%	9.6%
2	878	1,058	18	1.8%	2.1%	6.1%	5.8%
3	1,092	1,143	21	1.9%	1.9%	5.3%	4.4%
4	1,301	1,190	22	1.9%	1.7%	5.0%	3.6%
5	1,527	1,376	25	1.9%	1.6%	4.3%	2.9%
6	1,791	1,358	27	2.0%	1.5%	4.2%	2.4%
7	2,122	1,514	30	2.0%	1.4%	3.5%	1.9%
8	2,584	1,975	39	2.1%	1.5%	3.5%	1.2%
9	3,456	2,008	40	2.1%	1.2%	2.5%	0.9%
10	7,831	2,804	63	2.2%	0.9%	1.2%	0.1%

Urban households

Per capita income decile	Per capita income (yuan)	Per capita expenditure (yuan)	Charge per capita (yuan)	Charge / expenditure	Charge / income	Net benefit / expenditure	Net benefit / income
1	1,891	2,137	67	3.2%	3.6%	0.7%	0.3%
2	2,790	2,780	94	3.3%	3.4%	-0.6%	-0.9%
3	3,327	3,328	109	3.2%	3.3%	-1.0%	-1.2%
4	3,817	3,906	128	3.3%	3.3%	-1.2%	-1.5%
5	4,338	4,270	134	3.2%	3.1%	-1.4%	-1.5%
6	4,925	4,724	158	3.3%	3.2%	-1.7%	-1.8%
7	5,599	5,293	172	3.3%	3.1%	-1.8%	-1.8%
8	6,551	6,053	204	3.3%	3.1%	-2.0%	-2.1%
9	8,237	7,290	251	3.4%	3.1%	-2.3%	-2.2%
10	15,657	10,340	347	3.3%	2.5%	-2.5%	-2.0%

Source: Authors' calculations from 1995 CASS survey data.