Environmental Policy Issues for Sustainable Economic Development in China

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Abstract:

A central pillar of the sustainability movement is the call to include environmental accounting in standard measures of economic performance. This increased transparency would, in principle, mitigate the temptation of economic managers and policy makers to increase growth in material consumption at the expense of the environment. Moreover, as Repetto (1989) and others have argued, deducting depreciation of produced capital from NNP but not deducting depreciation of natural capital is inconsistent and debases NNP as a possible indicator of welfare. Based on the evidence available, it appears that while GNNP is substantially less than NNP, these adjustments do not adversely compromise existing estimates of economic growth for China.

1. Introduction

Sustainable development is accomplished when dynamic efficiency is pursued in the context of intergenerational equity and interdependence between rural and urban development and environmental degradation (Roumasset, 2002). The purpose of this paper is to assess the nature and degree of environmental degradation and resource depletion in China and its relationship to economic development and environmental policies. Section 2 reviews evidence on air pollution. Environmental Kuznets Curves for three major air pollutants are presented. In Section 3, we discuss China's Green Net National Product (GNNP) in light of ongoing pollution depreciation of renewable and non-renewable resource stocks. Based on the evidence available, it appears that while GNNP is substantially less than NNP, these adjustments do not adversely compromise existing estimates of economic growth.

2. Air Pollution

The three air pollutants of concern are currently sulfur dioxide (SO2) from the burning of coal for power generation; nitrous oxides (NOx), mainly from motor vehicle emissions; and total suspended particles (TSP) due in part to the growing desertification of the northwest and energy production in south. Due to China's dependence on coal (68 percent of energy consumption), SO2 emissions account for more than 13 percent of sulfur deposits in South Korea and up to 50 percent in Japan (Wishnick 2005). Higher incomes have led to increased car ownership (although this is still less that 2 percent), and motor vehicles account for 45-60 percent of NOx emissions and 85 percent of CO2 emissions in cities (Wishnick 2005). One-third of the total land area is prone to desertification, including 262 million hectares of pastoral and oasis land in the Xinjiang, Inner Mongolia, Tibet, Gansu and Qinghai provinces.

Air pollution is a major health issue in the country. Ambient and indoor air pollution has been blamed for the high incidence of premature deaths (World Bank 1997). Particulate matter with a diameter less than 10 microns (PM-10) is the most damaging air pollutant in terms of health costs. In 2002, SEPA tested the air quality in over 300 cities and found that two-thirds did not meet standards set by the World Health Organization (WHO) for acceptable levels of TSP's (Economy 2004). In 1995, the World Bank estimated that health damages due to air pollution accounted for 7.1 percent of national income. This estimate may be inflated, however, inasmuch as the methodology infers the value of life in China from U.S. estimates without accounting for the extent of overpopulation (see e.g. Dasgupta 1993, 2001).

The most recent report from the State Environmental Protection Administration (SEPA 2004) asserts that air pollution in major cities has been either improving or that the speed of deterioration has decreased, with falling emission levels and improved efficiency in plants. Total levels of NOx have fallen recently. Statistics show that SO2 and TSP have been declining in the major cities since the mid-1980's. With China's rapid development, a natural question arises regarding how these levels have fallen given increased production and economic output over this same time period. For example, SEPA asserts that in 2002, national environmental quality was maintained at the level of the previous year, while the national GDP grew by 8 percent. Furthermore, SEPA (2004) reports reduced levels of dust and sulfur dioxide, stable water quality, and improved air quality in some cities.

3. The Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) is a stylized fact according to which air pollution first increases with per capita income and then falls. The standard explanation is that environmental quality is a luxury good and that political economy induces environmental regulation accordingly. The rise and fall of the manufacturing sector relative to the whole economy and the comparative advantage that low income countries have in the exportation of "dirty goods" are also cited (Grossman and Krueger 1991, Panayotou 1993, Lieb 2002).

We conducted a fixed-effects regression analysis for three pollutants in 80 cities from 1990-2001. Results for the three regressions are presented in Table 1 and are illustrated in Figures 1-3. While the order of emissions reaching their turning points in other countries is typically SO2, TSP, then NOx (Brown 2005), for China we find that the NOx turns first around 28,000 Yuan (approximately 3,461 USD), followed by TSP around 44,000 Yuan (approximately 5,440 USD), then finally SO2, which is just reaching the flat portion of its curve around 58,000 Yuan (or approximately 7,171 USD). The order of the turning points appears to be different from Western countries, presumably due to the early fall in NOx.

Table 1. EKC Regression Results.

Emissions	*NOx per capita*	*SO2 per capita*	*TSP per capita*
GDP per capita	0.0000387 (5.77×10^{-6})	0.0001089 (0.0000174)	0.0002378 (0.0000607)
GDP per capita^2	-6.85×10^{-10} (8.11×10^{-11})	-9.09×10^{-10} (2.47×10^{-10})	-2.66×10^{-9} (8.51×10^{-10})
Year	- 0.027 (0.0027)	- 0.113 (0.0081)	- 0.251 (0.0281)
Constant	0.263	0.089	2.265

Standard errors in parentheses

Figure 1. EKC for NOx, 80 Cities 1990-2001

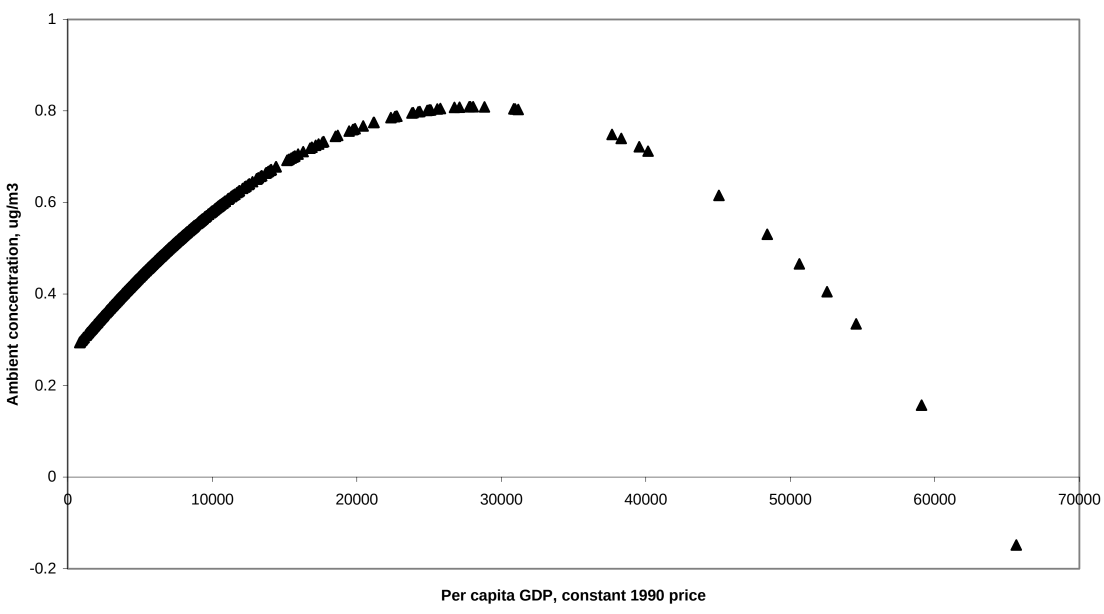


Figure 2. EKC for SO2, 80 Cities 1990-2001

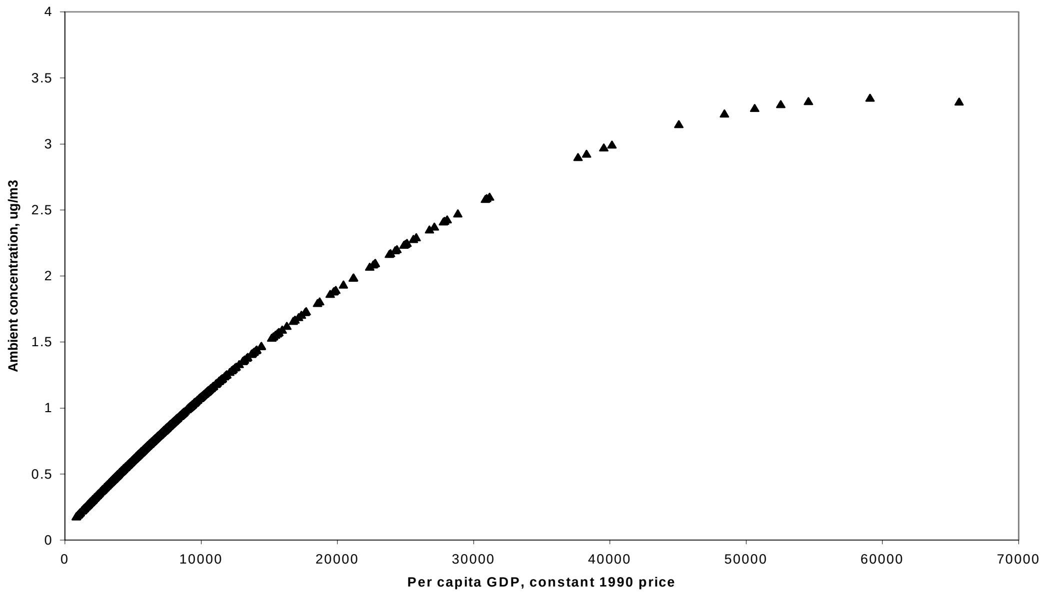
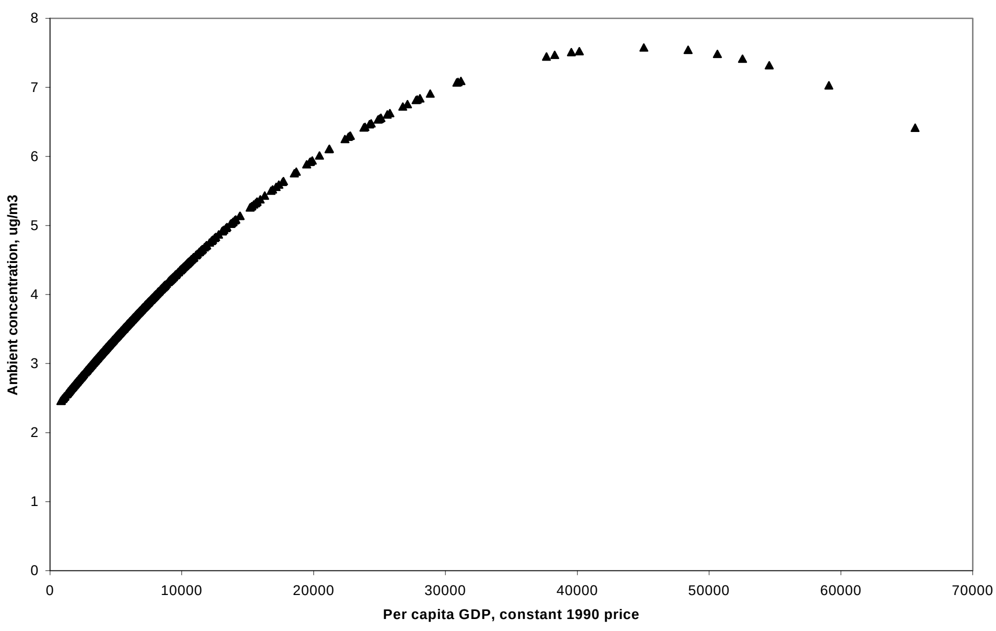


Figure 3. EKC for TSP, 80 Cities 1990-2001



The shape of the NOx curve seems implausible given the dramatic increase in automobile ownership during the same period. Mobile sources are believed to comprise approximately 45-50 percent of the total NOx emissions (Walsh 1998). However, in our data period (1990-2001) NOx is largely dominated by industry and manufacturing. The rapid growth in automobile ownership did not begin until close to 2002. In 2002 the demand for cars increased by 56 percent. The next year demand grew to 75 percent, before slowing in 2004 (when the government tightened rules on credit for car purchases) to around 15 percent[1]. Our data does not capture likely increases in NOx due to the extremely rapid increase in automobiles in recent years. One can hypothesize that there will be another phase of the EKC for NOx as the number of automobiles increases.

SO2 appears to just be reaching the flat portion of its EKC. This was also found to be the case for CO2 by Auffhammer et al. (2004). This study shows that most areas in China are likely approaching the flat portion of the curve, therefore emissions will no longer be driven by increases in China's per capita income. Instead, increases in CO2 emissions may be accelerated by population growth or changes in technology.

Finally, the EKC for TSP takes the expected shape and the turning point is consistent with other countries. The fact that per capita emissions are declining despite heavy industrial and manufacturing growth implies that either the country's reforestation efforts are indeed working, or perhaps there is an issue with seasonal measurements (see Section 3.3 for further discussion of this). There is also the issue of the exact makeup of TSP. While the smaller particles that are more detrimental to human health (less than 10 ppm) have begun showing up as separate measurements, it is not clear how the total composition had changed over time. Another issue that may be leading to the decrease in reported emissions is that manufacturing activities have to some extent moved away from city centers even though the receptors that monitor pollution have remained relatively fixed.

4. Green Net National Product

A central pillar of the sustainability movement is the call to include environmental accounting in standard measures of economic performance. This increased transparency would, in principle, mitigate the temptation of economic managers and policy makers to increase growth in material consumption at the expense of the

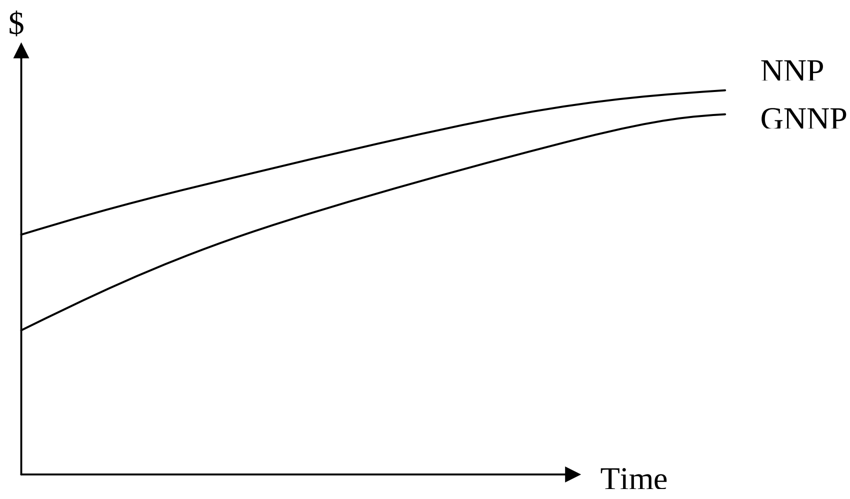
[1] "Dream Machines," The Economist, June 2, 2005, available at http://www.economist.com/business/displaystory.cfm?story_id=4032842

environment. Moreover, as Repetto (1989) and others have argued, deducting depreciation of produced capital from NNP but not deducting depreciation of natural capital is inconsistent and debases NNP as a possible indicator of welfare. In addition to deducting the depreciation in natural capital GNNP (green NNP) treats pollution in a more appropriate fashion. While defensive expenditures to limit pollution are counted as production in current NNP accounting, the correct practice is to deduct both defensive expenditures and pollution, valued at its marginal damage cost. Accordingly defensive expenditures must be deducted twice from the standard accounts.

The theoretical framework for GNNP requires consideration of three separate categories: nonrenewable resources, renewable resources, and pollution (stock and fund). For nonrenewable resources in a closed economy, forces of scarcity will require that a decreasing quantity of the resource be used every year. As the resource is depleted, the price of depletion is increasing, causing the value of the resource to increase. Furthermore, depletion causes the percentage of NNP to get smaller compared to the rest of the economy. The economy is thus growing faster than the resource being depleted.

Countries that are on the increasing portion of the EKC and are likewise increasing the depreciation of natural capital will exhibit the relationship between NNP and GNNP as shown in Figure 4. An industrializing country such as China is likely to be approaching a close to constant wedge between NNP and GNNP.

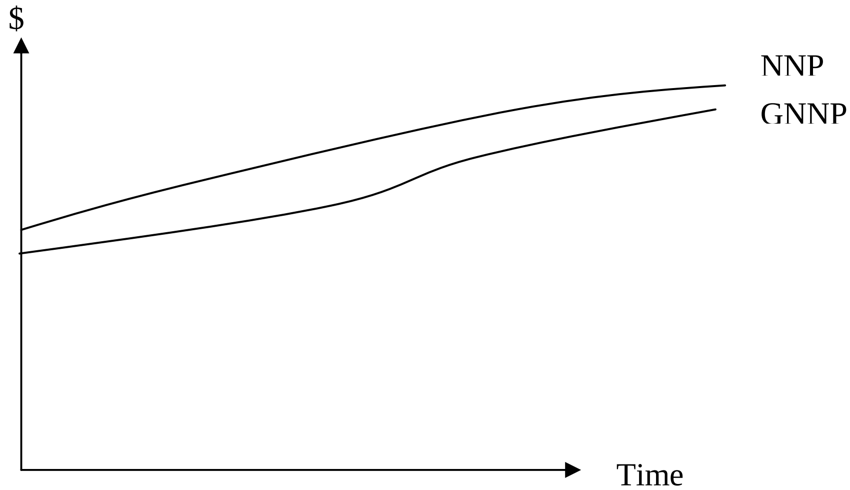
Figure 4. The gap between NNP and GNNP, natural resources



For renewable resources, this theory is even more pronounced, as the price will not change as much as in the nonrenewable case. If demand elasticity of resource use is elastic, or even slightly inelastic, growth in GNNP will be greater than growth in NNP. Only if resource demand is very inelastic will growth in GNNP be lower than in NNP (see proof of this in Appendix 1). As China does more with artificial capital, and less with natural capital, the percentage of renewable resources of the total economy shrinks, thus GNNP will grow faster than NNP.

The third category to consider is pollution. The relative growth rates of income under stock pollution should follow arguments similar to natural resources described above. For fund pollution, we turn back to the shape of the EKC for guidance. Once a country has passed the turning point on their EKC, GNNP will increase at a faster rate than will NNP. The proof in Appendix 2 outlines this argument. A comparison of growth rates for fund pollution is drawn in Figure 5. While the growth rate of GNNP is initially below that of NNP, after emissions reach their maximum (the turning point on the emissions EKC), the growth rate of GNNP for fund pollution will become faster than that of NNP. The gap between NNP and GNNP for stock pollution is similar to that of natural resources for analogous reasons.

Figure 5. The gap between NNP and GNNP, fund pollution



Repetto (1989) originally conjectured that GNNP growth is much slower than NNP growth. This is not necessarily the case, however, and probably not the case for China in the 21st century. Inasmuch as China is on the flat part of its EKC, even if emissions are growing, emissions per unit of NNP are falling.

GNNP accounting is still at the experimental stage due to remaining conceptual and measurement difficulties. Nonetheless, some preliminary findings are available. As measurement improves, we except empirical results to conform more to the theory outlined above. In any event, calculating economic growth using GNNP should produce estimates that are above traditional measures of growth.

Motivated by the 1993 United Nations Conference on Environment and Development (UNCED), China's government has begun to emphasize the importance of natural resources accounting and the importance of sustainable development. The country's goal is to develop stock and flow accounts for natural resources to facilitate the establishment of a new integrated national accounting system consistent with the UN SEEA framework (Markandya and Milborrow 1999). The SEEA (System for Integrated Environmental and Economic Accounting) contains both physical and monetary accounts, and has suggestions for converting physical data to monetary units, including market valuation and direct and indirect methods. The system emphasizes both *ex* *post* costs (expenditures on environmental protection) and *ex ante* (maintaining the environment at sustainable level) costs.

Because estimates of natural resource depreciation and environmental degradation are so disparate, we produce our own estimate of Green Income, "Green Gross National Income" (GGNI). Gross National Income (GNI, formerly Gross National Product or GNP) is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. Data are in 2004 U.S. dollars. Our estimate of GGNI was calculated by subtracting three components from GNI: net forest depletion, mineral depletion, and energy depletion[2]. See Table 2 for the value of each component.

Table 2. Green GNI Calculations, selected years 1970-2001

Year	GNI	Net forest depletion	Mineral depletion	Energy depletion	GGNI
1975	159.07	0.10	1.26	19.62	138.08
1980	213.85	0.35	1.83	38.66	173.02
1985	289.07	0.85	2.54	40.88	244.80
1990	412.76	1.39	3.28	33.58	374.50
1995	677.74	1.47	3.24	31.11	641.91
2000	1061.41	0.73	2.65	31.76	1026.28

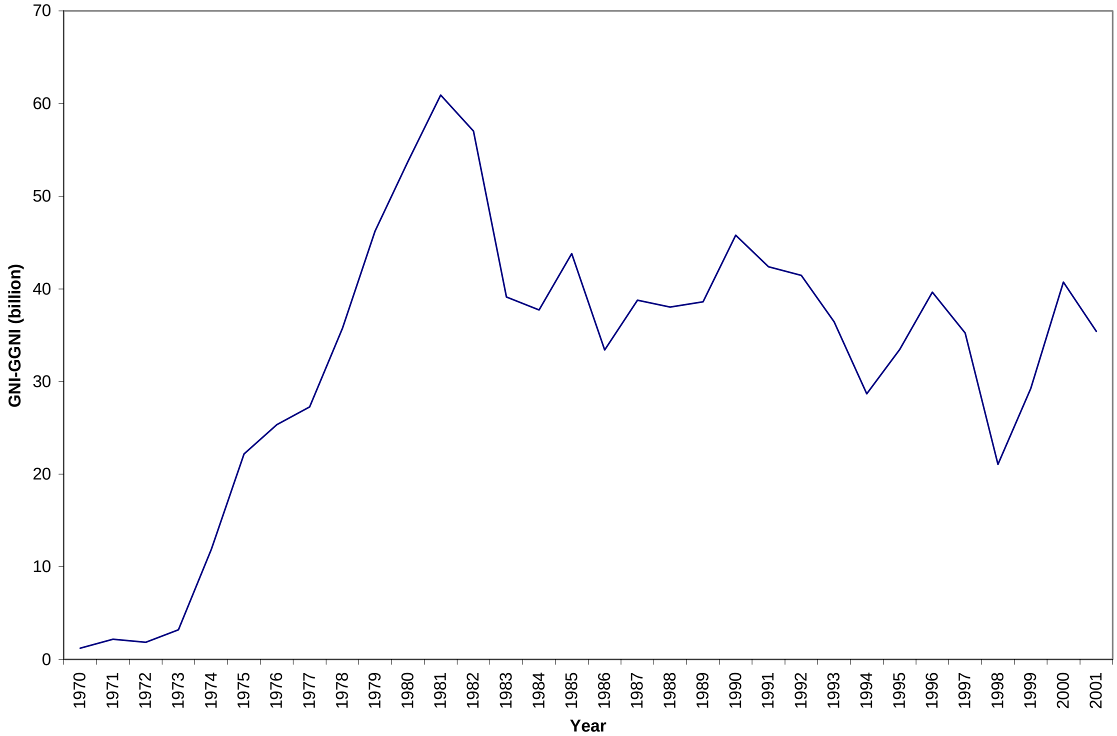
GGNI (billions) = GNI- (net forest depletion + mineral depletion + energy depletion). 10-year moving averages are reported, with the exception of 2000 which is a three-year average.

For net forest depletion, rent on depletion was calculated as the rent on that amount of extraction that exceeded the natural increment in wood volume. For mineral and energy depletion, rent was measured as the market value of extracted material minus the average extraction cost. Note that this preliminary estimate is a very incomplete calculation of GGNI, inasmuch as it does not include factors that are likely to be important in China, such as soil erosion and degradation, water pollution, and urban air pollutants.

[2] Forest, energy, and mineral depletion data was obtained from the World Bank's "Adjusted Net Savings: Results" spreadsheet, downloaded from www.worldbank.org/environmentaleconomics, December 1, 2004. GNI data from World Bank's World Development Indicators, 2004.

This estimate of GGNI can also be illustrated using the Environmental Kuznets structure, that is, environmental degradation as a function of per capita income. Using our estimates of GGNI, the corresponding Environmental Kuznets Curve[3] for natural resources (particularly forests, minerals, and energy) is illustrated in Figure 6.

Figure 6. Environmental Kuznets Curve for Natural Resources. Natural resource depreciation (GNI-GGNI), 1970-2001



Source: World Bank, www.worldbank.org/environmentaleconomics, and GNI data from World Bank's World Development Indicators, 2004

In April 2004 the National Bureau of Statistics reported work to set up a calculation system for Green NNP, selecting the Hainan Province and Chongqing Municipality as pilot areas for the system. China's system is expected to be created in three sequences: quantifying natural resources consumed in economic activity; measuring changes in the quantity and quality of environmental resources; and evaluating same. The accounting methods described above can determine whether the gap between NNP and GNNP is still growing or already shrinking.

[3] While the Kuznets curve is a long run theory, these results may be driven by price and other informational shocks. When the same analysis is done for the United States, the curve peaks at the same time, although at a much larger value. Theoretically, countries should experience their peak at different points in time.

In light of the findings of Auffhammer et al. (2004), pollution in the whole of China may be approximately constant. That is the current wedge between NNP and GNNP can be expected to fall from the current 8-12%. As China's own non-renewable resources are depleted and reliance on imported resources increases, non-renewable resource depletion will similarly decline as a percentage of NNP. Renewable resource depletion will decline even more, as China moves towards steady state depletion. Barring increased inefficiency, chances are high that future growth rates of GNNP will be even higher than that of NNP.

5. Conclusion

With respect to air pollution, China appears to have passed the flat part of the Environmental Kuznets Curve for two out of three major pollutants. Even if improved air quality in city centers turns out to be offset by increases in the urban periphery, reductions in pollution per unit of output are sufficient reduce pollution per capita and to reduce the value of pollution as a percent of NNP. Depreciation of natural capital also appears to be declining as a percent of NNP. In summary, both theory and preliminary evidence suggest that GNNP is growing as fast or faster than NNP. Accordingly, political concerns need not inhibit more careful and comprehensive environmental accounting and its integration into full income accounts.

While GNNP is a superior indicator of welfare, its increase is no guarantee of efficient resource management. Genuine savings (Hamilton et al., 2005) will continue to increase even as some dynamic inefficiencies remain. Eliminating these sources will promote faster GNNP growth and the pursuit of properly measured growth will promote the elimination of inefficiencies.

References

Auffhammer, M, R Carson and T Garin-Munoz. 2004. "Forecasting China's Carbon Dioxide Emissions: A Provincial Approach." Department of Agricultural and Resource Economics, University of California, Berkley.

Brown, J. 2005. "Travelling the Environmental Kuznets Curve." *Fraser Forum*, pp.16-17.

Dasgupta, P. 2001. *Human Well-Being and the Natural Environment*. Oxford: Oxford University Press.

Dasgupta, P. 1993. *An Inquiry into Well-Being and Destitution*. Oxford: Clarendon Press.

Economy, E. 2004. *The River Runs Black: The Environmental Challenge to China's Future*. Ithaca: Cornell University Press.

Grossman, GM and AB Krueger. 1991. "Environmental Impact of a North American Free Trade Agreement." Working paper 3914.

Lieb, C. 2002. "The Environmental Kuznets Curve and Satiation: A Simple Static Model." *Environment and Development Economics*, pp. 429-48.

Markandya, A and I Milborrow. 1999. "Green Accounting in China: The Role of Damage Estimation," in *Resources accounting in China*. Lanza, A, ed. Dordrecht: Kluwer Academic Publishers, pp. 21-52.

Panayotou, T. 1993. *Green Markets: The Economics of Sustainable Development*. San Francisco: ICS Press for the International Center for Economic Growth and the Harvard Institute for International Development.

Repetto, R. 1989. *Wasting Assets: Natural Resources in the National Income Accounts.* Washington, D.C.: World Resources Institute.

Roumasset, J. 2002. "The Yin and Yang of Scarcity and Abundance," in Xinjingji, Tiaojianxia, De, Shengcun, Huanjing, Yu, Zhonghua, Wenhua (eds.), *The New Economy, Living Conditions, and the Chinese Culture*, Hangzhou, China, 2002.

SEPA. 2004. "Analysis on the State of the Environment in China." http://www.sepa.gov.cn/english/SOE/analysis/index.htm#pollutant

Walsh, Michael. 1998. "Motor Vehicle Pollution Control in China: A Strategy for Progress." http://www.chinaenvironment.net/sino/sino2/page2.html

Wishnick, Elizabeth (2005) "China as a Risk Society," East-West Center Seminar, Honolulu, HI.

World Bank. 2004. "World Development Indicators," downloaded from http://www.worldbank.org/data/, December 1, 2004.

World Bank. 2001. "Adjusted Net Savings: Results," downloaded from www.worldbank.org/environmentaleconomics, December 1, 2004.

World Bank. 1997. *Clear Water, Blue Skies: China's Environment in the New Century*. Washington DC: World Bank.

World Bank. 1995. *China: Regional Disparities*. Washington DC: World Bank.

Appendix 1

Proof:

Denote $NNP = y = C + p_K \dot{K}$

$GNNP = g = y + p_N \dot{N} = y - p_N x$

where C is consumption,

p_K is shadow price of capital,
K is man-made capital,
p_N is shadow price of resource,
N is natural resource,
x is amount of resource extracted at each time.

Growth in GNNP exceed growth in NNP iff

$$\frac{\dot{g}}{g} = \frac{d[y - (p_N x)]/dt}{y - (p_N x)} > \frac{\dot{y}}{y}$$

$$y(\dot{y} - \dot{p}_N x - p_N \dot{x}) > \dot{y}(y - p_N x)$$

$$\dot{y} p_N x - y(\dot{p}_N x + p_N \dot{x}) > 0$$

$$\dot{y} p_N x - y\dot{p}_N x(1 + \varepsilon_N) > 0$$

where $\varepsilon_N = \frac{dx}{dp_N}(\frac{p_N}{x})$ is the elasticity of demand for resource

If $|\varepsilon_N| \geq 1$, (i.e. demand in elastic), then growth in GNNP is more than growth in NNP.

$|\varepsilon_N| < 1$, (i.e. demand is inelastic), then the sign is ambiguous. If it is near elastic, growth in GNNP will still be higher than growth in NNP. But if the demand is very inelastic, then growth in GNNP will be lower than growth in NNP.

Appendix 2

Proof that the percentage growth rate of GNNP (g) is larger than that of NNP (y) when (e/y) is falling, where e represents total emissions:

When $\frac{e}{y}$ is falling over time, we have

$$\frac{d}{dt}\left(\frac{e}{y}\right) < 0 \quad \Rightarrow \quad \left(\frac{\dot{y}}{y}\right) - \left(\frac{\dot{e}}{e}\right) > 0$$

$$\Rightarrow \quad e\,\dot{y} - y\,\dot{e} > 0 \quad \Rightarrow \quad e\,\dot{y} + y\,\dot{y} - y\,\dot{y} - y\,\dot{e} > 0$$

$$\Rightarrow \quad y\,(\dot{y} - \dot{e}) - \dot{y}\,(y - e) > 0 \quad \Rightarrow \quad \frac{(\dot{y} - \dot{e})}{(y - e)} > \frac{\dot{y}}{y} \quad \rightarrow (A)$$

Since $g = y - e \quad \Rightarrow \quad \dot{g} = \dot{y} - \dot{e} \quad \Rightarrow \quad \frac{\dot{g}}{g} = \frac{\dot{y} - \dot{e}}{y - e}$

$$(A) \Rightarrow \quad \frac{\dot{g}}{g} > \frac{\dot{y}}{y}$$

i.e., % growth rate of GNNP is larger than that of NNP