Estimates of energy subsidies in China and impact of energy subsidy reform

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A B S T R A C T

For a transitional economy such as China, some energy subsidies are reasonable, and sometimes even necessary for achieving social goals. However, with rising energy prices and environmental concerns, we see conflicts emerging between energy subsidies, energy demand/supply fundamentals and climate change considerations. Energy subsidies have important implications for sustainable development through their effects on energy use, efficiency and the choice of fuel source. This paper applies the price-gap approach to estimate China’s energy subsidies. Results indicate that China’s energy subsidies amounted to CNY 356.73 billion in 2007, equivalent to 1.43% of GDP. Subsidies for oil products consumption are the largest, followed by subsidies for the electricity and coal sectors. Furthermore, a CGE model is used to analyze the economic impacts of energy subsidy reforms. Our findings show that removing energy subsidies will result in a significant fall in energy demand and emissions, but will have negative impacts on macroeconomic variables. We conclude that offsetting policies could be adopted such that certain shares of these subsidies are reallocated to support other sustainable development measures, which could lead to reducing energy intensity and favoring the environment.

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1. Introduction

The rapid growth of China’s economy has accelerated its energy demand, posing a difficult question about how non-renewable energy resources are to be efficiently used, given their scarcity. Wu (2009) indicates that energy price hikes could improve energy efficiency significantly. Thus, the energy price mechanism is at the core of energy reform, and energy subsidies are an important determinant of energy prices. There is some confusion about what an energy subsidy actually is. The narrow and perhaps most commonly used definition of an energy subsidy is a direct cash payment by a government to an energy producer or consumer. The broader definition is any government action that raises the price received by energy producers, lowers the cost of energy production, or lowers the price paid by energy consumers (OECD, 1998; IEA, 1999). In China, energy subsidies are mainly due to the fact that the government artificially holds the price of energy below the full economic cost of production.  

Common reasons politicians give for justifying an energy subsidy include energy market failure caused by externalities; protecting a particular domestic industry against international competition; avoiding potential unemployment; and making modern energy services more affordable for specific social groups (UNEP/IEA, 2002). Therefore, governments, especially in developing countries, consider energy subsidies as an essential ingredient of macroeconomic policy, vis-à-vis social and environmental targets, as well as the internalization of any welfare losses resulting from externalities. For example: in the Czech Republic, energy subsidies amounted to $7 billion between 1994 and 1998, where 80.3% of the total subsidies were given to fossil fuels; in Indonesia, the net economic cost of subsidies to kerosene, diesel, gasoline and heavy fuel oil amounted to $4 billion in 2002; in Iran, the total value of energy subsidies in 2000 was roughly $15.6 billion. Globally, gas, oil and electricity are the most heavily subsidized energy types, each receiving more than a quarter of total energy subsidies (UNEP, 2003).

Given significant social inequalities that seem to inevitably result from an economy’s transitional friction (that is, transitioning from a developing to a developed country, and in China’s case, from socialist to market-oriented), transitional energy subsidies could arguably be both reasonable, and to a certain degree, necessary (given the importance of energy in both consumption and production-input bundles). However, due to the rigidity and inertia of many subsidies in practice, along with institutional and political barriers, subsidies have not always been successful. In fact, energy subsidies have generally hindered the progress of energy price
reform in China.² To design a proper price mechanism, it is necessary to better understand the structure and role of China's energy subsidies.

Subsidies could exist in a variety of ways and China possibly has them all. Some are direct, such as grants and tax rebates, while others operate indirectly, such as government expenditure on energy infrastructure investments, and technology R&D. Governments will often take into account various metrics in making their decision to provide a subsidy, including the costs of the program, the transaction and administration costs, as well as financial or social costs to different groups. However, governments will often keep subsidies “off-budget,” for political reasons (UNEP/IEA, 2002). In fact, any financial subsidies are often motivated by vested interests, which often compromise the accurate modeling of any subsidy framework.

Energy subsidies in China have distorted market price signals, resulting in higher energy consumption and production, and have also become barriers to entry for cleaner energy services. Substantial energy subsidies are provided to consumers by lowering end-use prices. This leads to more energy consumption and reduces incentives to conserve energy. For example, China's residential electricity tariffs in general much lower than their supply costs, leading to low energy efficiency. Similarly, production subsidies to the state owned oil companies promote the oil consumption. And the government interventions to maintain lower price for coal used to produce electricity lead to substantial rapid increase in coal fired power capacities. China's past energy subsidies could have resulted in inefficient consumption and production paths. This has been evident in the rapid growth of energy intensive industries, and generally low energy efficiency in these industries could have resulted in lock-in emissions.

As China is facing greater challenges from energy scarcity and CO₂ emissions, energy subsidies become a serious issue to address, and requires urgent attention from the government. The effects of energy subsidy reforms, which inevitably have economic, social and environmental implications, vary according to the type of subsidies and have deferent impacts on different groups (producers as well as consumers). With a coal dominated energy structure, the majority of energy subsidies in China have encouraged fossil fuels use. These subsidies increase energy consumption, and at the same time likely reduce energy efficiency, exacerbate environmental deterioration, and inevitably lead to losses in social welfare. Even if some subsidies are reasonable, the poor design of any energy subsidy could distort its initial goal, that is, it may fail in maintaining or increasing social welfare. Furthermore, energy subsidy reforms are imperative in the context of China's market-oriented reform.

Actions by the Chinese government suggest that it understands the negative impact that energy subsidies may have and seems willing to consider reforming energy subsidies, usually as part of energy pricing reforms. For example, the government reformed the oil pricing mechanism in early 2009, while maintaining universal subsidy on electricity that is more important in household budgets. Recently, the government has considered reforming natural gas tariffs and residential power tariffs, by applying volume-differentiated tariffs.

This paper aims to provide a preliminary discussion on the magnitude and effectiveness of China's energy subsidies. The remainder of the paper is organized as follows: Section 2 reviews the present literature on energy subsidies; Section 3 introduces the methodology of estimate energy subsidies; Section 4 estimates the scale of China's energy subsidies; Section 5 applies the Computable General Equilibrium (CGE) model to simulate the impact of energy subsidies reform on macroeconomic variables; followed by conclusions and policy suggestions in Section 6.

2. Summary of energy subsidies studies

Present studies relating to energy subsidies mainly focus on the size of energy subsidies, and there is no systematic reporting of energy subsidies at the international level. The most well known global study, carried out by the World Bank in 1992, put world fossil-fuel consumption subsidies at $230 billion per year (UNEP/IEA, 2002). The World Bank (1997) estimated annual fossil-fuel subsidies at $10 billion in the OECD and $48 billion in twenty of the largest non-OECD countries. Greenpeace International (1997) claimed that more than 90% of direct subsidies from European governments' subsidies to the energy industry over the period 1990 to 1995 went to fossil fuels (63%) and nuclear power (28%). Only 9% of total direct subsidies, or $1.5 billion a year, were directed to renewable energy. Myers and Kent, (2001) estimated the global energy subsidies may be on the order of $131 billion per year, of which $100 billion are perverse subsidies. IEA (1999) found that energy subsidies in eight of the largest non-OECD countries were about $95 billion in 1998. DOE (1999) computed that the total federal energy subsidies in 1999 amounted to $6.2 billion — equivalent to 1% of the total value of energy supply in the US. De Moor (2001) valued that the annual global energy sector received over $240 billion in public subsidies, including at least $151 billion allocated to fossil fuels. Riedy and Diesendorf (2003) estimated $6.54 billion per year in financial subsidies to fossil fuel in Australia. European Environment Agency (EEA) (2004) found that the total subsidies (excluding external costs) were €29 billion in 2001, of which €13 billion went to fossil fuels, €8.7 billion went to oil, €2.2 billion went to nuclear and €5.3 billion to renewable.

International Energy Agency (IEA) (2006) estimated that the energy subsidies of the twenty largest non-OECD countries amount to around $220 billion based on 2005 data, of which subsidies to fossil fuels were about $170 billion. World subsidies were estimated to be $280 billion per year, or around 0.6% of world GDP. By 2007, these subsidies had increased to $310 billion per year in the same twenty non-OECD countries (IEA, 2008). The majority of these subsidies are consumption subsidies by lowering energy price for end-users (Morgan, 2007). Based on 2004 data, the Stern Report (2006) claimed that government support to the deployment of low-carbon energy sources was $33 billion each year worldwide: $10 billion on deploying renewable energy, $16 billion on supporting existing nuclear power and $6.4 billion on biofuels. GTZ (2007) estimated the value of transport fuel subsidies was $90 billion based on 2004 data, of which gasoline subsidies totaled $28 billion and diesel subsidies $61 billion. The CSI (2009) found that subsidies provided to producers of fossil fuels were about $100 billion per year. The total order of magnitude of subsidies to producers and consumers — almost $700 billion a year — was roughly equivalent to 1% of world GDP (World Bank, 2009; OECD, 2008). Vedenov and Wetzstein (2008) yielded an estimate that the optimal ethanol subsidy was $0.22 per gallon of ethanol. Conclusively, energy subsidies are comparatively high and much larger in non-OECD countries. The fossil fuels subsidies share the majority.

Studies also suggest that many subsidies were inefficient, that is, they failed to make energy affordable to the poor. Conversely, the benefits to the non-poor households were found to be significantly more than that to the poor (Dube, 2003; Gangopadhyay et al., 2005; Kebede, 2006). Chattopadhyay (2004, 2007) found that cross subsidies in electricity tariffs ought to be reduced and were suboptimal for some customers in India.

² In China, subsidies and cross-subsidies are prevalent. For example, the same electricity price is adopted in both urban and rural regions, and industrial electricity prices are higher than residential electricity prices. Domestic gasoline prices are controlled by the government, and often lower than the supply costs.

³ The eight non-OECD countries are: China, India, Russia, South Africa, Indonesia, Iran, Kazakhstan and Venezuela.
Moreover, the effect of removing energy subsidies is also an important aspect. Burniaux et al. (1992) found that removing energy subsidies would place downward pressure on world fossil fuel price. By 2050, global energy demand would decrease by 16% and CO2 emissions would be reduced by 4% comparing to the base case scenarios. Anderson and McKibbin (1997) demonstrated that subsidies reform had the potential to provide substantial gains in economic efficiency and reductions in CO2 emissions. IEA (1999) estimated that the removal of consumption energy subsidies in these eight countries would reduce primary energy consumption and CO2 emissions by 13% and 16%, respectively, while increasing GDP by 0.73%. OECD (2000) found that global CO2 emissions would decrease by 6% at least by 2010 if subsidies aimed at lowering the price in industrial and electricity sectors were removed. Saunders and Schneider (2000) applied GTM model to indicate that for energy producing countries, removal of energy subsidies would increase energy prices immediately, which would result in a fall in energy consumption and rise in energy exports. Burniaux et al. (2009) used the OECD ENV-Linkages model to estimate the impacts of the gradual removal of energy subsidies from 2013 to 2020. They concluded that if consumer subsidies for fossil fuels and electricity in 20 non-OECD countries were phased out, by 2050, world CO2 emissions would be reduced by 13% and GHG emissions would be reduced by 10%. However, energy consumption might increase in other energy importing countries such as EU as falling demand (due to subsidy removal) would reduce international energy prices. The studies on OECD countries also showed that the removal of coal subsidies would not always reduce emissions (IEA, 2001; OECD, 2005).

There is limited literature referring to China's energy subsidies. The only comprehensive study on China's energy subsidies was conducted by IEA (1999, chapter 5). It quantified the size of fossil fuel and electricity subsidies, and assessed the potential impact that subsidy removal would have on energy consumption, as well as CO2 emissions. The results indicate that the average rate of energy subsidies in China was 10.9%, and the social welfare loss caused by energy subsidies was equivalent to 0.36% of GDP. Furthermore, if China's energy subsidies were removed, energy consumption and CO2 emissions would fall by 9.4% and 13.4%, respectively.

It has been more than 10 years since IEA's study, and there has been very little research focused on exploring China's energy subsidies since. However, the energy situation in China has experienced tremendous changes in recent years. China's energy demand has been increasing at very high rates (at an average of 11.07% per year for the past six years) (Fig. 1), induced by rapid economic growth and its industrialization and urbanization process. China's oil dependency increased at a rate of about 2% annually since 2006, and is currently about 52%. In addition, every year, increasingly more coal is imported into China. China's CO2 emissions have become the world's largest since 2006, and the country endures great pressure for emission reduction from international communities.

Like all developing countries, the Chinese government is facing difficult choices between energy efficiency and energy prices. In an effort to maintain low energy costs to support economic growth and social stability, the government often intervenes in the energy market through various administrative measures, including control of energy prices, particularly electricity tariffs. These lead to inevitably substantial energy subsidies.

Energy subsidies in China are used to alleviate energy poverty and support economic development by enabling access to affordable modern energy services. Therefore, the energy subsidy reforms should be analyzed in context, including their links to China's sustainable development, economic growth, poverty reduction and environmental protection. China's current energy subsidies are in general related to its energy resource endowments, its current development stage and its development objectives, and in particular, related to specific challenges such as energy pricing, energy structure and the energy sector reforms. Therefore, China's energy subsidies also should be analyzed based on national circumstances. Quantifying the size of energy subsidies in China, and exploring both short and long run effects of possible reforms is a starting point in finding solutions to these problems, and is what the rest of this paper aims to achieve.

3. Methodology

3.1. Price-gap approach

Different approaches are applied to estimate energy subsidies. The effective rate of assistance (ERA) covers any direct and indirect action that affects the price of a good. The producer subsidy equivalent (PSE), which was developed by OECD, looks at the value of subsidies to their recipients as a measure of their impact. The price-gap approach focuses on end-use energy consumption subsidies, and quantifies the gap between world energy prices and domestic (subsidized) end-user prices.

While ERA has the virtue of capturing the full extent of the subsidy in theory, such a measure is difficult to use in practice because it requires a wealth of reliable information/data, which in many cases is difficult to obtain. The PSE offers a feasible way to pursue the magnitude of impacts over time, but it would provide no information about effects on economic efficiency, greenhouse gas emissions and energy security. So this paper will apply the price-gap approach. Firstly, the price-gap approach has the advantage of conceptual and analytical simplicity, and is the most pervasive approach in analyzing energy subsidies. Secondly, the majority of Chinese energy subsidies are in the form of end-use subsidies.

The theoretical foundation of the price-gap approach was proposed by Corden (1957). It is based on the idea that subsidies to consumers of energy lower the end-user prices of energy products and thus lead to more consumption than would occur in their absence. McRone (1962) undertook an early application to agriculture subsidies in the UK. OECD (1998) applied this method to analyze the effect of fossil fuels on the environment, whereas IEA (1999, 2008), and Coady et al. (2010), used this method to estimate the magnitude of energy subsidies in other countries.

However, the price-gap approach also has limitations. Firstly, it only captures the subsidies on end-use. Secondly, it requires accurate data on world reference prices, domestic taxes and transport costs, all of which can pose difficulties. Thirdly, and in the context of this paper, it identifies only static effects. It compares given situations with and without subsidies, holding all other things equal. The dynamic effects of the removal of energy subsidies may well bring larger benefits than the static results. This suggests that the estimate itself may underestimate rather than overestimate the impact of energy subsidies (IEA, 1999). The results should therefore be seen as a lower bound of the true costs of energy subsidies.

3.2. Steps in the quantitative analysis

For its simplicity and the data availability, we first utilize the price-gap approach to estimate energy subsidies. We determine the consumer price\(^4\) and reference price\(^5\), and then compute the price gap:

\[
\text{Price gap} = \text{reference price} - \text{consumer price}
\]  

(1)

Second, the impact of the price gap on energy consumption is estimated.

The impact of the removal of the subsidies depends on the functional form of the demand function. The methodology described in IEA (1999) is adopted in this paper — we use the constant-elasticity inverse demand function. The advantage of using this function is that the demand elasticity stays constant along a range of possible values and the parameters are easy to estimate with limited data. It is specified as follows:

\[
q = p^\varepsilon
\]  

(2)

So, we can induce that:

\[
\ln Q_1 = \varepsilon \times (\ln P_1 - \ln P_0) + \ln Q_0
\]  

(3)

The impact on consumption is established by the formula:

\[
\Delta Q = Q_0 - Q_1
\]  

(4)

Here, \(\Delta Q\) is the decrease in consumption if the price gap is removed; \(\varepsilon\) is the long-term demand elasticity; \(P_0\) and \(Q_0\) are the price and quantity before the removal of the price gap, respectively; \(P_1\) and \(Q_1\) are the price and quantity after the removal of the price gap, respectively.

Third, the effect on CO\(_2\) emissions is estimated:

\[
\Delta CO_2 = \sum_i \Delta q_i \times CO_2 EF_i
\]  

(5)

Here, \(\Delta CO_2\) indicates the reduction of CO\(_2\) emission; \(i\) indicates the \(i\)th fuels; \(CO_2 EF_i\) indicates the CO\(_2\) emission coefficient.

The price-gap method applies the principle of opportunity cost of a pricing policy. In this paper, in the case of an internationally traded product, the reference used is the export or import unit value (adjusted for internal transport costs, tax and quality differences, where applicable), depending on whether China is a net exporter or importer of the product concerned. In the case of a product that is not commonly internationally traded, such as electricity, the opportunity-cost or the reference price is estimated based on the long-run cost of production. In some cases, current price is used as a proxy for the actual price that would have been paid during a given period, at least for marginal change in production or consumption.

4. Estimates of Chinese energy subsidies based on 2007 data

4.1. The consumer price and reference price

4.1.1. Coal

China relies heavily on coal to meet its energy requirements (Fig. 1). The magnitude of China’s coal consumption was 2.58 billion tons in 2007, which accounts to 69.5% of its energy mix. Of China’s coal consumption, about 75% was made up of intermediate consumption and 25% was made up of end-use consumption. Of the intermediate consumption, the breakdown was as follows: 66.9% for power generation, 21.3% for coking, and 7.9% for heating. Of the end-use consumption, 78% was consumed by industry.\(^6\) Conclusively, more than half of coal is used to power generation. The industry (excluding the power sector) shares about 44.58% of total coal consumption (Fig. 2).

Because of the domination of coal in its energy structure, coal could have a significant impact on China’s economy. After several reforms in China over the last three decades, coal prices are supposed to be market determined. Compared to other energy products, the variation in coal price is more closely related to coal demand and supply conditions. However, in an effort to maintain low electricity tariffs, the government continues to control electricity tariffs. The price of coal in China is still indirectly influenced by the government. The allocation of thermal coal is still greatly influenced by government interventions, through administrative persuasion to state owned coal mines and more importantly, through allocation of transport capacity, which represents a large portion of the coal price (sometimes up to 25% of coal price). Therefore, the pricing of thermal coal, though undergoing several reforms, is certainly not subject to perfect market conditions.

\(^4\) The end-use price is the actual price to energy consumers. All taxes, fees, levies, surcharges and so forth, as well as all rebates and reductions, were included in actual prices. The end-use price presents in domestic currency.

\(^5\) Reference prices correspond to the “efficient” prices that would prevail in the absence of subsidies. They reflect either the price of a good traded in a competitive international market or the long-run marginal cost of production (LRMC) costs.

Qinhuangdao port is China's largest coal transfer port and the most important channel for coal transport from the north to the south of the country, accounting for more than 40% of the total coal transport in China. Qinhuangdao port is also the terminal of the special railway line (Daqing railway). Therefore, the Qinhuangdao coal prices are good proxies that can reflect the trading price of domestic coal and be considered as representative reference prices. Steam coal is the most commonly used coal for power generation. There are five kinds of steam coal in the Qinhuangdao coal market, and we use the average price of these to represent the thermal coal price. As for sulphur and ash content, there are consequent variations in the coal price resulting from different grades of coal. However, due to data limitations, this paper only estimates an average price. In 2007, the average FOB price of Qinhuangdao steam coal was CNY 426.43 per ton.\textsuperscript{12} According to the report of State Electricity Regulatory Commission (SERC and Coal Industry Yearbook (2008)), the average FOB price of thermal coal was CNY 385.68 per ton.

There are three main railway lines from Qinhuangdao to the primary area of coal consumption, including Guangzhou, Shanghai and Ningbo. Based on the data reported by China Coal Transportation & Sale Society (CCTS), the average fee of shipping was CNY 94.6 per ton in 2007.\textsuperscript{8} Therefore, the reference price of domestic thermal coal was CNY 521.01 per ton, the end-use price of thermal coal was CNY 480.26 per ton.

Finally, we assume that there are no subsidies for imported coal, because that the five largest power generating companies directly import their coal from the international market.

\subsection*{4.1.2. Oil products}

The oil products in this paper include gasoline, diesel oil and fuel oil.\textsuperscript{9} Due to data limitations, we assume that the retail prices, determined and announced by the National Development and Reform Commission (NDRC), are the same to all consumers [Table 1]. As for imported oil, the reference price = import price + tax + transport cost, i.e. delivered duty paid (DDP) + transport cost\textsuperscript{10}, and for domestic oil, the reference price is the export price (in principle). However, we find that China's gasoline and diesel export prices are even lower than the retail prices and this is clearly a result of China's subsidies on exported oil, as a means to gain international competitiveness and to consider other social objectives. It is therefore more appropriate to use the international price as the base reference price. This is computed by the international price + tax + transport costs.

Based on 2007 data for gasoline, the average international price was $86.42 per barrel, i.e. $735.43 per ton, and the average import price was $787.70 per ton. For diesel oil, the average international price was $84.45 per barrel, i.e. $617.66 per ton and the average import price was $757.10 per ton. For fuel oil, the average international price was $53.08 per barrel, i.e. $338.89 per ton and the average import price was $374.80 per ton.\textsuperscript{11}

\begin{table}[h]
\centering
\caption{Fuel price in 2007.}
\begin{tabular}{|l|c|c|c|}
\hline
 & Consumer price & Reference price of domestic production & Reference price of import \\
\hline
Coal CNY/ton & 480.26 & 521.01 & – \\
Gasoline CNY/ton & 6478.44 & 7593.30 & 8219.85 \\
& 6478.44 & 7904.26 & 8530.81 \\
& 6478.44 & 8111.57 & 8738.12 \\
Diesel oil CNY/ton & 5693.87 & 6270.46 & 7667.09 \\
& 5693.87 & 6543.76 & 7940.60 \\
& 5693.87 & 6725.97 & 8112.60 \\
Fuel oil CNY/ton & 3425.21 & – & 3958.29 \\
& 3425.21 & – & 4122.70 \\
Natural gas CNY/m\textsuperscript{3} & – & – & – \\
& – & – & – \\
& – & – & – \\
Electricity CNY/MWh\textsuperscript{4} & 2.47 & 2.94 & 3.49 \\
& 2.15 & 2.94 & 3.49 \\
& 2.09 & 2.94 & 3.49 \\
Resident & 470.88 & 1030.67 & – \\
Large industry & 514.18 & 483.39 & – \\
Commerce & 851.79 & 606.23 & – \\
Agriculture & 401.80 & 576.14 & – \\
Non-common industry & 692.83 & 541.56 & – \\
\hline
\end{tabular}
\textsuperset{Note: **-** indicates that no subsidies or imports are non-existent.}\textsuperset{4 The consumer prices of electricity don't include the government funds.}
\end{table}


\textsuperset{8 The data reported by CCTS is monthly data for each channel, and we calculate the average as the shipping charge.}

\textsuperset{9 We do not compute the subsidies for kerosene, as kerosene consumption is rather small and there are many varieties of kerosene whose prices vary significantly.}

\textsuperset{10 Delivered duty paid = [(cost + transport insurance) + conversion coefficient between ton and barrel] + exchange rate} + [1 + custom + excise] – [1 + VAT] + harbor dues) + quality ratio. The transport insurance is $15.5/bbl. The conversion coefficient of gasoline is 8.51, diesel oil is 7.31 and fuel oil is 6.38. The custom duty for gasoline is 2%, for diesel oil is 2%, and fuel oil is 3%. VAT is 17% for all oil. To simplify the computation, we assume the quality ratio is 1 for gasoline, diesel oil and fuel oil. $1 = \text{CNY} 7.804.

\textsuperset{11 Source: The international price data is from Platt's Oilgram, Reuters. We choose the price in US Gulf. Gasoline refers to the Reg, Unl; Diesel oil refers to 0.2% Sulfur diesel oil; Fuel oil refers to 0.3% Sulfur fuel oil. The import data was taken from the general administration of customs of China.}

\subsection*{4.1.3. Natural gas}

The pricing of natural gas in China is most confusing due to historical reasons and adopts a basic cost-plus method. Natural gas prices are tightly controlled by the government and all prices require government approval. End-user prices basically comprise of three parts: production costs, pipeline transmission costs and city distribution costs. The production cost (or factory price), which is controlled by the government, is uniform for a particular gas source. Pipeline transmission and city distribution costs depend on the length of the pipeline network and city distribution characteristics, and sometimes, even the level of incomes of certain consumer groups or certain locations.

As the government controls the production cost, it is impossible to estimate a reasonable average reference price based on the domestic data. Therefore, this paper uses American Henry Hub's natural gas price as the benchmark of domestic production cost, which was $6.95 per Btu in 2007, i.e. CNY 1.89 per cubic meter.\textsuperscript{12} End-user prices are end-user category specific, and these categories are made up of residential, industrial and public sector consumers. We compute an average price of 36 cities. In 2007, the average gas price was CNY 2.15 per cubic meter for residential consumers, CNY 2.47 per cubic meter for industrial consumers and CNY 2.09 per cubic meter for public sector consumers.\textsuperscript{13}

\subsection*{4.1.4. Electricity}

Rapid economic growth has led to dramatic growth in China's electricity demand. In 2007, China's electricity consumption was 3271.18 TWh. Of the total consumption, 75% was used by industry, 3% by agriculture, 2% by the transport sector, 1% by the construction sector, and 5% by other sectors. Household consumption accounted for approximately 11%.\textsuperscript{14}

China is currently in its industrialization and urbanization stage and reliable and sufficient electricity supply is crucial to its economic

\textsuperset{12 Source: BP statistical review full report workbook 2008.}

\textsuperset{13 Note: this paper calculates the yearly price on the basis of twelve months price. Source: China Economic Information Network.}

growth objective. Pricing of electricity is consequently a very sensitive issue in China, and is still firmly controlled by the government. There are two basic characteristics of China’s electricity tariff. Firstly, the overall tariff level is generally lower than supply costs and lower than that of developed countries. Secondly, the tariff for industry is much higher than the residential tariff, leading to a large cross subsidy. This is due to the government’s effort to maintain the low electricity tariff to support its rapid economic growth, competitiveness of Chinese products in foreign trade, and other social economic objectives. According to the State Electricity Regulatory Commission (SERC) (2008a) and China Electric Power Yearbook (2008), in 2007, the average consumer price was CNY 470.88 per MWh for residential customers, CNY 514.18 for large industry customers and CNY 851.79 for commercial customers. Asian Development Bank (2003) estimated the LMRC of China’s power generation and based on the estimates, this paper adjusts the LMRC by applying CPI.

Table 2

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Natural gas</th>
<th>Resident</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>−0.529</td>
<td>−0.310</td>
<td>−0.584</td>
</tr>
<tr>
<td>Production oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resident</td>
<td>−0.230</td>
<td>−0.584</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>−0.269</td>
<td>−0.158</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>−0.193</td>
<td>−0.84</td>
<td>−0.60</td>
</tr>
</tbody>
</table>

Note: Only the main consumption category of each fuel is listed.

### 4.2. Price elasticity of demand

Due to data limitations, we were unable to compute meaningful cross-elasticities between different types of energy. Qi et al. (2009) estimated the price elasticity of China’s industrial and residential electricity demand as −0.60, and −0.16 respectively. We use the same values of price elasticity of electricity demand in this paper. There are a number of studies conducted on the price elasticity of fuel. Lin et al. (2007) found the price elasticity of coal was −0.26 in China. Espey (1998) showed that the average short-run price elasticity of gasoline was −0.26, and that the long-run elasticity was −0.58. Brons et al. (2008) obtained the short run and long run price elasticity of gasoline as −0.34 and −0.84, respectively. However, very few studies have estimated the price elasticity of specific sectors. Therefore, we apply an econometric model to estimate these price elasticities.\footnote{Because of limited space and the numerous parameters that need to be estimated, we only list the result of the price elasticity. Because each kind of energy consumption has its own characteristics, the econometric models are different from each other. The dependent variable for each econometric model is the same, that is, fuel consumption. As for independent variables, all models comprise the price variable. Furthermore, owing to the different use of each fuel, we consider other influential non-price factors such as vehicle population, power generation, and so on. We conduct the \( R^2 \) test and \( t \) test on the significance of these estimates.}

The results are listed in Table 2.

### 4.3. Chinese energy subsidies and the effects

Based on the results in Table 1, we apply the price-gap approach to estimate the magnitude of China’s energy subsidies. Using the elasticities in Table 2 and the constant-elasticity inverse demand function in Section 3.2, we estimate energy consumptions after the removal of the price gap and calculate the differences in energy consumption emissions with and without subsidies, and then compute the effects of energy subsidies on CO\(_2\) emissions when these energy subsidies are removed. The results are presented in Table 3.

Table 3 indicates that in 2007, China’s end-use energy subsidies amount to CNY 356.73 billion — roughly equivalent to 1.43% of GDP. IEA (2008) had estimated that China’s energy consumption subsidies were about CNY 300 billion in 2007. Our estimation is larger than IEA’s, the main difference of which is the magnitude of coal subsidies, which may have resulted from the different view of China’s coal price mechanism. Moreover, the choice of reference and end-use prices may be different as well. From the perspectives of different fuel sources, oil products subsidies amount to CNY 189.03 billion, which share about 53.0% of total energy subsidies and 0.76% of GDP, and responsible for the majority of energy subsidies. The large amount of oil products subsidies are mainly because that: firstly, the prices of oil products are controlled by the National Development and Reform Commission (NDRC). International oil price kept on high increasing in 2007, however, the adjustment of domestic oil products price rather lagged. Secondly, Chinese oil consumption increases rapidly, especially in the transport sector. Electricity net subsidies represent the second largest subsidy, amounting to CNY 76.39 billion, approximately 21.41% of total subsidies and 0.31% of GDP. Coal subsidies are estimated at CNY 53.2 billion, amounting to 14.91% of total subsidies and 0.21% of GDP. The coal subsidies result from the control of the thermal coal price and the large coal consumption in power sector. In 2007, the power sector consumes 1.34 billion tons of coal, accounting for more than half of the total coal consumption. Only until recently, coal prices have been subject to market fundamentals, and even then, the thermal coal price does not fully reflected the market prices. This is because that the government continues to influence the prices of thermal coal through administrative persuasions and transportation capacity, which is still allocated by the government planning. The subsidies to natural gas are CNY 38.11 billion, about 0.15% of GDP. Recently, the Chinese government has intended to reform natural gas prices,\footnote{According to the (Information about the adjustment of pipeline transmission price of natural gas issued by the NDRC, since Apr 25th, 2010, the government has unified the pipeline transmission price of natural gas which is standard, and increased it by 8 cent per cubic meter.} and if the reform continues, natural gas subsidies are likely to decline. Naturally, removing these energy subsidies will result in an increase in energy prices. Since the price elasticity of demand is negative (see Table 2), the potential energy savings will reach 65.07 million tons equivalent (about 2.45% of the total energy consumption), when subsidies are removed. The decrease of energy consumption will reduce CO\(_2\) emissions. We assume that the higher energy prices will result in lower energy demands and there is no energy substitution occurring. Therefore, the potential CO\(_2\) emissions reduction will be 172.3 million tons-equivalent (2.56% of the total emissions).

According to IEA (1999), the removal of such subsidies would yield 9.41% of energy savings and 13.4% of CO\(_2\) emission reduction. Comparing IEA’s results, we find that although the magnitude of China’s energy subsidies have increased in the past 10 years, the proportion of energy subsidies in relation to GDP is smaller, and therefore the savings and emission reduction when removing these subsidies are much smaller than that of IEA estimates, indicating that there have been improvements in China’s energy pricing over time.

The subsidies for each sector are calculated in Table 4. From the perspective of the subsidies to sectors, Table 4 shows that the residential sector receives the most subsidies, and above 90% of them is provided through electricity consumption, as the electricity tariff for the residential sector is much lower than its supply cost, consideration of affordability of the poor people. The second largest receiver of subsidies is the transport sector, and nearly all the subsidies are from oil use. The power sector receives CNY 57.93 billion subsidies, and the majority is comprised by coal-fired power.
generation. This is due to the fact that the coal-fired dominates power generation (accounting for 80% of the total electricity generation). The sectors with negative net subsidies include industrial, commercial and others, indicating substantial cross-subsidies in China.

It is important to note that China's five largest power generating companies have been incurring significant losses in the past few years. This has been mainly due to government efforts to maintain low electricity tariffs. Although coal prices have increased substantially over last few years, electricity tariffs that were controlled by the government could not be adjusted accordingly and in time, due to the government's concern over various issues, such as inflation, industrial competitiveness and economic recovery during the financial crisis. Financial loss suffered by power companies is a direct result of the government's effort to maintain low electricity tariffs. In other words, with electricity tariffs below supply costs, the coal subsidies to the power companies were directly passed down to the consumers. In 2007, the five biggest power generating companies' profits were CNY 31.3 billion, however in 2008, with the rapid increase in coal prices, these profits (losses) were CNY – 32.3 billion.\(^ {17} \)

5. CGE model and the macroeconomic impact

China's energy subsidies were equivalent to 1.43% of GDP in 2007. Energy subsidies not only increase the government's financial burden, but also lead to over-consumption of energy, and cause a significant increase in GHG emissions. In 2006, China's CO\(_2\) emission had become the largest in world and in 2007, it accounted for 24.35% of the world's total emissions, and the increment took up about 60% of the world's increment. As global concern, China continues to endure great international threatened sustainable development, and has become a major global concern, China continues to endure great international pressure for emission reductions. This reinforces the urgency for China to reform its current energy subsidy mechanism. However, before considering the type of reform necessary, it is important to identify the magnitude of macroeconomic impacts such a reform may induce. We apply a Computable General Equilibrium (CGE) model to analyze the macroeconomic impacts of energy subsidies reform.

5.1. Modeling framework

The CGE model is based on the Arrow–Debreu General Equilibrium model, and defines the production and consumption functions, which reflect the interdependent relationship among multi-sectors and multi-markets. Therefore, the CGE model can reveal more comprehensive economic relationships than partial equilibrium or econometric models.

5.1.1. Social Accounting Matrix (SAM)

The SAM provides an underlying data framework for the CGE model. It represents flows of all economic transactions that take place within an economy (regional or national) and is based on an input–output (I/O) table, combining national income and product accounts, as well as the institutional account (household, firm, government and the 'Rest of Economy' sector). A SAM is a square (columns equal rows) matrix in the sense that all institutional agents are both buyers and sellers. Columns represent buyers (expenditures) and rows represent sellers (receipts). Each cell represents a payment from a column account to a row account. Following the conventions of double-entry bookkeeping, the total receipts (income) and expenditure of each actor must balance. That is, for a SAM, every row sum must equal the corresponding column sum. The basic framework comprises six accounts: actives, commodities, factors, institutional agent, capitals and foreign. The actives account reflects the production activity of the manufacturer; the commodities account reflects the transaction activity in the domestic market; the factors account reflects the flow of the productive factors; the institutions account reflects the interaction between domestic institutions; the capital account reflects the activity in capital market; the foreign account reflects international economic activity.

In order to capture the relevant interactions among energy, economy and environment and provide a consistent and integrated data framework for calibrating the environmental CGE model, the framework of an environmentally extended SAM is developed. According to the

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method applied by Xie and Saltzman (2000) to deal with pollution abatement, we construct China's energy-environment SAM. The energy-environment SAM regards enterprise's abatement as an 'active', which is different from a traditional SAM. Therefore, the active account includes two sub-accounts: a production and an abatement account. The pollution abatement sector produce pollution cleanup, and is purchased by other productive sectors as an intermediate input. So, the commodity account includes the goods and cleanup accounts.

Based on the I/O table, we combine the 42 existing sectors into 15 sectors, categorized as agriculture, light industry, heavy industry, construction, service, coal, oil and natural gas, coal power, oil/gas power, hydropower, nuclear power, renewable power, carbon dioxide abatement, sewerage abatement and waste abatement. Assuming each active produces one commodity, the active and commodity accounts are the same. The factors account includes capital and a labor sub-account. The residential, enterprise and government accounts together compose the institution account.18

Due to the problem of converting national accounting data into money flows and the introduction of non-SNA data, complicated by issues of inconsistent national accounting data, the estimated SAM is not in balance in the first collation. We therefore use a Cross Entropy Method (CEM) to balance the SAM. The CEM originates from the information theory of Shannon (1948), and is used in statistical deduction by Jaynes (1957). The data is mainly sourced from the China Statistical yearbook, China Financial yearbook, China Environmental yearbook, and the China Energy Statistical yearbook.

5.1.2. The CGE model19

Based on the SAM, the CGE model is constructed, and we integrate energy and environment into the model. Coal, oil, natural gas and electricity together compose the energy production sector. The abatement active is introduced into the CGE model as a derivative of the production sector. Hence, the domestic production consists of five sectors: energy, other inter-input, labor, capital and abatement, and the sum of each sector's output form gross domestic product. As there is incomplete substitution between domestic and imported goods, this paper applies Armington supply to reflect this. The model structure is expressed in Fig. 3.

Constant Elasticity of Substitution (CES) function is applied to describe the production and utility functions. The CES function in term of two input factors can be expressed as follows:

\[
Y(L, K) = \left(\alpha L^{-\rho} + (1-\alpha)K^{-\sigma}\right)^{1/\rho} \\
\]

(6)

Here, \(\sigma = 1/(1+\rho)\) is the substitution elasticity between the two factors. The CES production function has more universality than the Cobb-Douglas and Leontief production functions. When \(\rho \to -\infty\), \(\sigma \to 0\), CES production function becomes the Leontief production function; when \(\rho \to 0\), \(\sigma \to 1\) CES production function becomes the Cobb-Douglas production function. Moreover, CES production function is homogeneous and its substitution elasticity is constant, which reduces the limitations on the hypothesis of the production function. Therefore, the CES function is very practical in modeling. The nesting structure of the production and utility functions are shown in Figs. 4 and 5, respectively.

5.2. Simulation and results

In order to discuss the impact of energy subsidy reforms more comprehensively, we set three distinct scenarios and run the corresponding simulations. Scenario 1 models a world where all energy subsidies are removed, and no further redistribution of these subsidies.

From the Chinese government's social perspectives, it would be necessary for the government to simultaneously adopt offsetting policies to minimize the negative effects caused by subsidy reforms. Therefore, we assume that such offsetting policies would involve savings from energy subsidy removal are redistributed. The Chinese government's revenue in 2007 was CNY 5132.18 billion, of which the tax and transfer payments were CNY 1811.24 billion, accounting for about 35% of total government revenue.20 Scenario 2 therefore models a situation that 35% of the savings from subsidy removal are reallocated to those sectors in favor of energy intensity and emission, namely agriculture, services and light industry. Therefore, reallocation does not consider heavy industry.21 In Scenario 3, we further assume that 50% of savings for subsidy removal are reallocated to agriculture, service and light industry. The simulation results are shown in Table 5.

The Scenario 1 shows that if all energy subsidies are removed, macroeconomic variables will suffer significantly adverse impacts due to an increase in the general level of energy prices. Welfare, GDP and employment will decrease by \(-2.03\%\), \(-1.56\%\) and \(-1.41\%\), respectively. However, we will see significant improvement of energy intensity, which will decrease by \(3.56\%\). As expected, we also see a large decrease in CO2 and SO2 emissions by \(7.02\%\) and \(6.83\%\), respectively. This again indicates that in a developing country like China, an increase in energy price is key factor to improve energy efficiency and reduce emission. However, China is in its transitional period, economic growth directly related to social development and stability. Large negative impacts on macroeconomic variables such as GDP and employment due to subsidy reforms will prove to be a real challenge.

The Scenario 2 indicates that removing present energy subsidies and reallocating a certain proportion of these subsidies back into the economy will induce positive impacts. Welfare, GDP and employment will increase by \(0.16\%\), \(0.37\%\) and \(0.53\%\), respectively. However, comparing with results in Scenario 1, energy intensity will still fall, albeit by a lesser extent (by \(2.79\%\)). Similarly, CO2 and SO2 emissions will also fall by a lesser extent, by \(5.91\%\) and \(4.83\%\), respectively. The lower emissions reduction result is expected, as the redistribution of funds into the economy will result in offsetting some of the emission reductions.

As expected, when 50% of the savings are redistributed, the positive impacts on macroeconomic variables are greater. Welfare, GDP and employment will increase by \(1.52\%\), \(1.74\%\) and \(2.07\%\), respectively. However, energy intensity and emissions will decrease, but by a smaller margin comparing with the results in Scenarios 1 and 2.

Comparing the three scenarios, we find that the more the savings from subsidy removals are reallocated into certain sectors, the greater the positive effects will be on macroeconomic variables, with smaller benefits on emissions and energy intensity. This is because the fund reallocations will promote economic growth and employment, but generating more emissions due to the "rebound effect". Therefore, the reallocation of savings from reducing subsidies also needs to be carefully studied and well targeted. If the government inclines towards economic growth and social stability, a large proportion of the savings will be reallocated. If however, the government wants to

18 Lin and He (2008) use China's SAM.
19 Due to limitations on length of the paper, we only present the structure of the CGE model.
21 The revitalization program of light industry was passed in February in 2009, which suggests that China will strengthen the support of light industry development.
22 To avoid confusion in results, it should be clarified that there are two results of CO2 emissions reduction. Table 3 indicates that CO2 emissions will decrease by 2.56%, but the CGE model under Scenario 1 indicates that CO2 emissions will decrease by 7.02%. It is not surprising to get such results, as the scenarios we set in the two separate estimation frameworks. In Table 3, we estimate the emission savings directly caused by energy savings. However, in the CGE model, the economy as a whole is taken into account, and the change in one sector affects other sectors. Therefore, it is reasonable that the extent of CO2 emissions reduction in Table 3 is smaller than that of our CGE model.
improve the energy intensity and reduce emissions, the negative impact on the economy will be greater. This is the trade-offs facing the government.

The results of the CGE simulation also indicate that energy subsidies are not the most efficient way to solve social issues. Removing energy subsidies and at the same time increasing investment in certain targeted sectors, such as light industry, education, health and public infrastructure, independently or simultaneously, will not only improve welfare, GDP and employment, but also decrease energy intensity and emissions.

6. Conclusions and policy suggestions

This paper applies the price-gap approach to estimate China's energy subsidies in 2007 and the impact of removing these subsidies. The results suggest that even when considering only the end-use subsidies, China's energy subsidies were sizable, estimating at CNY 356.73 billion or about 1.43% of GDP in 2007. The potential energy savings and CO$_2$ emissions will be about 65.07 million tons coal equivalent and 172.3 million tons, respectively, if the subsidies are totally removed. Therefore, we can conclude that reducing or removing energy subsidies, which will result in increasing energy prices, will have significantly positive impacts on energy conservation and CO$_2$ reduction.

From energy type, oil products related consumption received the majority of energy subsidies, about 53.0% of the total. This may because that the soar of international oil price contrasts with the lagged adjustment of domestic oil price. Electricity net subsidies represented the second largest (21.41%). Coal subsidies were estimated at CNY 53.2 billion, amounting to 14.91% of total subsidies. The subsidies result from the control of the thermal coal price and large coal consumption in the power sector. In terms of sectors subsidized, the resident sector was the largest recipient, and more than 90% of these subsidies were provided through electricity consumption.

Three scenarios of CGE model simulations indicate that different levels of reforms of energy subsidies will have different impacts. Scenario 1 shows that GDP and employment will suffer significant negative impacts when removing energy subsidies with no reallocation of subsidy savings, although emissions will decrease remarkably.

![Fig. 3. The structure of the CGE model.](http://www.paper.edu.cn)

![Fig. 4. The structure of the production function.](http://www.paper.edu.cn)
Scenarios 2 and 3 suggest the reallocation of the subsidies savings will lessen the negative impacts on the economy, though the effect on emission abatement will be weakened.

In China, the common practices of government energy price setting imply energy subsidies. For a transitional economy like China, some energy subsidies are justifiable, sometimes even necessary. In general, energy subsidy could be justified if the gain in social welfare (including environmental benefits) that it carries exceeds the net economic cost, while sustaining incentives for efficient delivery and consumption. In practice, due to over-subsidization and the defects in subsidy design, energy subsidies are often unsuccessful and contradict initial targets. Subsidies for fossil fuels usually fall into this category. Therefore, it is inevitable that reforming the present subsidy framework is essential, especially for developing countries like China with energy scarcity and environmental concerns. Moreover, all subsidy reforms should take into account the impacts on the economy, society and environment.

The fundamental principles of energy subsidies focus on who, what, how and how much (UNEP/IEA, 2002). Therefore, energy subsidies should be considered under four essential frameworks: object, scope, manner and amount. Two things need to be considered when proposing subsidies reforms in China. First, for subsidies to be more effective, China should change its past practices of focusing on supply side subsidies. Demand-side subsidies with clear targets should be adopted, even though the management cost could be more expensive. Second, for a developing country like China, subsidies will be mainly applied to address basic social issues, as guaranteeing basic energy needs is the obligation of government. A lifeline tariff or incremental tariff approach, which will support basic energy needs, should be adopted in this regard. As most energy companies in China are state-owned, reforming energy subsidies that target the poor more will also support social equality.

Our results indicate that China will need to reform its energy subsidies to improve energy efficiency and reduce emissions. Obstacles will certainly appear in the process of energy subsidy reforms, which mainly arise from the government's concerns regarding the impact of reforms on social stability and potential resistance from subsidy beneficiaries who are not targeted groups. Given the track record of the government, China's subsidy reforms will likely be implemented in a gradual and programmed fashion, together with short-term measures to alleviate the impact of tariff increases on the poor. If reforms reduce the purchasing power of a specific social group, especially the poor, the authorities could introduce compensating measures to maintain their real incomes in more direct and effective ways. For instance, the Chinese government subsidized the taxi and bus fares after fuel oil tax reforms in early 2009. Furthermore, there is a need to communicate clearly to the public the overall benefits of subsidy reforms to get the most support. When considering the overall benefits of subsidy removals, it is a generally false assumption that removals have negative impacts on competitiveness.

The Chinese authorities usually consider the removal of energy subsidies might affect its social policy goals. However, energy subsidies are not the only way to address social issues. Lin and Jiang et al. (2009) have found that low-income households, who accounted for 22% of the total population, only shared 10.1% of the electricity subsidy to the residential sector. However, 9% of the population, comprising of high-income people and who do not need the subsidy, received 18.6%. The poor performance of current electricity subsidies is largely deviated from its policy intention. Therefore, social issues could be better addressed by other measures, such as direct welfare payments or investments in social services. In fact, our results show that redistribution of these subsidies savings has positive impacts on social welfare and macroeconomic variables. It may have greater impact if the government improves the social security system rather than lowering energy prices for the poor. The results of this study also suggest that reallocating subsidy funds to social welfare programs, including network connection, health, education, job retraining and so on, is a better long-term social development strategy. These reforms will not only improve economic growth and employment, but also decrease energy intensity and emissions. This can lessen the apparent conflicts among economy, energy and environment, and promote socially sustainable development, and cost much less than energy subsidies.

Our results indicate that China's energy subsidies are sizable and the reforms of energy subsidies are necessary. As it has been observed, poorly implemented energy subsidies are economically costly to taxpayers and damage the environment through increased CO₂ emissions and other air pollutants. If energy subsidies could not be removed due to justifiable reasons, the redesign of energy subsidies should be carried out, considering the reality of tradeoffs between energy efficiency, social equality and environmental impacts. It is crucial that energy subsidy reforms are not independent, but rather need to be integrated into overall economic and social reforms. For example, financial reforms to improve energy tax mechanisms and social safety nets to protect the poor should be consistent with and complement the reforms on energy subsidies. The policy makers must realize that education and training, health and welfare policies rather than subsidies should be the primary vehicles for addressing social issues. Furthermore, energy subsidies must be transparent and

Table 5

<table>
<thead>
<tr>
<th>Percent change</th>
<th>Welfare</th>
<th>GDP</th>
<th>Employment</th>
<th>Energy intensity</th>
<th>CO₂ emissions</th>
<th>SO₂ emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>-2.03</td>
<td>-1.56</td>
<td>-1.41</td>
<td>-3.56</td>
<td>-7.02</td>
<td>-6.83</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>0.16</td>
<td>0.37</td>
<td>0.53</td>
<td>-2.79</td>
<td>-5.91</td>
<td>-4.83</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>1.52</td>
<td>1.74</td>
<td>2.07</td>
<td>-1.95</td>
<td>-4.73</td>
<td>-3.61</td>
</tr>
</tbody>
</table>
carefully designed to ensure they are not distorted; otherwise they may go to those who do not really need them. China’s energy scarcity and environmental deterioration is obvious, but fear of social instability and unfounded optimism often become excuses for policy short-sightedness.

It is now clear that energy pricing reforms are necessary for China’s economic sustainability. If due to various reasons the Chinese government needs to continue to control energy prices, better designs of energy subsidies are required, including better targeting of beneficiaries to improve energy efficiency and social equity, particularly in a situation where most energy companies are state owned.

The energy subsidies in China are complex. This paper is the beginning of an effort to analyze and propose reforming China’s energy prices and energy subsidies. Due to data limitations, the price-gap methodology has its shortcomings. For example, China has large endowments of coal. According to OPEC, the appropriate benchmark could be the cost of production and this could change the size of China’s energy subsidies substantially. However, given that it is commonly applied, consistent and comparable subsidy estimates will allow us to measure the progress in rationalizing and phasing-out energy subsidies. This study provides estimates of energy subsidies and the impact of removal and reallocation of energy subsidies from an economic point of view. However, for a developing country like China, the removal of energy subsidies needs to take into consideration affordability constraints. For the subsidies that are designed to support the poor to access commercial energy and that do not necessarily lead to wasteful consumption, could be reasonable and therefore, be temporarily maintained. This implies that the reforms of energy subsidies in China are not purely to address efficiency issues, but require social and equity considerations as well.

Several possible extensions of this study would be necessary for future studies. Firstly, we only estimate the net energy subsidies of end consumers, and do not cover the subsidies to producers. A global study for energy subsidies indicate that subsidies provided to end consumers, and do not cover the subsidies to producers. A global study for energy subsidies indicate that subsidies provided to producers of fossil fuels may be in the order of US$ 100 billion per year (GSL, 2009). Secondly, subsidies to other non-fossil-fuel energy sources in China are considerable and have been increasing over time. Thirdly, since a CGE model is static, the policy analysis is still within a comparative static analysis framework. Therefore, improving estimation of energy subsidies and assessing the impacts of subsidy reforms more comprehensively in a dynamic CGE model should be considered in further studies.

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