A GREEN ACCOUNTING OF COAL PRODUCTION IN CHINA

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INTRODUCTION

Gross domestic product (GDP) is a measure of production, not of what is available for consumption. If a country were to (over time) consume all of GDP, there would be nothing left with which to rebuild factories, replace machinery, build infrastructure, etc. The economy would be driven into the ground. Despite this, growth of GDP is traditionally used to measure the strength of the economy. It is a deceptive measure of policy. It cannot be seen as an all-encompassing indicator because it only measures production.

Net domestic product (NDP) attempts to correct this by subtracting out the depreciation of equipment and facilities from gross investment (a component of GDP). The question then becomes, can we consume NDP over the long term and sustain the economy? (Daly, 1996) It is a leading question and, obviously, the answer is no. What NDP does not take into account is the depletion or use of natural resources or even human capital, social situation, or living standards.

The current focus of research on integrating environment into national accounts is overly concentrated on adjusting GDP. The United Nations has even developed a framework for calculating an environmentally adjusted GDP measure called EDP (environmentally adjusted net domestic product). This methodology has been applied to Mexico, Thailand, and Papua New Guinea, with many difficulties emerging. There have also been a plethora of industry-specific case studies that have been met with strong criticism and have probably over-estimated impacts because of faulty accounting procedures.

The purpose of this paper is to explore the usefulness of estimating the growth of the coal industry in China with and without considering environmental costs of production and to discuss whether the current methodology is sufficient. This is not only an attempt to calculate environmental damages and money spent on damages, but also an analysis of what the indicator adds to the knowledge of the industry.

CHINA'S COAL INDUSTRY

Coal is the main source of energy in China, comprising approximately 70 to 75 percent of China's primary energy output since 1975. (SETC, 1996) Three-quarters of the coal mined in China is bituminous, 4% is lignite, and the rest is anthracite. Two-thirds of the bituminous coal is coking coal, though only a fraction is used as coking coal. (Sinton, 1996) The average heat content of Chinese mined anthracite is 26.5 MJ/kg. Bituminous coal ranges from 22.3 to 29.6 megajoules per kilogram (MJ/kg). (Sinton, 1996) Lignite is a low energy type coal.

State-owned mines in China concentrate on developing higher-grade coals. Bituminous coal accounts for about 75 percent of annual production and anthracite most of the rest. (USDOE, 1997) All of the large state-owned mines are located in northern China, particularly Shanxi Province. Shanxi Province contains most of China's easily accessible coal. Southern types of coal tend to be higher is sulfur and ash, and therefore unsuitable for many applications, particularly in-home use. (USDOE, 1997)

Structure of the Coal Industry

Small, collectively, and individually owned mines have been allowed and even encouraged by China's central government since the early 1980s. New rural mines account for over 40 percent of output and 70 percent of the total growth in output. Output from state-owned mines has declined, (Sinton, 1996), although state-owned mines account for 45 percent of nationwide production. Collective or private-ownership mines as well as some state-owned mines operate at the provincial, prefectural, or county level. (USDOE, 1997) State-owned mines are controlled by the Ministry of Coal Industry, which allocates coal production quotas and coordinates production activities for state-owned mines.

Government Policy

Development of China's natural resources is hindered by the country's bureaucratic and legal structure, underinvestment, poor infrastructure, illegal activities, and the lack of market incentives. Ironically, these same conditions have hampered the development and use of environmentally friendly or clean technology. China's current five-year plan (1996-2000) states China's commitment to stabilizing output in the eastern part of the country and developing mines particularly in Inner Mongolia, Shanxi, and Shaanxi. Amendments to China's Mineral Resources Law that went into effect in January 1997 provide a legal framework for exploration and exploitation of coal resources. The hope is that the framework will encourage foreign investment in the coal industry. The goal of the current five-year plan is to increase total output to 1.4 billion tons by 2000. (USDOE, 1997) This includes accelerating the development of clean technology, but primarily emphasizes new mines. Coal prices have been deregulated since January 1994.

As part of the five-year plan, the government has also announced mergers between several of the major coal-mining companies. The government of China hopes this will create more efficient and competitive mining companies, and, as an added benefit, increase exports. The government also plans to open at least 300 coal projects to foreign investment. Priority is given to coal mining projects related to power plants (the largest consumer of coal) and transportation facilities (the biggest bottleneck to providing energy in the country). (Liboiron, 1997)

In 1994, the Old Mining Law was revised. Detailed implementing rules were issued expressly permitting foreigners to conduct exploration and mining projects in China as partners with Chinese companies. Wholly foreign owned businesses are prohibited. Investments over USD 30 million must still be approved by central government authorities; investments of less than USD 30 million must be approved by provincial authorities. (Liboiron, 1997)

In the 1980s, underinvestment in the coal and energy sector led China to become a net importer of coal. Since then, China has tripled its coal exports and it is currently a net exporter of coal. Part of the expansion has been facilitated by building coal washing, rail, and port facilities. This has allowed the industry to transport high quality coal to ports for export. Japan is China's most important customer. The Japanese have provided loans for railroad and port improvement. Both North and South Korea are also large customers of Chinese coal. (USDOE, 1997)

Economic Problems of the Coal Industry

Underinvestment in the coal industry in the 1980s is responsible for many of the economic and environmental problems in the industry today. The underinvestment is partly due to very low controlled coal prices. Controlled prices, lack of transportation (due to underinvestment in the transportation system), and lack of economic incentives to mine coal efficiently contributed to coal shortages that began in the late 1980s. During this period, many power plants and factories were unable to operate at full capacity, leading to electricity shortages. (Sinton, 1996)

Small amounts of investment for updating equipment (as opposed to investment in opening up new mines) have led to reductions in suspended particles in China. However, for another significant environmental gain, more money must be invested. At this time, the cheap and no-cost methods of reduction have been incorporated. What is left are expensive scrubbers and new power plants and transportation infrastructure. In addition, no reclamation activities have currently been completed. These multi-million dollar activities are normally financed by the government or a donor agency. In the United States, this money comes from a tax placed on coal to fund old-mine reclamation. New mines are the liability of the mining company that owns them.

Table 1: Increased Production Capacity of State-Owned Enterprises, 1981-1990

Coal Mining and Coal Washing (Mt/yr)	Capital Construction Investment Return	Technical Updating Investment Return	Total Suspended Particulates (mg/m^3)
1981	15.98	4.33	703
1982	10.75	7.65	729
1983	26.27	5.38	600
1984	29.35	5.91	660
1985	23.13	5.28	590
1986	34.35	6.03	570
1987	32.76	4.66	590
1988	37.47	3.01	580
1989	48.05	6.51	432
1990	35.17	4.84	379

Source: Sinton, 1996.

In 1990, it was estimated that 30 percent of energy from coal could be saved by raising prices to market levels. (World Bank, 1994) In 1994, prices were deregulated. The major issue in estimating costs and revenues of China's coal industry is the fact the prices were set by the government until 1995. This causes major distortions in revenues from selling coal, government expenditures on coal, and estimates of depreciation of capital and natural stocks.

Table 2: Price Comparison: China vs. U.S. Market for Coal, USD/metric ton

	1985	1991	1992
U.S. — cost at mine mouth	$68.00	$40.60	$38.10
China — cost at mine mouth	$5.00	$9.58	$10.52

Source: U.S. data from WDI, 1997; China data from China Energy Databook, 1997

Most coal is consumed by electric power generation. Because most coal (or at least the high-energy, low-sulfur coal) is located in the north and the main economic areas are located in the south, regional imbalances occur between coal supply and demand. This necessitates the transportation of large quantities of coal.
Coal is the freight industry's largest account. Over 50 percent of the coal is shipped by rail and a large percentage of the rest is shipped by barge. Transportation is by far the coal industry's biggest bottleneck. Possible solutions to the transportation problem could include alternatives such as coal pipelines, liquification, and coal-by-wire. (USDOE. 1997)

Only 12 to 30 percent of Chinese coal is washed and, therefore, most of the coal transported contains relatively large amounts of waste material. Transportation of large amounts of waste materials taxes an already overburdened transportation system. Investment in coal washing has been overlooked. This means more burden on the transportation system, less end-use efficiency, and higher emissions. (Sinton, 1996)

Environmental Damage Associated with Coal and Coal Mining

China currently emits 694 Mt of carbon dioxide (carbon weight), accounting for 11 percent of worldwide emissions (1991), and is the third largest contributor of anthropogenic carbon dioxide emissions in the world. If growth of China's coal-dominated energy system is allowed to continue on the same trajectory, China will become the world's largest emitter of carbon dioxide early in the next century. China would then have the distinction of being the single largest contributor to global greenhouse gas emissions. (Sinton, 1996)

Like all fossil fuels, coal produces CO_2 when burned. However, burning coal has two more damaging side effects: the production of sulfur dioxide and ash. Sulfur content in coal can be as high as 5 percent (by weight) in the form of pyrite (FeS_2). Sulfur gases are produced when the coal is burned, notably SO_2. This gas is not only poisonous and damaging to eyes and lungs, but also reacts with water to form sulfuric acid. This creates acid rain and acidic soils and runoff in the areas near where the coal is burned. Low-sulfur coal is not always available. However, sulfur gases can be trapped by "scrubbers" in exhaust stacks, but this process requires a significant investment.(Montgomery, 1997)

Sulfuric acid is also produced during the mining processes when FeS_2 is released from the rocks surrounding it, reacts with water in the soil or in a nearby stream, and produces sulfuric acid. The sulfuric acid kills surrounding plants and aquatic life in any nearby streams. (Montgomery, 1997)

Direct Links Between Energy and Environment:

Water pollution

Since mining began at Shengmu (Shaanxi Province), Zhungeer (Inner Mongolia) and Fugu (Shanxi Province), 119 million tons of silt per year are dumped into the Yellow River. (Ning, 1996) This silt contains toxic metals and sulfur compounds such as sulfuric acid.

Environmental accidents

The number of mining deaths in China is appalling: more than four deaths per million tons of coal mined. Death rates range from 5.1 per Mt in small rural mines to 3.6 per Mt in centrally administered mines. The average for most developed countries is 0.1 deaths per Mt. (Sinton, 1996)

Land use and siting impact

China produces over 300 million tons of tailings each year. In 1989, this represented 30 percent of the total solid waste generated in China. Approximately 2,000 hectares/year are swallowed by this increasingly large problem, costing the industry 10 billion yuan (1.2 billion USD) in maintenance, power consumption, and wasted resources. Four billion tons of open-air mine tailings present a huge threat to air, water, and soil. (SEDAC, 1997)

Solid waste disposal

Coal also produces a great deal of solid waste called ash. This residue is typically 5 to 20 percent of the original volume. Ash contains noncombustible silicate minerals and toxic metals causing air and water to be contaminated with metals. The magnitude of the waste-disposal problem is huge. (Montgomery, 1997) No data on disposal of this ash is available for China.

Hazardous air pollutants

Coal accounts for 90 percent of So2 emitted, 70 percent of NOx emitted, and 73 percent of dust particulates released. Environmental fees have been used as a disincentive for many years; however, up until 1995, all environmental fees on emissions were fed back to the industry as a direct subsidy. The net effect is that there were no fines until recently. Now, enforcement of the regulations in light of China's corruption problems is the issue.

Ambient air quality

Indoor air pollution is believed to cause 111,000 premature deaths each year in rural areas. No data exist for the number or percentage of homes that have levels over the official Chinese standards.

Table 3: Indoor Air Pollution Attributed to Coal Burning in the Home

Pollutant	Rural Households	All Households
Total Suspended Particulates	0.21-2.8	0.01-20
Carbon Monoxide	0.58-97	0.70-87
Sulfur Dioxide	0.01-5.8	0.01-23
Nitrogen Oxides	0.01-1.8	0.01-1.7
Benzo(a)pyrene*	0.3-190	5.3-19000

*Benzo(a)pyrene is a proxy for a class of combustion products, polycyclic aromatic hydrocarbons (PAHs), many of which are known carcinogens.

Source: China Databook, 1996.

Urban residential use of raw coal has been declining due to the increased production and use of coal briquettes. Regular statistics are not available on briquette production, but evidence indicates that production rose from 37 Mt in 1990 to slightly over 50 Mt in 1993. (Sinton, 1996) Use of these briquettes is cleaner and more efficient than use of raw coal. However, ambient air quality inside homes is still lower than WHO standards.

Acid deposition

Acid rain is estimated to have reduced crop and forestry productivity by 3 percent in China, and it threatens to damage another 10 percent of land area. Burning coal is the major contributing factor to acid rain. The Chinese government has estimated that the area affected by acid rain increased from 1.75 to 2.8 million square kilometers China between 1985 and 1993, which is approximately one-third of total land area in. (Sinton, 1996)

Mining of high-sulfur coal has been banned in areas where acid rain is a severe problem by China's Atmospheric Pollution Control Law of 1987. These problem areas cover only 11.4 percent of China's total land area; more than 30 percent of China's land area is affected by acid rain.

Stratospheric ozone depletion

China is the third largest emitter of CO_2. Most of this (approximately 75 to 80 percent) is due to coal burning. Methane release, which occurs during the mining of coal, is also a serious problem though little hard data exist. (World Bank, 1994)

REVIEW OF THE U.N. METHODOLOGY

Many articles have been written on methods of calculating GDP with environmental concerns factored into the accounts (see e.g., Vincent, 1997; Hanley, et al., 1997; Milon, et al., 1995; BEA, 1994; Dorfman, 1997). In general, the idea is that depreciation of capital, depletion of a natural resource, and residual environmental damage should be subtracted from GDP.

The Statistical Division of the United Nations (UNSTAT) has developed a methodology for a system that integrates environment and economic accounting. The objective of the accounting system is to address the “flaws” of conventional national accounts. The system approaches the problem by separating flows and stocks, environment and economic accounts, then summing up each of these “modules” into the environmentally adjusted national account, EDP. (Milon, 1995)

Table 4: System of Integrated Environmental and Economic Accounts (SEEA) Model (Bartelmus, 1995)

Opening Stocks (economic + environmental assets)

+

	Domestic Production	**Final Consumption (households, governments)**	**Capital Accumulation Economic**	**Capital Accumulation Environmental**	**Rest of World**
Supply of Products (goods and services)	Output (O)				Imports (M) Imports of residuals (-Rm)
Use of Products (goods and services)	Intermediate consumption (IC)	Final Consumption (C)	Gross Capital Formation (CF)	Environmental accumulation (ACCe)	Exports (X)
Use of Fixed Capital (capital consumption)	Depreciation (D)		Depreciation (D)		
Value added (VA)/NDP	VA = O–IC-D NDP = ΣVA				
Use of Natural Assets (depletion and degradation)	Environmental costs of industries (ECi)	Environmental costs of households (ECh)	Environmental disacumulation (EC)		Exports of residuals (-Rx)
Environmentally adjusted indicators	EVA = VA – EC EDP = Σ(EVA-ECh)		ACC = (CF – D) + (ACCe – EC)		

+

Other volume changes, evaluation, adjustment, revaluation

=

Closing stocks (economic assets & environmental assets)

EDP = O – IC – D – EC = C + ACC (net) + (X - Rx) – (M – Rm)

Where ACC (net) = (CF – D) + (ACCe – EC)

This system is more complicated than most of the systems proposed in the literature mainly because it was created with the aim of providing information on linkages between economic production and natural systems. It is not strictly intended for use as an improved welfare measure. (Vincent, 1997)

Review of the literature provides several simplified versions of the above. The basic formula is as follows:

EDP = NDP – EDD – RES

Where NDP is net domestic product (GDP minus capital depreciation), EDD is environmental degradation and depletion (basically, depreciation of natural capital stock), and RES is residuals emitted or discharged that damage the environment.

Combining the above equation with the U.N. framework, the following can be written (Bartelmus, 1995):

EDP = O – IC – D - EC which equals

EDP = C + ACC(net) + (X - Rx) - (M - Rm)

where ACC(net) = (CF - D) + (ACCe - EC)

In other words: EDP = Value of final consumption – value of environmental damages of flow type + value of net change of all stocks. (Kristrom, 1995)

In some ways, this is an easier concept to understand because the first two terms in this equation are flow and are concerned with current welfare. The last term is a stock and is concerned with future welfare.

The overall concept is complex. The problem is in estimating environmental stocks and flows in an economy or industry with regulated or non-market prices.

The China Scenario

The Chinese government is beginning to recognize the value of environmental protection and that environmental degradation costs money. In an *Atlantic Monthly* article, Li Yining, one of the architects of China's transition program, is quoted as saying: "'inadequate ecological protection' was one of the few things that could prevent China's economy from growing at 10 percent a year 'for a very long time.'"(Hertsgaard, 1997)

The World Bank (1997) estimated environmental damage from both air and water pollution to be at least $54 billion a year. This figure is approximately 8 percent of China's annual GDP.

A variety of other estimates exist as well. The official newspaper of China's Communist Party, *China Daily*, has estimated the annual cost of China's environmental problems as 7 percent of the gross domestic product. Assuming the government tends to publicly underestimate such costs, this would seem to be the lower end value of the possible range. On the high end of the range, Vaclav Smil, a leading expert on China's environment, has estimated the cost at 10 to 15 percent of GDP. (Hertsgaard, 1997) A range from 7 percent of GDP to 15 percent of GDP means that growth rates where environmental concerns are taken into account would have low or negative values over the last 20 years.

Industry Level Analysis – Coal Industry in China

Using the same type of analysis described above, but at an industry level, a value-added indicator can be constructed.

EVA then becomes:

EVA = Value of final consumption – value of environmental damages of flow type + value of net change of all stocks, both economic and environmental. (Kristrom, 1995)

Following the adjustments listed above for national accounts, gross domestic product of coal can be transformed into environmentally adjusted domestic product for the coal industry.

Table 5: Components Included in Modified Coal Accounts

Change in Stocks	Value of Environmental Damages (flow type)
Capital stock depreciation	CO2 exported
Resource stock depletion	SO2 exported (Acid Rain)
Land stock lost	Particulates exported
Water stock damage	
Health stock reduced (respiratory damages)	

DATA AND CALCULATIONS

Different Types of Valuation: Market, Maintenance, and Contingent

Past SEEA case studies used three types of valuation techniques to try to put a dollar value on health and environment: market, maintenance, and contingent valuation techniques. Market valuation only covers goods that claim a monetary value in the marketplace. Contingent values are based on willingness to pay by households. Maintenance costs are those "costs of using the natural resource which would have been incurred if the environment had been used in such a way that its future use had not been affected at all or, at least, if environmental uses would have complied with widely accepted standards." (Bartelmus, 1995)

A combination of these techniques is used to calculate environmental costs.

Data and Estimations for Flow of Environmental Goods/Damages

This paper leaves aside the question of human capital in the sense of education and worker safety. It focuses on adding natural capital and natural capital depreciation only. In some cases, human capital and natural capital overlap in the sense that pollution causes health problems. For the purposes of this paper, the cost of health problems will be considered a cost associated with residuals (or emission flows) from the inefficient use of natural capital.

CO_2 was not included in the calculations of EVA because the damages caused are not fully understood. The valuation of global warming is, for now, impossible because cause and effect relationships cannot be stated with confidence. There is also a problem with positive and negative aspects of global warming. Increased farmland due to a milder climate would be a positive aspect, economically speaking. Negative aspects could include severe weather, which causes millions in damages, or out breaks of diseases that were previously kept under control by cold winters.

SO_2, NOx, and particulates have health ramifications that can be measured in terms of lost income to families. Three diseases are highly correlated with air pollution: lung cancer, pulmonary heart disease, and chronic bronchitis. These are not necessarily the only diseases, but they are the diseases that are most likely to be caused by pollution. Incidence of these three diseases above the natural rate of occurrence in China, multiplied by days lost, population exposed, family days lost, and hospital costs, provides a rudimentary estimation for air pollution (flows) each year.

$$H = P \{ Y [S I_i*(L_i + F_i)] + (S I_i*M_i) \}$$ [1]

where H = health costs associated with air pollution
i =lung cancer, chronic bronchitis, pulmonary heart disease
P is the population exposed to air pollution in millions
Y is per capita income (yuan)
I is the incidence of disease in polluted areas above the natural incidence of the disease
L is the average annual loss of labor of the patient
F is the average annual loss of labor by the family members who take care of the patient
M is the average medial expense in yuan per year for each disease

Stocks of Environmental and Capital Goods

Estimates of capital depreciation were originally based on rates of U.S. coal mining companies because China's data were not available. The estimates for capital depreciation were compared to trends in investment and output as well as supply and demand. In the 1980s, underinvestment led to a decreased supply of coal due to the dilapidation of the industry's capital stock. These depreciation estimates were found to be appropriate when compared to the time span and so the estimates were not adjusted. It could be argued that machinery breaks down more rapidly due to the lack of spare parts in China and, therefore, the depreciation rate should be higher. However, the opposite can be argued. The fact that China has less equipment does not change the depreciation rate since the rate is a percentage. The best approximation was 8 percent of capital stock. While this is an imperfect estimate, no other estimates exist.

Calculating the depreciation of China's coal reserves is also a tricky issue. "Depreciation" is defined as the "negative of the change in asset value of the stocks." (Vincent,1997) The asset value is based on future market prices.

Current asset value = Current resource rent + Asset value next period/(1+i)

where i is the discount rate.

Based on this,

Depreciation = Current resource rent – i x Asset value next period/(1+i)

(Vincent, 1997)

In order to calculate an estimate of depreciation of coal reserves, the assumption had to be made that the government-regulated price reflected the resource rent. In other words, the subsidies given to the coal industry covered costs of production. Otherwise, no estimate of depreciation can be made. Also, the discount rate is based on the Chinese system of banking, which is not market based. This distorts the true discount rate. The official rate is most likely lower than the market rate, but depends on the government's current policy. These estimates were based on past data, making the asset value for the next period easier to calculate than for future time periods.

The depreciation of land stock was based on the following data as reported by the Chinese government. (SEDAC, 1997) State-owned, collective and individually owned mines discharge 300 million tons of tailings each year, representing approximately 30 percent of all solid waste (1989 figures), 2000 additional hectares are used each year for disposal of tailings, and a total of 4 billion hectares contain the stockpiles from mines (1995 figure). These stockpiles cost 10 million yuan (1.2 million USD) per year in maintenance and wasted resources. Because land does not have a market price in China, these effects are difficult to price. However, if it is assumed that the government subsidizes the costs of production other than land, then by using the government-regulated price for grain, an estimate of value lost can be made (Xia, 1996):

Value of grain lost (kg) = Market price of grain (yuan/kg) x Lost grain output (kg)

Yields per hectare are approximately 21,300 kg (NEPA) and the government regulated price in 0.32 yuan/kg in 1985. The 2,000 hectare per year that are affected by tailings give a lost grain output of 42,600,000 kg. This produces a loss of 27,264,000 yuan per year additional plus future yields depreciated by the discount rate. These calculations do not include disposal of ash after the coal is burned.

These calculations should not be confused with environmental damage to crops due to coal burning. They are a way to estimate the cost of the land as a economic and natural resource input into the coal industry. The calculations measure a change in stock in an economy with no property rights or market values for land.

Water stock depreciation was estimated based on the data collected from the Yellow River Basin. In the 1980's, 91.73 million yuan (11 million USD) per year in damages were caused by only three major mines, Shngmu, Zhungeer, and Fugu. These mines dump 119 million tons of silt into the Yellow River, which ironically causes major problems with the hydropower plants along the river and tributaries. These damages are based on water lost to industrial processes and to individuals because of pollution and the cost of dredging because of the siltation problem. (Ning, 1996) This obviously does not include all water damage done by mines. Few studies on coals direct effect on rivers have been documented. Water pollution in China is a complicated problem and difficult to untangle without more studies.

Table 6: Data Comparison for VA and EVA in Billion of 1980 Yuan

	Domestic Product (coal industry)	Environmentally Adjusted Net National Product (coal industry)
1982	25	-652
1983	28	-686
1984	32	-711
1985	36	-715
1986	40	-735
1987	42	-737
1988	41	-740
1989	38	-718
1990	51	-707
1991	54	-705
1992	60	-782

Based on these calculations, China had a highly negative coal-specific industrial growth between 1980 and 1992. This reflects years of inefficient mining and coal burning practices caused by regulated pricing and direct subsidies.

CONCLUSION: GET PRICES RIGHT

Why would anyone conduct research like this on one sector of the economy? The answer is twofold: to expand the understanding of this technique and perhaps learn how to improve it, and to better understand an industry and environmental implications.

The technique for adjusting economic indicators is rather crude at this point, particularly in countries that do not have sophisticated economic data collection systems. Case studies such as this one are providing economists with examples of the problems faced when calculating these indicators and, in some cases, economists are able to pose possible solutions to methodological hang-ups. This particular study found that the major problem was pricing. Half of the huge gap between environmental damage and value added of coal can be explained by non-market prices. The value-added variable was calculated using official Chinese data. Official data are based on the government-regulated price of coal and transport of coal. This underestimates the VA of coal by a factor of approximately 10, depending on the year in question. However, many of the environmental adjustment variables used market values or estimates of market values because much of these data were based on losses to individuals and businesses dealing in goods that have market prices. No discussion of this in the literature was found and no examples of how to overcome this problem were found.

Other problems occurred during the calculation and analysis. The numbers above are incredibly large. In 1992, the environmental damage estimated above accounted for 65 percent of total GDP. Some of this can be explained by the nascent methodology. Currently, there are no standard ways of calculating (or converting) the damage into currency. In addition, data on China collected from any source are in question because of the quota system employed in state-run institutions. Despite the methodological problems, the study does demonstrate a trend that cannot be denied.

Analysis of the data and the behavior of the coal industry itself points again to non-market prices. Non-market prices are the culprit behind the inefficient use of coal and electricity, problems (both economic and environmental) with the transport of coal, and the severe environmental problems associated with using coal. Free land has made dumping of ashes and mine-tailings easy. Lack of wastewater fees/fines or water charges have made dumping heavy metal waste into rivers a free option for mines. Low prices of electricity and coal have made it impossible for firms to invest in technologies that reduce waste of all kinds.

What message does this study send to policymakers? Get prices right and make firms pay market prices for all inputs. This study shows that the result of not undertaking these basic economic reforms can be environmental damage on a large scale.

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NOTE

[1] This methodology is used by the Chinese Environmental Protection Agency. See: Xia Guang, "An Estimate of the Economic Consequences of Environmental Pollution in China," Policy Research Center of the National Environmental Protection Agency, Beijing, 1996. However, I have not used his data set. When comparing his assumptions with other work done in China, I believe he drastically underestimated the damage.