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China's coal price disturbances: Observations, explanations, and implications for global energy economies

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HIGHLIGHTS

- Since China decontrolled its coal prices, the price of coal has risen steadily in China, accompanied by unusual volatility.
- Relatively high and volatile coal prices have triggered widespread power shortages in China.
- Coal and oil prices have already become, and continue to become, more closely linked globally.
- China's demand will likely drive up global coal prices and make them as volatile as that of other fossil fuels.
- Policymakers should monitor China's economic reform agenda to anticipate and respond to changes in the global energy economy.

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ABSTRACT

Since China decontrolled coal prices, its coal price has risen steadily and been unusually volatile. In 2011 in particular, high coal prices and capped electricity prices in China discouraged coal-fired power generation, triggering widespread power shortages. We suggest that these coal-price disturbances could be symptomatic of a major change in pricing dynamics of global fossil-fuel markets, with increasing correspondence between coal and oil prices globally. Historically, global coal prices have been more stable and lower than oil and natural gas prices on a per-heat basis. In recent years, however, coal prices have been increasingly volatile worldwide and have tracked other fossil fuel prices more closely. Meanwhile, the recent development of unconventional gas has substantially decoupled US natural gas and oil prices. Technically, low US natural gas prices, with potential fuel switching, could drive US domestic coal prices lower. However, this effect is unlikely to counteract the overall trend in increasing coal consumption globally. China's market size and unique, partially-controlled energy system make its reform agenda a key force in the global economy. Policymakers in the US, E.U. and elsewhere should monitor China's economic reform agenda to anticipate and respond to changes accompanying China's increasing importance in the global energy economy.

1. Introduction

Since China began its transition from a planned economy to a market economy in the late 1970s, its importance in the global economy has increased. However, not all sectors in the Chinese economy were simultaneously transformed, nor are they equally open to international trade. The Chinese government maintains control over many strategic sectors considered to be of national interest, such as capital, land, and natural resources, including energy supplies. The market reforms for these sectors have lagged behind the rest of the Chinese economy, although there have been discussions and some plans for reforming them. As China rises in the global economy, its continuing economic reforms will have unforeseen impacts globally.

In order to understand recent coal price disturbances in China, the disturbances must be placed within China's unique economic context, which includes a largely market-driven coal mining sector, suspended reforms in the power sector, and a price-controlled and state-owned, natural gas sector. Coal price decontrols coupled with continued price controls for electricity are causing conflicts between the coal-mining and coal-fired-power industries in China and will likely have impacts in other countries through international trade. Since the early 2000s, China's coal prices have not only been rising but have also become more volatile and more likely to move in step with oil prices. If these trends continue, they will have substantial energy and economic impacts in China, and in the rest of the world, as well.

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In this paper, we examine the Chinese context for energy institutions. We introduce the issue of recent disturbances in the coal and power sectors and discuss the role of coal pricing in China and its relationship to oil and gas prices in China and globally. For ease of discussion, we focus foremost on China and the United States, although many of the implications will likely apply to other countries. For example, Europe and Japan are also major importers of coal and could encounter significant impacts from China's increasing influences on international coal prices.

2. The Chinese context of coal price reform

Unlike the sudden privatizations and price decontrols adopted in many countries of the former Soviet Union and Eastern Europe, China opted for more gradual economic reform. Its reforms were meant to increase the use of market forces, to provide incentives to lower costs, and to reduce the burden of government's administrative control over the economy.

China's economic reforms have tended to take a fairly consistent form. They typically began by allowing producers to sell excess output in a free market, while requiring the same producers to deliver their quota at planned, government-stipulated prices. This approach is called the dual-track system, creating two prices – market and planned – for the same commodity. Over time, the proportion of market-priced output usually increases, compared with planned output. Eventually, the planned portion of the economy becomes insignificant, and abolishing it is fairly straightforward. China's dual-track market reform is largely complete in most of the economy, although coal and natural gas are among the commodities for which market reform is ongoing.

The dual-track strategy has achieved great success in reforming much of China's economy, but it has faced challenges in particular sectors. These sectors tend to be dominated by either governmental entities or large national corporations that benefit from the dual-track arrangement and sometimes work to impede further market reform (Zhang and Heller, 2007). The energy sector is a typical example of a reform that has been hindered in China's transition to a more free-market-based economy.

Market reform for coal in particular began in the 1980s. Before then, the Ministry of Coal was in charge of all coal production in China, with the coal mines often suffering financial losses, or at least low profits, from the 1950s to 1990s. In 1983, the Chinese government implemented a dual price scheme where the coal producers were allowed to sell excess coal output at higher, administratively-set prices, outside the typical within-quota prices. Meanwhile, China also began to allow local governments and private entities to invest in coal mining. In 1984, the price of out-of-quota coal output was de-controlled, initiating a market price for coal in China that continued on a dual-track system for more than two decades. During this period, thousands of local private and public (provincial, township and village) coal mines were established. As a result, the coal industry has become highly fragmented and the coal market highly competitive.

China's decontrolling of coal prices followed a gradual process with contradictory policies. It is difficult to pinpoint a date when price decontrolling was completed. China's central government stopped setting prices for non-electricity-related coal in 1993, but continued to convene annual contract meetings for major coal and power companies, issuing a reference price for electricity-related coal for each year until 2001. Over the past decade, the central government has still attempted to intervene in coal-market prices through mediating contract negotiations, setting temporary price caps, and issuing warnings and directives on price-setting.

Today, the central government owns all five of the major power corporations, whereas provincial governments own most of the large coal mines. Conflicts between coal producers and the power industries are therefore often conflicts between provincial and national interests. Chinese provincial governments enjoy great autonomy in economic affairs and can often resist or negotiate national policies (Zheng, 2007).

During China's gradual process of decontrolling coal prices, numerous market participants and interest groups have been established in the coal sector. Despite the central government's reluctance to completely cease price interventions, its influence has become fairly limited. Not only has the government failed to contain coal prices, it has not always succeeded in securing adequate coal supplies for power generation. Instead of using price-controlled coal to generate power, some companies apparently sell it in the market for profit (He, 2009). In December 2011, the NDRC once again announced a cap on the price of coal to be supplied for electricity generation. Because the cap only applies to coal for electricity, suppliers can sell coal at higher prices to non-electricity-related users. Since then, coal prices have declined, largely in step with oil prices. Whether the government's prices cap has delivered the desired stabilizing effect, or was simply a coincidence, is as yet unknown.

Increases in coal prices have reversed the historical relationship between the coal-mining and electric-power industries in China. The state council announced a policy agenda in 2002 for power-sector restructuring, with an eventual goal to establish competitive wholesale and retail electricity markets. Unfortunately, there has been little progress since 2002. Electricity prices remain administratively set by the NDRC. Before coal prices were decontrolled, the coal-mining industry suffered consistent financial losses or minimal profits, whereas the power sector was profitable. Since prices were decontrolled, the coal-mining industry has become one of the most profitable in China, despite its highly fragmented and competitive nature. In contrast, power generators possess a relative oligopoly but are now consistently losing money (Bai and Chen, 2011b; He and Du, 2011).

3. Coal price disturbances

Coal prices have increased steadily in China since price decontrols began. The price of coal has more than tripled since 2003. Fig. 1 shows China's producer price index from 1990 to 2010 (NBS, 2012).

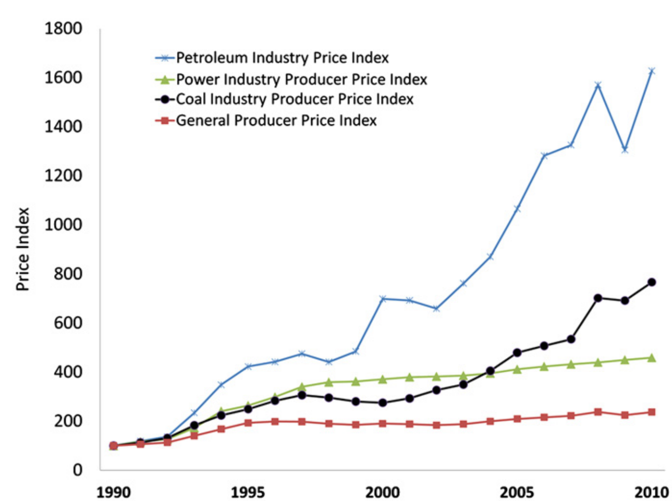

Fig. 1. China's producer price indices overall and for energy-related sectors (NBS, 2012).

In contrast, administratively-set electricity prices have been too rigid to reflect the rising costs of coal and thus have been unable to keep up with rising coal costs in recent years. In response to the power sector's accumulating losses, the NDRC announced a temporary mechanism in 2005 for automatically adjusting electricity prices to reflect the movement of coal prices. This mechanism was suspended after 2006, though, because of concerns over inflation (Chen and Peng, 2009). Burdened with increasing financial losses, China's coal-fired power generators are losing incentives to generate electricity. Most notably, widespread power shortages appeared in 2011, without an obvious shortage of either coal or generating capacity.

Some people in China have blamed speculators for the rapid increase in coal prices (Duan, 2011). The NDRC issued an emergency notice on March 28, 2011 warning against coal price fixing (NDRC, 2011). However, it seems unlikely that the thousands of coal suppliers could collude in price-fixing vis-à-vis the oligopolistic coal-fired electric power industries.

Unlike most economies where coal is predominantly used for power generation, only about half of China's coal consumption is used this way. Incidents where coal-fired generating companies sold their control-priced coal in the open market suggest that high, and volatile, coal prices may be driven by the market equilibrium of supply and demand. The question, then, becomes what is driving up coal prices in such a rapid manner in recent years?.

Compared to other parts of the world, Chinese coal prices are fairly consistent with global prices (Fig. 2) (IMF, 2012; NACEC, 2011; Li, 2010; EIA, 2011c). Furthermore, the juxtaposition of oil and coal prices reveals a similarity in their movements in recent years. This tandem movement is contrary to conventional wisdom, which suggests that coal prices are supposedly more stable than oil prices and relatively uncorrelated with them (Ellerman, 1995). Several reasons may have contributed to the stability of coal prices in the past. First, coal is relatively abundant, and reserves are spread across many countries, compared to the Middle East-dominated abundance of global oil reserves. Second, coal is primarily used for power generation globally, with relatively stable demand, whereas oil is used for transportation and chemical manufacturing, where demand fluctuates more with consumer choices and economic cycles.

The stronger correlation between coal and oil prices is a relatively new phenomenon. Ellerman (1995) examined the relation between coal and oil prices and concluded that "the price of crude oil has not been the primary determinant of coal prices." Fig. 3, however, shows the relatively tight correlation between oil and coal prices in recent years (see Electronic Annex 1 for a statistical analysis of the correlation between coal and oil prices, and Annex 2 for the dataset itself) (IMF, 2012). Since the start of the 2000s, the correlation coefficients between monthly coal and oil prices have been consistently >0.8, a value higher than in any previous period since 1980.

The fact that coal prices have become as volatile as oil prices, and that coal and oil prices now move largely in parallel, deserves careful scrutiny. In the following sections, we attempt to offer an explanation for this new phenomenon and consider possible implications for energy and environmental policies.

4. Possible explanations for a stronger link between coal and oil prices

One possible explanation for the recent coupling of coal and oil prices is that the rapid growth of the Chinese economy in recent decades has shifted the balance of the world coal market. Up until the 1990s, China's coal industry remained largely a separate and protected sector, relatively isolated from international trade (Ellerman, 1995). Price decontrols and market reforms since the 1990s have integrated China's coal market more into the global economy. As a result, China's shares in global coal production and consumption have grown from less than 20% in the 1970s to over half in 2010 (IEA, 2012). China remained a net exporter of coal until 2008. In 2009, China for the first time had a net import of coal and immediately became the world's second largest importer after Japan (IEA, 2012).

China not only depends more on coal for power generation than most other economies do, it also uses coal for more diverse purposes. In the United States, about 92% of coal consumption is for power generation (EIA, 2011b), while only half of coal in China is (Table 1) (NBS, 2011). China has developed an unusually large coal-based chemical industry, which uses coal as a feedstock for products that other countries would produce from petroleum or natural gas (Yang and Jackson, 2012). The non-power coal demand likely has significant influences on coal prices in China. Outside of China, South Africa has the largest non-power coal consumption due to its coal-to-liquid fuel industry. South Africa, however, consumed only about 2.7% of the total worldwide coal produced in 2010, compared to China's 48.1% (IEA, 2012); thus, South Africa's influence on worldwide coal prices is likely small.

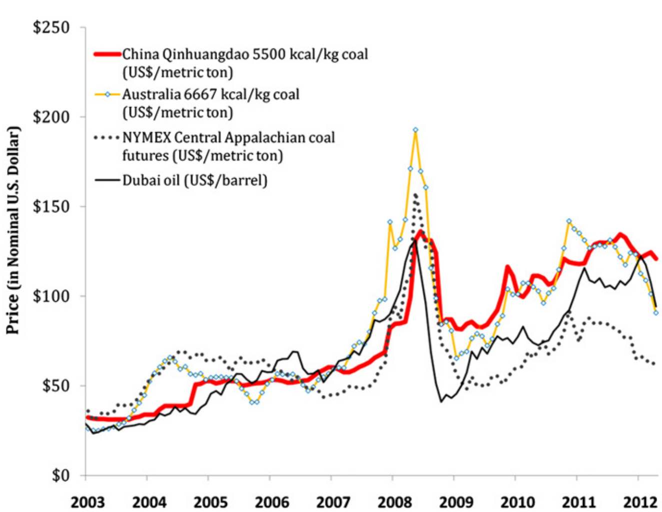

Fig. 2. Price movements of oil and coal (IMF, 2012; NACEC, 2011; Li, 2010; EIA, 2011c).

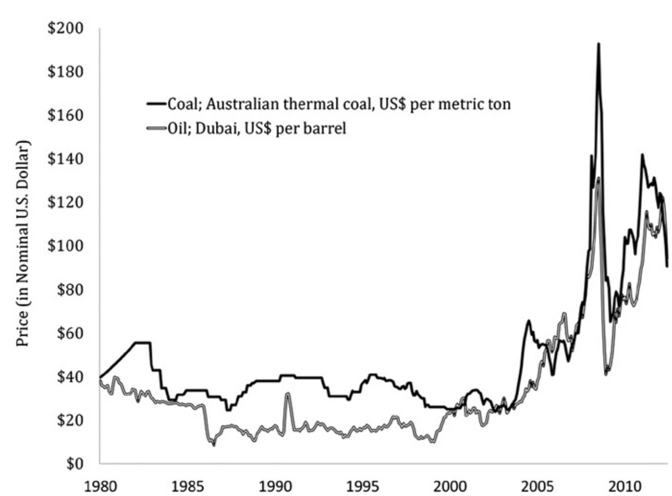

Fig. 3. Coal and oil prices since 1980 (IMF, 2012).

Table 1
China's coal consumption by sector (NBS, 2011).

Sector	(million metric tons)						%					
	2000	2005	2006	2007	2008	2009	2000	2005	2006	2007	2008	2009
Total consumption	**1411**	**2319**	**2551**	**2727**	**2811**	**2958**	100.0	100.0	100.0	100.0	100.0	100.0
Non-industry	**133**	**164**	**166**	**165**	**155**	**159**	9.4	7.1	6.5	6.1	5.5	5.4
Industry	**1278**	**2155**	**2385**	**2562**	**2656**	**2799**	90.6	92.9	93.5	93.9	94.5	94.6
Electric power and heat power	574	1063	1211	1337	1367	1449	40.7	45.8	47.5	49.0	48.6	49.0
Mining and quarrying	115	158	169	190	195	217	8.2	6.8	6.6	7.0	6.9	7.3
Coking, processing of petroleum, processing of nuclear fuel	91	198	229	250	264	272	6.4	8.5	9.0	9.2	9.4	9.2
Raw chemical materials and chemical products	88	129	137	142	151	150	6.3	5.6	5.4	5.2	5.4	5.1
Non-metallic mineral products	138	200	207	204	230	238	9.8	8.6	8.1	7.5	8.2	8.0
Smelting and pressing of ferrous metals	123	213	226	228	241	266	8.7	9.2	8.8	8.4	8.6	9.0
Others	148	194	207	211	207	208	10.5	8.4	8.1	7.7	7.4	7.0

In recent years, the coal-based chemical industry in China has grown rapidly but, because the coal market grew overall in China, its market share did not change (Yang and Jackson, 2012). In Table 1, most of the output from the sector "Raw Chemical Materials and Chemical Products" and some of the output from "Coking, Processing of Petroleum, Processing of Nuclear Fuel" are coal-based chemicals. However, due to the lack of detailed data, we cannot determine how much of the coal-based chemical products are substituting for petrochemical counterparts. Although we know that the coal-based chemical industry is a substantial coal consumer in China, we cannot determine the degree to which the Chinese coal-based chemical industry has contributed to a substitution effect between coal and oil.

In recent years, there has been enthusiasm for investing in coal-based chemical production (Yang and Jackson, 2012). One of the most prominent coal-based chemicals produced in China is methanol, in part used as a transportation fuel. A popular saying in China's coal industry is that by converting coal to methanol, the added value increases four fold; further processing of methanol to olefins and other chemicals increases the added value by eight to twelve fold in total (Xinhuanet, 2011). The cost-competiveness of coal-based methanol versus gasoline as an automotive fuel in China is therefore important to examine, with an eye to understanding why coal and oil prices might have become more closely coupled.

According to an estimate by the US Energy Information Administration (EIA, 2012), the cost of crude oil in the United States accounts for roughly 68% of retail gasoline prices ($2.78/gallon, or $992/metric ton), whereas refining costs and profits account for only 7% (i.e. ~$69 refining cost per metric ton of gasoline), with distribution, marketing, and taxes account for the rest. We lack information for the cost structure of gasoline in China, but the costs of crude oil and refining are likely to be similar in relative terms. Excluding the costs of distribution, marketing and taxes, which are likely country-specific, one metric ton of gasoline in 2010 cost roughly $744 in the United States ($675 for crude oil and $69 for refining). In 2010, the Chinese government's stipulated gasoline retail prices, which supposedly covered all elements of costs and profits, ranged from ¥7990 to ¥8530 ($1170–1284) per metric ton.

An estimate of the costs for coal-based methanol production in China suggests a fairly competitive cost basis compared to oil as a transportation fuel. According to a Chinese study, at ¥800 per metric ton the cost of the coal feedstock would account for about 60% of the cost of methanol. Additionally, 9% of the total production cost is spent on the extra coal burned to supply processing heat, with additional processing-plant costs (water, power, labor, additives, capital depreciation, maintenance, etc.) accounting for an additional 29%, or about ¥714 (~$105) per ton of methanol (Table 2) (Zong, 2008). To replace one metric ton of gasoline would require roughly 1.4 metric tons of methanol, which would in turn require $\$193 \times 1.4 = \$270$ of material coal, $41 of fuel coal, and $146 in processing. The materials, fuels and processing of 1.4 metric ton of methanol in China cost roughly $458, significantly lower than gasoline's cost. Although the processing cost for coal-to-methanol is higher than for refining crude oil to gasoline, the cost advantage of coal over crude oil more than compensates for the difference. The cost-competitiveness of coal-based methanol as an automotive fuel in China seems real. However, coal-based methanol production comes with high environmental costs in terms of water and air pollution, potential soil contamination, and waste disposal. It is unclear if and how China is working to minimize these environmental externalities.

Table 2
Cost structure for coal-based methanol in China (Zong, 2008).

	In Chinese Yuan (¥)	%	In US Dollar ($)
Per metric ton of methanol in China			
Coal feedstock	**1320.00**	60	193
Coal as fuel	**196.00**	9	29
Processing costs	**713.78**	29	105
Additives and catalysts	30.93	1	5
Water	30.00	1	4
Electricity	182.20	8	27
Labor	18.00	1	3
Depreciation	241.98	11	35
Maintenance	158.00	7	23
Miscellaneous	52.67	2	8
Byproduct	**−194.26**	−9	−28
Sulfur	−63.40	−3	−9
Liquid Argon	−20.10	−1	−3
Steam	−110.76	−5	−16
Management	**13.00**	1	2
Finance	**99.84**	5	15
Marketing	**38.00**	2	6
Total	**2186.36**	100	320

Note: US$1 = ¥6.77 (average exchange rate of 2010).

The price gap between oil and coal may partially explain the rapid expansion of China's coal-based methanol use, which is increasingly becoming a substitute for petroleum-derived gasoline. National statistics do not fully account for the coal consumed for methanol production because a significant volume of methanol is blended into gasoline illegally (Wang, 2010). The increasing local substitution between coal-based methanol and petroleum-refined gasoline in China may thus contribute to the coal–oil price correlation.

An alternative contributor to the link between coal and oil prices could come indirectly from the global substitution between coal-fired and natural gas-fired power, primarily outside the

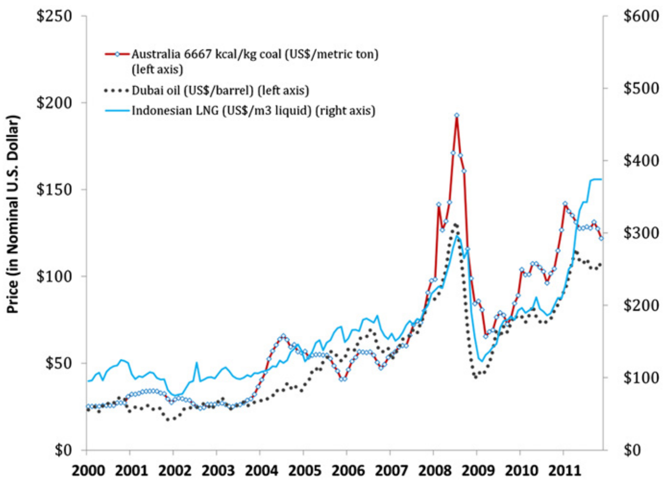

Fig. 4. Movements of Australian coal, Dubai oil, and Indonesian LNG prices (IMF, 2012).

Chinese economy. Although natural gas-fired power accounts for a small share of China's power, coal and natural gas power globally are the two largest competing resources for power generation. In many markets, natural gas contract prices are commonly pegged to oil prices. There has been increased short-term substitution between oil and gas in the United States and Europe since the 1970s, likely because many oil-fired power plants were retrofitted to burn both oil and natural gas in the 1970s (Söderholm, 1999, 2000). Very recently, there has also been more long-term substitution of natural gas for coal for electricity generation, particularly in the United States. Fig. 4 shows the price movements of Australian coal, Dubai oil, and Indonesian Liquefied Natural Gas (LNG) (IMF, 2012).

Although pinpointing exactly what is driving the correlated coal–oil price movements is difficult, coal and oil prices now appear to be moving more in tandem, an observation with important implications for energy pricing and supply.

5. Implications and future prospects

Outside of China, coal is predominantly used for electricity generation. Rising and more volatile coal prices are thus likely to have implications for electricity generation worldwide. Higher coal prices could encourage power companies to pursue fuel switching from coal to other sources, likely natural gas and possibly nuclear energy. The implications of new coal price dynamics, however, must be examined in specific national contexts, particularly those of China and the United States.

Increased coal prices, along with fixed electricity prices, make coal-fired power unprofitable in China and have sometimes resulted in power shortages. The Chinese government so far has been reluctant to increase electricity prices. Instead, it is encouraging power companies to acquire coal mines so they can use the profits from the mining sector to cross subsidize their losses from power generation. This strategy is unlikely to be effective because the integration of coal mining and power generation can neither lower coal prices nor return power generation to profitability in China. Even when coal mines and power plants are managed by the same company, managers still have incentives to minimize the loss-making operation (power generation) of their business. Eventually, the Chinese government will need to raise electricity prices either administratively or through price decontrol, such as establishing a competitive wholesale electricity market.

The possibility of fuel switching is predominantly a political decision in China. Globally, the two major competing energy resources with coal-fired power are nuclear and natural gas; both of these alternatives remain centrally planned in China. China already has a long-term plan to deploy nuclear power, but nuclear projects require years of planning and construction. Because of the recent Fukushima accident in Japan, Chinese policymakers have also become more cautious about ramping up nuclear deployment. A rapid switch from coal to nuclear power in response to rising coal prices is unlikely in the near future.

China's natural gas sector is another planned sector of the economy. Only a few national oil and gas corporations are allowed to explore for natural gas in China, and no local government, private company, or foreign investors are allowed. The NDRC administratively sets natural gas prices. Price controls, restricted access to mineral rights, and rationed markets have reduced commercial interest in developing natural gas resources in China. Additionally, prior to 2005 the Chinese government adjusted natural gas prices only irregularly, typically only once every few years. The controlled prices are also fixed on a nominal Chinese Yuan value, meaning that the real, inflation-adjusted prices of natural gas will in fact gradually decline after each price adjustment. In the past, each price adjustment/increase was followed by a new round of exploration and discovery, which then gradually declined. These policy-driven exploration cycles indicated that the scarcity of natural gas in China may be partly a result of regulatory failure (Zhou, 2008).

Based on the historical precedent of China having limited natural gas resources, the Chinese government appears cautious about natural gas pricing reform and is proceeding slowly to avoid large impacts, such as price hikes, on residential and industrial users. Nevertheless, with an increasing gap between supply and demand, China will likely decontrol natural gas prices gradually. In December 2011, China initiated a new pricing scheme for natural gas in two provinces, Guangdong and Guangxi, a major breakthrough in its natural gas reform (Bai and Chen, 2011a). How quickly – and if – this breakthrough will lead to a broader reform is difficult to predict. The planned nature of the gas sector suggests that the future of natural gas markets in China cannot be predicted based solely on economic and technical principles. Chinese politics and policymaking play an important role.

After the most recent price adjustment on June 1, 2010, natural gas is priced in the range of US$3.0–6.2 per GJ in China (NDRC, 2010). For comparison, the prices of imported Indonesian LNG in Japan, a common reference price for natural gas prices in East Asia, ranged from US$8.1 to US$9.2 per GJ in 2010 (IMF, 2012). The centrally controlled Chinese natural gas prices are therefore significantly lower than the prevailing market prices in the broader region. Although Chinese natural gas prices are comparable to or cheaper than coal prices in recent years, natural gas is unlikely to compete with coal in power generation because power generators have little access to natural gas resources as a fuel.

Imported natural gas is also subject to price control in China. Natural gas importers are required to sell at government-set domestic prices, which are typically below cost. The state-owned importers fulfill their political mission of gas imports by accumulating financial losses. The loss-making nature tends to make China's natural gas import market politically driven and unpredictable.

As of 2010, China had only 28 GW of installed gas-fired power capacity, representing 3% of its total capacity. The Chinese power system relies on coal-fired generators for both base-load and peak-load electricity. Coal-fired generators are far less efficient in serving peaking power than gas turbine generators are. The efficiency gain in replacing peaking coal-fired capacities with gas-fired ones may help compensate for the price difference between natural gas and coal. Furthermore, gas-fired power has several other advantages, including reduced air emissions, cooling-water consumption, capital investment, and construction times. Government controls on the natural gas sector have nonetheless largely prevented China from enhancing its gas-fired power capacity. However, Chinese economic planners are starting to appreciate the merits of gas-fired power, in part due to recent public attention in Beijing on air pollutants such as $PM_{2.5}$ (fine particulates less than 2.5 μm in diameter) (Page, 2012). High coal prices and coal-fired power shortages that resulted might also have encouraged policymakers to consider gas-fired power. The city of Beijing recently decided to replace all its coal-fired power plants with natural-gas-fired ones. Other cities may follow Beijing's example. In its 12th five-year plan (2011–2015), China plans to expand its gas-fired capacity to 60 GW, which would increase gas-fired power's share to 5% of total power capacity in 2015.

Recently, inspired by the success of the United States for shale gas development, the Chinese government is trying to encourage shale-gas development in China. The Ministry of Land and Mineral Resources officially announced that it will categorize shale gas as a new and independent resource rather than as a sub-category of natural gas (Bai and Chen, 2011a). By designating shale gas as "different" from traditional natural gas, Chinese policymakers are exempting shale gas resources from the ineffective regulatory system for natural gas, which has several important consequences. Private and foreign investors may be allowed to explore for shale gas in China. The Chinese government has also indicated that it will liberalize wholesale prices of unconventional gases, including shale gas, so that these energy sources will not be subject to the price controls of conventional natural gas (Bai and Chen, 2011a). Because shale gas will be treated as a market commodity, unconventional gas resources are likely to be developed before conventional natural gas resources are. Overall, and over the long term, shale gas could become a significant replacement for coal in China.

In the long-term, the Chinese demand for coal could have large impacts on the US coal market. Coal-fired generators in the US typically purchase coal under long-term contracts, often for 15–30 years. Such long-term contracts help stabilize power generators' costs and have caused the movement of electric coal prices to lag behind the spot market. However, over the long term, we expect contract prices to converge toward the same long-term direction as the spot market. Fig. 5 show the recent movements of US utility electric coal prices and the near-month settlement price of Central Appalachian coal futures on the New York Mercantile Exchange (as a selected proxy of spot-market coal prices) (EIA, 2011c). The US spot-market coal prices have largely moved in tandem with coal prices in other markets (Fig. 2). The utility contract prices are more stable but are also gradually increasing each year.

The tandem movement of coal and oil prices is relatively new, under-appreciated, and, therefore, not typically reflected in price projections. Fig. 6 shows per-heat-value prices of major fuels in the United States as well as the US Energy Information Administration's projections for energy prices (EIA, 2011a,b,c). The projections appear to follow the conventional wisdom that coal prices will be stable and fairly low over the long term. However, if the observed tandem movements of coal and oil prices continue, a very different scenario is possible, with coal prices rising rapidly and becoming more volatile.

Another interesting new development in the energy market is the recent decoupling of natural gas and crude oil prices in the United States (Bock and Gijón, 2011). If this decoupling continues, and if coal and oil prices become increasingly coupled, we may expect coal prices to match or even surpass natural gas prices on a per heat value basis in the near future in the United States. If that happens, the competitiveness of coal-fired power will be dramatically diminished in the United States. Coal-fired power plants typically are more capital intensive, tend to be less flexible in ramping up and down production, consume more water resources, and emit more air pollutants than gas turbines, and have large volumes of boiler ash and fly-ash to contend with. The major advantage of coal-fired over gas-fired power has traditionally been cheaper fuel costs. In the coming years, we may see the long-term competitive edge of coal prices disappear in the United States—if natural gas prices stay as low as they are now, which may itself be unlikely in the long term. Unlike China, the US natural gas price is market-driven and the power industry is dominated by private companies. Replacing coal-fired with gas-fired power will be far easier in the United States than in China.

The US nuclear power industry has remained largely static since the 1980s. Rising coal prices may encourage companies to pursue new nuclear power projects. For example, the US Nuclear Regulatory Commission has recently approved a license to build two reactors in Georgia, the first new nuclear reactors to be built in the United States in decades. However, with uncertainties

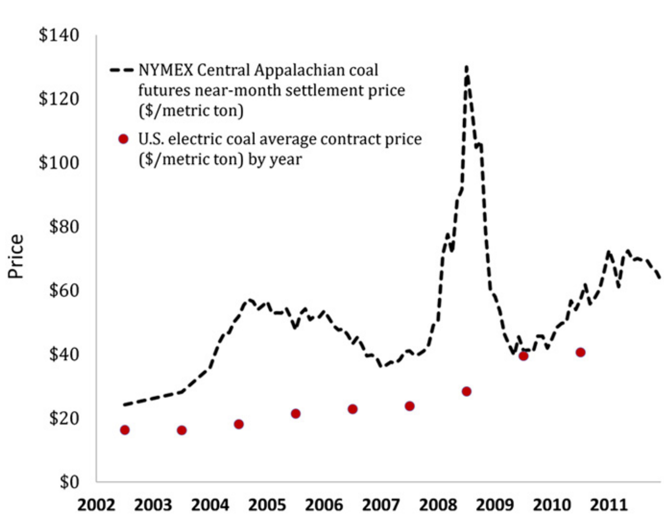

Fig. 5. US spot market and utility contract coal prices (EIA, 2011b,c).

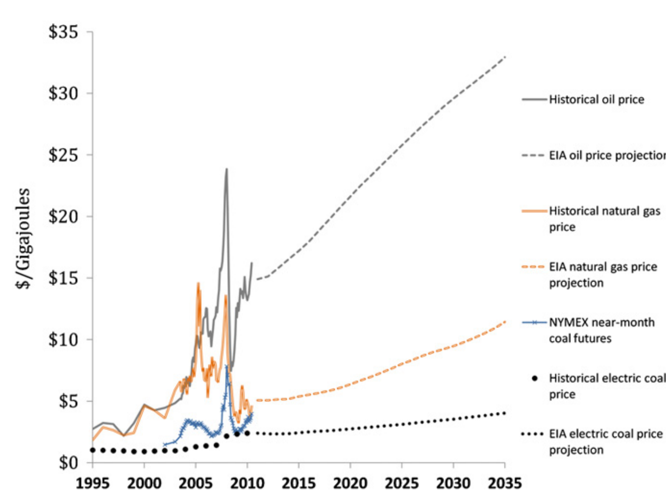

Fig. 6. Major fossil fuel prices and projections of future prices in the United States (EIA, 2011a,b,c).

for potential cost overruns and public opposition, large-scale switching from coal-fired to nuclear power appears unlikely in the United States (Yang, 2011).

Certainly, the cost of fuel is only part of the equation in determining the cost of power generation. The majority of coal-fired power plants are >25-years old, and their original capital investments are mostly fully depreciated. If a utility company builds a new gas-fired generator to replace an existing coal-fired power plant, whose capital cost has been fully depreciated, the advantages in fuel cost alone may not be enough to compensate for the additional capital costs. However, new coal-fired power would become uncompetitive if natural gas is priced similar to, or lower than, coal on a per-heat-value basis.

Reversed price competitiveness between coal and natural gas would have many implications for environmental policy. Currently, most of studies on carbon capture and storage (CCS) are focused on coal-fired power. With natural gas prices potentially similar to or lower than coal prices, requiring CCS on coal-fired power may simply cause the utilities to replace coal-fired power with gas-fired power. Policymakers may also choose to devote more attention to the feasibility of capturing carbon from gas-fired power.

International coal prices in recent years have been several times higher than the prices US utilities are paying. Increased coal exports from the United States may significantly increase its domestic coal price, although reduced US demand could counterbalance this trend. US coal producers are already seeking to export to China. There are controversies on coal export-terminal proposals on the west coast of the United States. Although local opposition may delay or even stop some coal export proposals, the overall trade of coal is unlikely to cease. US coal exports to China would likely narrow the gap between US domestic coal prices and international prices.

The impacts of rising coal prices would manifest themselves differently depending on institutional contexts. Parts of the US power sector have been restructured into competitive wholesale markets, with the rest remaining regulated by state/public utility commissions. In the restructured regions, market mechanisms could adapt to higher coal prices and reach a new equilibrium, likely with higher electricity prices and less coal-fired generation. In regulated states, the utility commission may expect more requests for rate increases in the coming years, a process that is often politically charged and sometimes unsuccessful. If US coal prices increase quickly in the coming years, we could see disturbances in the regulated power sectors in the United States, similar to what China is experiencing today.

Because of China's controlled natural gas sector, the prospect of US natural gas exports to China is more difficult to predict and would depend greatly on Chinese policy. If China continues to set imported LNG prices below the importers' costs, US LNG exports to China are unlikely to be commercially viable. China's reform agenda for its natural gas sector will thus have profound implications not only for China, but also for the United States and elsewhere.

6. Conclusion

China's economic expansion and rising energy use are fundamentally changing the global energy economy. The unique structure and institutions of China's partially market-driven and partially planned energy system may distort the global energy economy and energy prices in unusual ways. China is moving broadly toward deregulation and greater free-market policies, but how and how soon the Chinese government implements its reforms will have short- and long-term global impacts. For example, China's volatile coal prices and power shortages may appear to be largely domestic issues for China, but their consequences are likely to be felt globally if Chinese coal imports increase rapidly.

Understanding China's unique institutions and politics is increasingly necessary for decision-makers in governments and industries worldwide. Policymakers should pay close attention to China's development and reform agenda to anticipate and respond to upcoming changes in energy use and pricing. Failing to do so will mean ignoring important trends in the pricing of supply and coal and natural gas.

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Appendix A. Supporting information

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