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Environmental Policy Outlook

Beyond Kyoto: Real Solutions to Greenhouse Emissions from Developing Countries

By Roger Bate and David Montgomery

Whether the Kyoto Protocol is ever ratified is fast becoming irrelevant. Many of the European nations that ratified the convention are failing to reach their targets, while developing countries, not required to comply with Kyoto, claim they will never participate in targets and timetables, as it would retard their economic growth. Given that developing countries are likely to emit well over half of future greenhouse gases (GHGs), a more promising strategy would be to devise an approach that limits emissions while helping development.

Stabilizing global concentrations of GHGs will require both research and development to create new technologies that are more energy-efficient than those now used in developed countries and effective action to spread these technologies to developing countries. Until these new technologies are available, significant savings in energy use and carbon emissions could be achieved by transferring current Western technology to developing countries. However, barriers to such transfer exist. Lack of economic freedom is one of the important factors that stands in the way of improving standards of living for developing countries, and that lack of economic freedom is also a major obstacle that hinders technology transfer. The prospect of simultaneously reducing poverty and increasing energy efficiency makes a compelling argument for developed countries to take a new approach to partnership with developing countries, one centered on improving economic freedom in a way that will allow smoother technology transfer and faster economic growth.

With the Kyoto Protocol all but dead and antagonism between Europe and America over climate change at an all-time high, now is a good time to assess real-world, if even only partial, strategies for the potential problem of climate change. One of the main reasons that the United States refused to ratify the Kyoto Protocol was that it addressed only the emissions of the wealthy countries (members of the Organization for Economic Cooperation and Development, or OECD). While the Kyoto Protocol seems fair on one level (we, the developed, have benefited from our massive use of energy and should pay the price of any harm), it ignores the fact that most of the forecast emissions will come from the developing parts of the world.

Developing countries seem unwilling to be drawn into a new, updated Kyoto-style process of targets and timetables since they refuse to limit their energy requirements. These countries rightly see increased energy use as a prerequisite for the economic development so badly needed to combat the major problems they face today, including disease, famine, and violent conflict.[1]

The result of thinking about the needs of developing countries, rather than the desires of Western greens, leads to certain questions: Given that developing countries will need to use energy to develop economically, can their energy use, and hence greenhouse gas (GHG) emissions, be lowered through improved technologies to produce the same amount of wealth? Can this shift in technology be achieved by policies that also advance the economic development of developing countries? By comparing energy efficiencies and economic freedom, this paper attempts to introduce answers to these questions.

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Economics, Energy, and Emissions

Growth requires energy, and countries with low income per capita use little energy per capita. All developed countries together produce about 15 billion metric tons of carbon dioxide per year, which is about 10.8 metric tons per capita. This is comparable with developing country emissions totaling about 9 billion metric tons of carbon dioxide, with per-capita emissions of about 1.9 metric tons. The disparity in per-capita emissions, based in large part on widespread poverty, is one of the reasons developing countries resist suggestions that they should in any way limit their economic growth to reduce their greenhouse gas emissions.

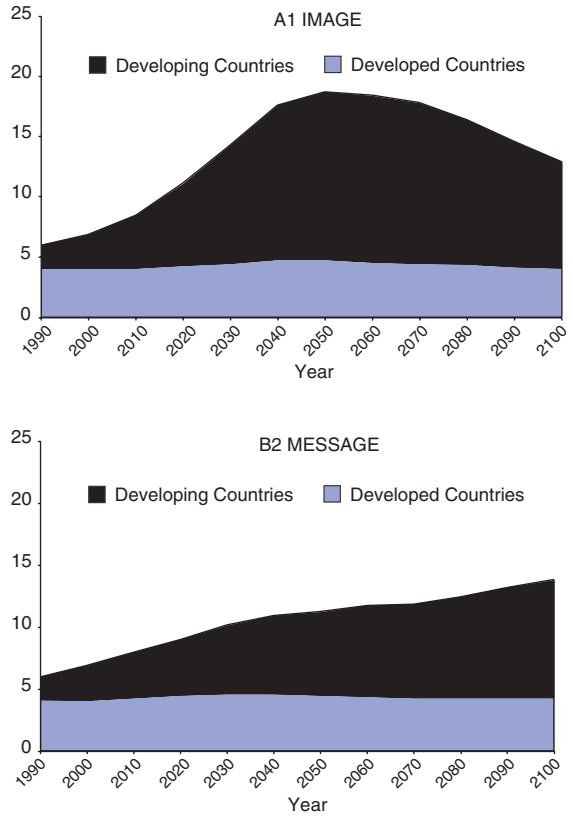
Table 1: Carbon Dioxide Emissions: Per-Capita Measures and Shares

	Carbon dioxide emissions		
	Per capita (metric tons)		Share of world total (%)
	1980	1999	1999
Developing countries	1.3	1.9	36.6
Least-developed countries	0.1	0.2	0.5
Arab States	3.0	3.7	4.0
East Asia and the Pacific	1.4	2.3	17.9
Latin America and the Caribbean	2.4	2.5	5.4
South Asia	0.5	1.1	6.4
Sub-Saharan Africa	1.0	0.8	2.0
Central and Eastern Europe and the CIS		7.2	12.5
OECD	11.0	10.8	51.0
High-income OECD	12.2	12.3	46.4
High human development	10.9	10.8	53.5
Medium human development	1.3	2.3	38.3
Low human development	0.4	0.4	1.0
High income	12.2	12.4	48.2
Middle income	2.3	3.2	35.9
Low income	0.5	1.0	10.3
World	3.4	3.8	100.0

SOURCE: UN Development Program, *Human Development Reports* 2003.

Proponents of the approach to climate change laid out in the Kyoto Protocol claim that we should instead base policy on reducing Western per-capita emissions (IPCC, 2000). But consensus is missing on the desire to follow a Kyoto-style approach in the face of its high costs using currently available technologies. The result is that no openly democratic and informed political system can coerce its citizens to reduce energy use in the near term without much better evidence that climate change will be harmful; few countries have been able to persuade their citizens of the importance of such action.

Figure 1: Emission Scenarios Show Developing Countries Will Have the Largest Share of Future Emissions



SOURCE: IPCC SRES Image A1 and Message B2 Scenarios.

Similarly, no democratic system can hold developing countries back from economic progress and using whatever energy they require. However, it is possible to influence how these countries develop and to help them with their energy efficiency—not by mandate but by investment.

It is indeed critical that this realistic engagement with the needs of developing countries take place because it is impossible to address the risks of climate change without making substantial changes in how developing countries use energy. Although developing countries have low per-capita emissions, they have huge populations. The rapid growth of this already large population leads to the paradox that developing countries will contribute the bulk of greenhouse gas emissions over the next century. Figure 1 gives an example of projections of GHG emissions, expressed as tons of carbon equivalent, over the next decade. It shows that under a wide range of scenarios developed by the UN scientific advisory group, the Intergovernmental Panel on Climate Change (IPCC), GHG

emissions by developing countries will exceed those from developed countries by a factor of two or three over the next century. The scenarios illustrate the high and low ends of the range of forecasts for cumulative GHG emissions and the share of developing countries (IPCC *Special Report on Emissions Scenarios*).[2]

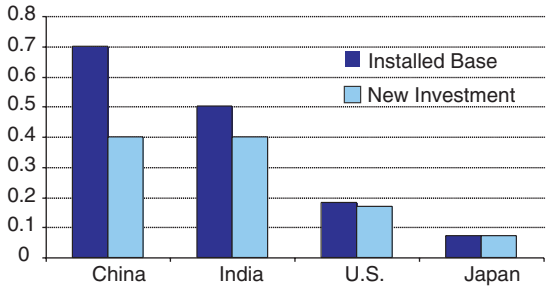
The question, then, is how this engagement can be accomplished. Developing countries clearly and rightly place the highest priority on addressing current problems that pose real risks to life and health—disease, food, and sanitation—that can only be alleviated by rapid economic growth. Engagement on climate will only be possible if the route to bringing down projected GHG emissions simultaneously contributes to economic growth. To begin to develop answers, we start with a review of how developing countries use energy in comparison to developed countries, and how changing energy usage is connected to economic growth. We then review the current understanding of some of the key requirements for economic growth and ask if there are policies that can simultaneously advance economic growth and begin to make changes on a large scale in energy usage.

Energy Use and Economic Growth in Developing Countries

Two key facts about energy use and carbon emissions in developing countries emerge clearly from historical statistics: Energy use per dollar of output (energy intensity) and greenhouse gas emissions per dollar of output (emissions intensity) are far higher in developing countries than in developed countries.[3] Both energy intensity and emissions intensity are improving in developing countries, but even the modernizing sector of developing countries still has intensities far higher than seen in developed countries.[4]

The theory of economic growth based on embodied technical progress, originated by Solow (1956), Swan (1956), and Solow (1957), helps determine the extent to which key developing countries continue to lag behind industrial countries in their energy and emissions intensity. Solow and Swan introduced the key notion of "embodied technical change"—that the level of productivity is "built in" to capital equipment, and that new technologies can only be brought into play through new investment. The subsequent growth literature suggests that technical change is a key component of growth. The theory reinforces the empirically

Figure 2: Emission Scenarios Show Developing Countries Will Have the Largest Share of Future Emissions



demonstrable idea that new technologies, which are embedded in new equipment, improve labor productivity, improve energy efficiency, and hence reduce carbon emissions. To achieve these improvements, it is necessary to retire old and build new equipment embodied with better technology.

Bernstein et al. (2004) used this approach to examine the historical record for economic growth and emissions reduction and found a clear lag in technology, even that accompanying new investment. For example, consider that China grew at 7.6 percent annually between 1995 and 2000, and its emissions grew at an annual rate of 4.5 percent. This clearly suggests that China's new investment incorporates technology that is more energy-efficient and produces fewer carbon emissions than the installed base. But when Bernstein et al. combine these growth rates with information on the level of investment and estimates of the life of capital equipment and a few other macroeconomic indicators, they estimate the energy/GDP ratio associated with new investment. What they find is not encouraging. The results for China, and similar calculations for India, the United States, and Japan, are summarized in figure 2. China is rapidly improving its energy/GDP ratio, but its new investment is still characterized by much higher energy use per dollar of output supported by that investment, than the United States or other OECD countries.

Figure 2 shows that in 2001, emissions intensity associated with the installed base substantially exceeded emissions intensity associated with new investment in China and India. China produced on average about 0.7 million tons of carbon emissions for every billion dollars of GDP (measured in constant U.S. dollars at market exchange rates) and about 0.4 million tons of carbon emissions for every billion dollars of GDP produced from

new capital equipment. India produced about 0.5 million tons on average, and also 0.4 million tons per billion dollars of GDP from new capital. In contrast, the United States produced under 0.2 million tons per billion dollars of output and Japan under 0.1 million tons. Even new equipment in China and India had emissions intensity more than twice that of new equipment in the United States.

These findings suggest that there is significant potential for reducing emissions from developing countries by increasing the rate of investment to speed the process of modernization and capital turnover, which is even now reducing emissions intensity and improving the technology used in new investment to a level comparable to that in developed countries. Although China has continuously improved its energy efficiency, historical evidence shows that the embodied technology in new investment in China and India has not caught up to the West. Our finding that even new investment in developing countries embodies far lower energy efficiency than new investment in developed countries suggests that an efficient way to reduce global emissions is to stimulate additional investment in developing countries, so as to replace their existing energy-inefficient technologies with more energy-efficient ones. These countries could achieve higher energy efficiency at par with developed countries if there were rapid technology transfers.[5] There are immediate benefits from making this transition.

Bernstein et al. (2003) estimate that if just China and India were able to adopt the technology now in use in the United States in their new investment and were to accelerate the replacement of their existing capital stock with its high built-in emissions, the resulting savings in carbon emissions by 2012 or 2017 would be comparable to the emission reductions that could be achieved by the Kyoto Protocol over the same period *if all Annex B parties met their original commitments*. In the real world, in which Kyoto commitments are likely to be met by relatively few countries, the emission reductions available through improving technology in developing countries dwarf those achievable in the developed countries. The question is whether this potential can be achieved and in a fashion consistent with the development goals of developing countries. The key to answering this question is found in another question: are lack of economic freedom and remediable market imperfections in developing countries responsible for the observed differences in technology?

Choice of Technology in Developing Countries

Western countries also differ in their energy efficiency and GHG emissions per dollar of GDP. Japan's emissions per dollar, which are about half those of the United States, are influenced in part by its available resources, higher population density, and a series of government policies that tax auto fuels and vehicles highly. Moving the United States to the Japanese level of efficiency would likely impose high costs on the United States. The United States has a free and efficient set of markets, whose operations lead to cost-effective choices about energy use—in the sense that the cost of investments to save additional energy, or use less coal and more renewable energy, would be greater than the market value of energy saved (Cameron et al. 1997 and Jacoby 1998). Can developing countries also make cost-effective energy technology choices, or do they suffer from market imperfections that hinder such choices? If the latter is true, policy changes that benefit economic development and reduce GHG emissions are possible.

As figure 2 shows, new investment in China and other developing countries clearly does not incorporate world-class technology. What is responsible for these differences in technology? One theory is that optimal allocations (including energy technologies) will have occurred given supplies of labor, capital, energy, and other factor endowments. Under this theory, in order to slow emissions growth in developing countries, it is necessary to undertake costly measures to restrict energy use or deploy expensive renewable energy technologies to replace fossil fuels. If these countries are already using energy optimally, given their resource endowments, then any change will entail a cost, just as it does in advanced, free market economies. These changes in patterns of energy use will occur only if forced by a policy regime that limits or penalizes GHG emissions. This is the fundamental idea behind the notion that the way forward under the Kyoto Protocol (and beyond) is for developing countries to agree to emission limits and participation in the international emission-trading system.

Participating in international emission trading is seen as a means of providing compensation to developing countries for the additional costs they would have to incur. The inducement would be to make those emission limits sufficiently higher than projected emissions growth so that developing countries could sell their excess permits and use the proceeds to cover the cost of emission

reductions. This is the same concession that Russia negotiated for the first commitment period, with an emission cap considerably greater than its actual emissions. Russia can profit from selling the excess permits, which have come to be referred to as "hot air," to other countries—the European Union, Japan, and Canada in particular—that need the permits because they cannot meet agreed emission limits on their own without great economic cost.

To some extent, this approach shifts the burden of paying for emission reductions in developing countries to the developed countries that will buy the permits. But the cost remains, and developing countries doubt that adequate compensation for restraint on growth will be provided since the required scale far exceeds current aid budgets and the willingness of developed countries to make large-scale wealth transfers. They also rightly perceive that this system will systematically slow their industrial development and put their future well-being at the mercy of the developed countries' willingness to continue these transfers.

Fortunately, existing market failures in developing countries strongly suggest that it is possible to involve these countries in a process of improving their well-being while simultaneously reducing their GHG emissions. First, it is far from clear that energy is currently used optimally in developing countries. Second, there is also strong evidence from a variety of sources that developing-country markets do not function as freely and effectively as those in the developed countries of the world and that lack of economic freedom is a very strong reason why they remain poor and underdeveloped. Third, there is very strong evidence that market imperfections in developing countries explain why their energy use and carbon emissions per dollar of output are so high. If this is the case, then cooperative efforts to remove these market imperfections and improve economic freedom can therefore also be highly effective in reducing GHG emissions. To develop evidence on the extent and importance of market imperfections, we examined some of the recent comprehensive studies of economic freedom and market institutions throughout the world.

Economic Freedom, Market Imperfections, and Greenhouse Gas Emissions

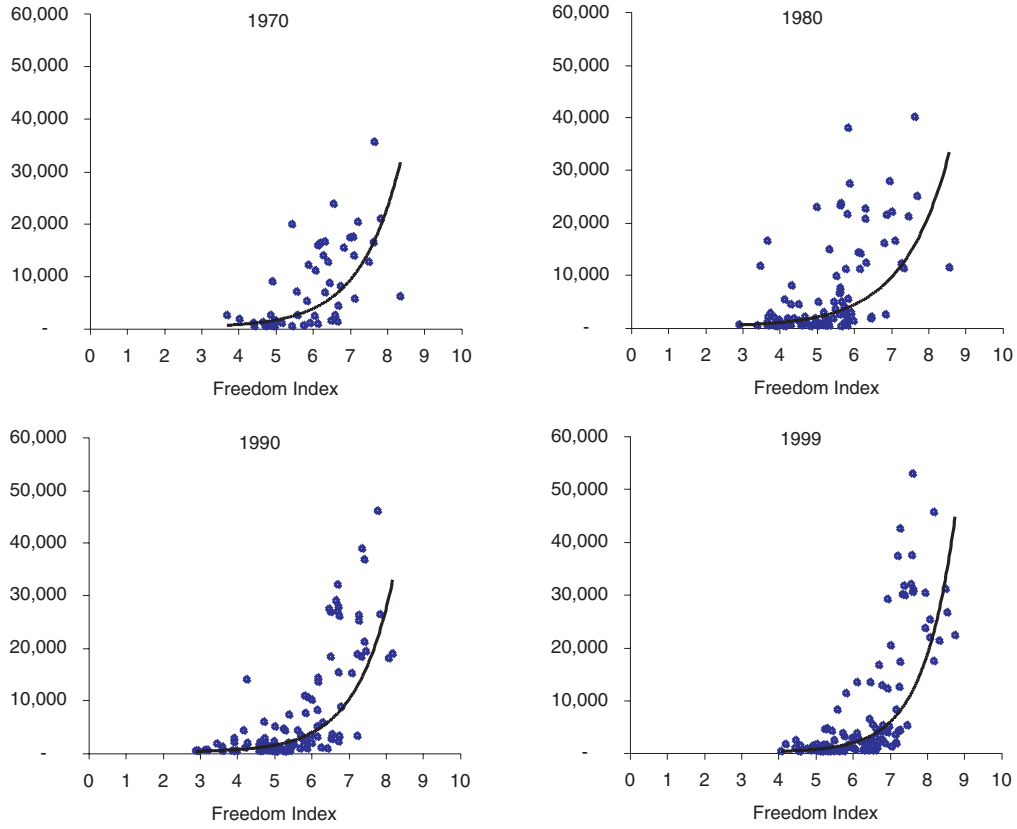
Freedom and wealth. Ever since Adam Smith asserted in 1776 that freedom from government intervention is essential for economic growth and thus the wealth of a nation, economists have attempted to gauge the relative importance of various determinants of growth. These variables include economic factors such as private and government spending, flexibility of tax regimes, and investment in the form of domestic or foreign capital, as well as broader, societal parameters. Those in the latter category include key social, legal, and political institutions; rule of law; property rights; and enforcement of contracts.

Clearly then, there are numerous variables and indicators that can be linked to economic development. In assessing any nation's economic health, various research studies argue for the importance of judicial independence (Berkowitz 2000); the impartiality and integrity of the court systems (Sen 2001); the level of overall governance (Kaufmann and Mastruzzi 2003, Kaufmann and Kraay 2003); the adequacy of business and economic laws and regulations (World Development Report 2002); the protection of investment and recognition of ownership of intellectual property rights (Maskus 2000); an increase in openness to internal markets (Antweiler et al. 2001); the development of an enabling investment climate, policies, and institutions (Moran 1998); and political freedom (Friedman 1962, North 1990). Dawson (1998) provides strong empirical evidence demonstrating the relationship between institutional visibility and economic growth, as well as the causal effect of economic freedom on both political and civil liberties.

To gain a better understanding of the connection between economic freedom and economic welfare, various groups of researchers have compiled detailed data on over 120 countries into indices of economic freedom. For our purposes, it is also important that the indices identify many of the market imperfections and distortions that prevent developing countries from accessing and adopting the technologies that produce low emissions per dollar of output in the West.

We used data from the Economic Freedom of the World (EFW) index developed by the Fraser Institute[6] in order to investigate whether economic freedom has a strong influence on the energy technology used in a country.[7] The index correlates positively with measures of income per capita, economic growth, the UN Human Development Index, and longevity. It correlates negatively with indexes of corruption and poverty. The analysis in the literature demonstrates that the correlation is most likely causal and the direction is certain—overall freedom drives development. This conclusion has also

Figure 3: Economic Freedom Compared to GDP per Capita



SOURCE: Economic Freedom of the World, Annual Report 2003 and World Development Indicators, World Bank, 2000.

become one of the central lessons of modern development economics.

A recent Economic Freedom of the World Annual Report examined 128 countries in 2001, and concluded that:

- "Economic freedom is highly correlated with per-capita income, economic growth, and life expectancy."

- "Economic freedom continues to gain ground around the world. Based on the 10-point scale of this index, the average economic freedom rating was 6.35 for 2001, up slightly from 2000's average rating of 6.34. However, this compares well with the average rating of 5.96 in 1995. Economic freedom decreased through the 1970s, falling from 6.07 in 1970 to 5.36 in 1980. It has been on the rise since then."

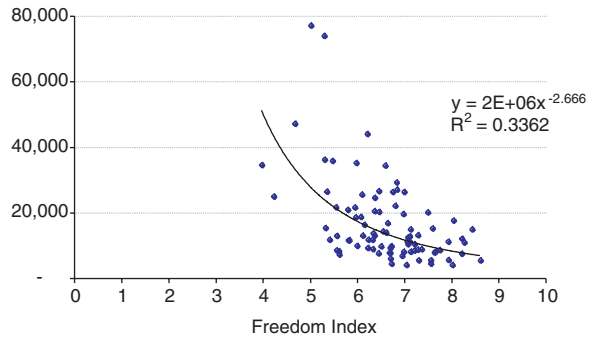
- "Hong Kong retains the highest rating for economic freedom, 8.6 of 10, closely followed by Singapore at 8.5, the United States at 8.3 and New Zealand and the United Kingdom, both at 8.2. The rankings of other large economies out of 123 countries are: China, 100; India, 73; Brazil, 82; and Russia, 112."

- "Most of the lowest-ranking nations are African, Latin American or former communist states." [8]

Economic freedom and per-capita income are closely associated. Figure 3 illustrates the close association of these variables over the past three decades and reaffirms the relationship.

The connection between GDP per capita and economic freedom is striking. It suggests asking whether there is also a connection between economic freedom and energy efficiency and carbon emissions per dollar of GDP. We find that there is an equally striking connection between levels of economic freedom and key indicators of how efficiently energy is used in developing countries. Figure 4 shows the remarkably close association between the EFW index and energy use per dollar of output using the cross-country data for 2001. Out of the 128 countries in the EFW index, we included the

Figure 4: Economic Freedom Compared to Energy per Dollar (Btu per 1995 $) of GDP (2001)



forty-eight countries for which data on energy use and GDP were available from the U.S. Energy Information Administration.

Economic Freedom and Energy Use

Countries with low scores on economic freedom have above-average energy use, and vice versa. Table 2 illustrates this relationship with data for five economies—four developing countries and one economy in a transition country (Russia).[9]

Based on statistical analysis of the two data series, we find that the Economic Freedom Index explains over 36 percent of the variation in energy use per dollar of GDP across countries, see Table 3 for the R^2 value.[10] We also examined the relationship between the Freedom Index and greenhouse gas (carbon) emissions per capita and found an association nearly as strong. Moreover, we separated the developing countries and examined the relationship between the Freedom Index and energy and emissions intensity and found that the Freedom Index has similar power in explaining differences in energy and emissions intensity among developing countries. That is, the overall relationships between economic freedom and energy or emissions per dollar of GDP are not based solely on comparing developed and developing countries. Even within developing countries, a country with a higher freedom index is likely to have significantly lower energy use and emissions per dollar of GDP.

There are several causal routes through which greater economic freedom could lead to lower energy use and emission per dollar of output. One is by improving economic well-being per se. Other researchers have addressed the question of wealth and GHG emissions

Table 2: Energy and Carbon per GDP for Five Countries (2001)

Country	Energy per GDP (Btu per 1995 $)	Carbon per GDP (MMTC per 1995 $b)	GDP per capita (Thousands of 1995 $)	Freedom Index
China	36,578	0.77	0.9	5.49
India	27,053	0.54	0.5	6.12
Indonesia	20,376	0.37	1.0	5.57
Russia	75,546	1.15	2.5	5.04
South Africa	25,568	0.58	4.0	6.77

SOURCE: Energy Information Administration, International Energy Annual, 2002.

Table 3: Market Imperfections with the Strongest Influence on Energy Intensity

Explanatory Variable	Parameter Estimate	t-Value
Constant	109541	5.6
Transfer and subsidies as a share of GDP	-3478	-2.6
Government enterprises and investment as a share of gross investment	-1425	-1.6
Hidden import barriers	-6548	-3.3
Restrictions in foreign capital market exchange	-435	-0.5
Time with government bureaucracy	-2704	-1.5
R-Square = 0.36	-2704	-1.5

by analyzing the relationship between per-capita income and GHG emissions per dollar of output. Schmalensee et al. (1998) find that there is a relationship, and that emissions per dollar of output increase until a middle level of per-capita income is reached and then begin to decline. The "inverted U" pattern often referred to as the environmental Kuznets curve is based on Simon Kuznets' studies of how demand for various goods changes as income increases. Schmalensee and his colleagues find evidence of the environmental Kuznets curve with a within-sample peak between carbon dioxide emissions per capita and per-capita income. Developing countries with low levels of income tend to see accelerating growth of emissions, while for the developed countries this growth trend is relatively flat or may even be decreasing. None of these studies included indicators of economic freedom as explanatory variables. Based on the relationship identified by Schmalensee et al., it is likely that increasing per-capita income is associated with economic changes that increase energy and emissions intensity in the short run for developing countries, and thus is working in the opposite direction to the relationship we found between economic freedom and energy or emissions intensity.

The adoption of technology is also a specific process of supply and demand. Countries that are successful in growing rapidly also benefit from the diffusion of this technology throughout their economy and the establishment of modern business and production techniques that displace traditional practices and outdated equipment. All countries start with a legacy of plant, equipment, and infrastructure from pre-market, pre-industrial, or centrally planned eras. More rapid investment speeds the process of replacing this legacy of less efficient capital equipment. Economic freedom promotes all these processes. Market imperfections that hinder investment—particularly foreign direct investment—and discourage outside investors from transferring their best technologies, or that protect domestic industries from competition, will frustrate the economic changes that lead to lower energy use and carbon emissions.

Evidence shows that technology used in developed countries is not being adopted in developing countries, even in their new investment. Acquiring new technology requires replacing old capital with new capital through higher rates of investment. New investment could be domestic or foreign. For most developing countries, foreign direct investment (FDI) has been the engine for more rapid technological progress. The technology from the developed countries diffuses to developing countries largely through the process of FDI or aid from individual countries and multilateral institutions (official development assistance, or ODA), though FDI dwarfs ODA in magnitude. But there are several market barriers standing in the way of that investment and technology. If there are obstacles to the inflow of foreign investment or disincentives for use of technology that is cost-effective in developed countries, then there will be less transfer of technology to developing countries. Similarly, if there are policies in developing countries that distort factor prices, such as subsidies for energy use or protection of domestic industries, the adoption and diffusion of technology will be hampered. The Freedom Index also includes data on these types of obstacles to FDI and domestic market imperfections relevant to the choice of energy technology.

Since economic freedom increases per-capita income and also reduces GHG emissions per dollar of output, it is indeed difficult to disentangle the effects of greater economic freedom that work through increased income from those that work through removal of market imperfections hindering technology transfer. We made one simple test, which was to include per-capita income as an explanatory variable for emissions per dollar of GDP.[11] Although not as sophisticated as Schmalensee et al., this test reveals that economic freedom, as measured by the Freedom Index continues to have a significant effect on emissions over and above that of per-capita income.

Energy Technology and Market Imperfections

Figures 3 and 4 tell a very clear and important story. Economic growth, which improves income per capita, is stimulated by economic freedom. Economic freedom is also associated with much lower energy use per dollar of output, and lower energy use per dollar of output translates into lower emissions of greenhouse gases per dollar of output.

Understanding this effect requires a closer look at how energy is used in developing countries and how those patterns of use are caused by lack of economic freedom. Doing this requires looking more closely at the components of economic freedom that have the most influence on energy choices.

The same set of market imperfections that slow progress of economic and overall social well-being are connected with high carbon emissions per dollar of GDP.

The following list provides some of the components of the Economic Freedom Index that can directly influence the energy technology used in a country: pricing distortions that remove the incentive to adopt cost-effective technologies include distorted internal pricing mechanisms, a lack of markets, and subsidies administered through state-run enterprises. Internal policies make markets inhospitable to foreign investment with world-class technology owing to the lack of contract law, protection of property rights, protection of intellectual property, protection of inefficient industries, restriction on free flow of funds into and out of a country, and the lack of infrastructure, education, and skills to handle technology.

We expect, in principle, that certain of these market imperfections will slow investment, retard technology transfer impeding the development of the energy sector, and make more efficient technologies unable to compete effectively with the protected and subsidized status quo. These elements of economic freedom are important because the process of investment and technology transfer can be frustrated by barriers to foreign investment, pricing systems that make technologies with lower energy use less economically viable, and protection of domestic

industries with their legacy capital and lack of access to world-class technology for new investment. Barriers to foreign investment include explicit barriers, such as prohibition of foreign ownership in specific industries or regions, which are endemic in the developing world. Lack of both strong contract law and protection of property rights, as well as excessive currency controls, clearly discourage foreign investment, since they introduce risks that expected returns will not be earned or that invested capital will be lost or not be allowed to be repatriated. Lack of protection for intellectual property discourages multinational companies from using their best technology for fear it will be illegally copied. Protection of inefficient industries implies that even if FDI is successful in bringing in new technology, that technology will be confined to the industries in "foreign enterprise zones" where multinational companies can compete but will not diffuse to the rest of the economy.

How market prices are formed, and whether they reflect true economic conditions and world prices or are distorted by internal regulations and subsidies, is critical to the success of the transfer and diffusion of new technologies. Most developing countries have some form of subsidized or regulated pricing of energy, with little competition. In many cases dominant state-run enterprises administer prices far removed from economic reality through cross-subsidization of inter- and intra-industry processes, which benefit selected vested interests.

The Economic Freedom Index also includes variables that reflect infrastructure investment and access to education. Case studies of developing countries make it clear that wasteful energy use is caused by lack of gas and electricity transmission capacity. This reduces the availability of the most efficient fuels and interferes both with the economic dispatch of electricity generation and with competition between efficient large-scale units and inefficient local generators. Diffusion of technology can also be hindered by a lack of skills in the labor force that is often remedied directly through FDI in which global enterprises provide training, as well as financial resources and technology.

To perform an empirical test of the theory that market imperfections are significant contributors to excessive energy use and emissions, we therefore examined each of these components of the Economic Freedom Index. We discovered that there is an even more significant relationship between energy intensity and the specific market imperfections that could be expected to prevent increased investment and technology transfer through FDI. The t-statistic indicates the likelihood that the variable in fact has a significant influence. A t-statistic of approximately two implies that there is a 95-percent probability that the indicated market imperfection has an influence on energy intensity.

This combination of variables has an R-square value of 0.36, which is even larger than that for the Economic Freedom Index as a whole, indicating that this subset of variables explains even more of the variance of energy intensity across countries.

In understanding the causes of economic growth, the statistical maxim that "correlation is not causation but it's a pretty strong hint" is particularly useful. There are strong theoretical reasons to believe that the processes that lead to lower energy use per dollar of output are frustrated by market imperfections of particular types (Bernstein et al. 2004). This theoretical connection is supported by the strong statistical association between economic freedom as a whole and energy use and the even stronger association between specific market imperfections that frustrate investment and technology transfer and energy use.

In addition, we examined other explanations of energy intensity and GHG emissions per dollar of output, and none are as strong as the link to economic freedom. One idea is that increase in income itself produces a preference for environmental benefits and leads directly to lower emissions. This is likely true for such pressing environmental needs as clear air, clean water, and efficient sanitary systems, but we find a relatively weaker relationship between per-capita income and GHG emissions per dollar of output (see figure 5). We have also partially controlled for the type of goods produced in different countries, and this does not alter the significant relationship between GHG emissions and GDP.

Figure 5: Emission per Dollar of GDP Compared to Gross National Income per Capita (2001)

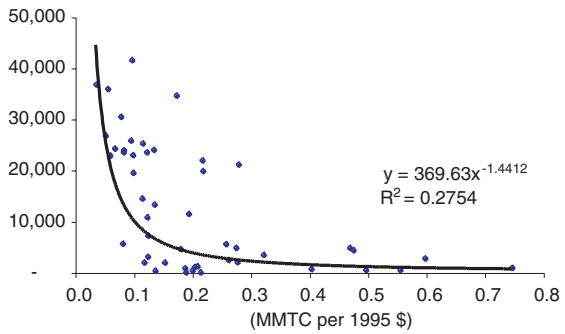


Table 4: Market Imperfections in Key Countries

China
• Large state sector, party management of business, managerial tenure • Direct price controls and subsidies through state enterprises • Banks must loan to state enterprises • FDI largely confined to Special Economic Zones and export industries, not replacing capital for domestic goods • Poor protection for property rights and contracts • Food, transport and energy prices below free market level • Investment and output figures exaggerated • FDI appears high but a large share is due to domestic savings, sent out of country and reinvested in China, but without technology transfer
India
• Large state enterprises • Restriction of some sectors to small businesses • Restrictions on FDI • Financial sector required to direct loans to specific sectors • Removing petroleum price controls but not completely free • Labor regulations skew investment toward capital-intensive operations
Indonesia
• Heavy state ownership in energy and energy-intensive industries • Regulation of energy prices • Poor enforcement of property rights and contracts • Explicit barriers to FDI and intrusive regulatory regime
Russia
• Crime and corruption, regulations discourage FDI • Restrictions on FDI in strategic sectors including gas and power • Restrictions on repatriation of capital earnings • Energy and other prices below free market levels • Gas, electricity and telecom prices set arbitrarily • Protection of property rights and contracts is weak • Large enterprises generally limited on price increases • Inconsistent and corrupt regulation increases cost and uncertainty
South Africa
• Regulation of petrol, coal and utility prices • Regional instability

Source: *Index of Economic Freedom 2004*, produced by the Heritage Foundation and the *Wall Street Journal*.

Table 4 above summarizes market imperfections that have been documented in five developing countries and one economy in transition, Russia, where emissions per dollar of GDP are similar to those of developing countries.

China's low score on economic freedom indicates pervasive market distortions. The large state sector is insensitive to market pressures to improve efficiency. Subsidized energy prices remove incentives for energy efficiency and promote coal use. Regulation, institutional bias (Blackman and Wu 1998), and lack of protection for real and intellectual property discourage multinational companies from using their best world-scale technologies, and the prevalent restriction of FDI to specific enterprise zones producing export goods does not provide for technology diffusion through the domestic economy. The European Union's refusal to recognize China as a market economy is indicative of the extent of market imperfections in China.[12]

India's large state enterprises are insulated from the market forces that promote efficiency. Many domestic industries are protected and offered favored financing that allows them to continue using inefficient technology and practices without losing out to international competition. There are also restrictions on technology imports, designed to protect domestic industries, and restrictions on FDI prevent technology transfer. Energy price regulations encourage inefficient energy use, and lack of infrastructure limits the available skills for using new technology.

Indonesia combines four of the most damaging market imperfections: pervasive government enterprises indifferent to efficiency, price regulations that discourage energy efficiency, severe restrictions on FDI, and a legal and political regime that puts all investments at risk and discourages the kinds of projects that bring in new technology.

South Africa has promise, but regulated prices, which reduce market incentives for efficient energy use, and political instability that discourages foreign investment are problems. South Africa is an interesting case, in that it also uses cheap and dirty domestic coal for power production and has an economy highly tilted toward energy-intensive activities such as gold and platinum mining and aluminum smelting. The modest score on economic freedom might be a reason why South Africa does not attract investment creating greater value-added in mining and minerals that would reduce energy intensity. South Africa's energy and carbon intensity may require a combination of policies addressing market imperfections and research and development to find new processes and forms of energy with lower emissions.

Russia's long list of severe market imperfections explains how such a powerful economy still lags so far in energy technology and greenhouse gas emissions.

Policy Implications

1. With good institutions (property rights and contracts protected, and freedom of capital flows), energy

technology will become available from overseas, and it will be viable in domestic markets if subsidies are removed and protection of state-run enterprises reduced. Inefficient technologies will be replaced faster as investment increases.

2. Traditional "sustainable development" projects sponsored by USAID and the Clean Development Mechanism (CDM) under the Kyoto Protocol will not be successful unless these market imperfections are remedied. An approach of building one project at a time with heavy subsidies in a hostile economic environment will produce no diffusion of technology—even if the project itself succeeds.

3. One size does not fit all. Different countries have very different types of market imperfections, and in some countries, emissions intensity follows logically from resource endowments. Finding the right mix of policy changes requires dialogue between individual countries, likely starting with a diagnosis of what market imperfections exist and how they can be addressed.

4. While technological improvements improve ratios of GDP to carbon dioxide, this says nothing about overall emissions. If improvements in economic freedom are achieved so that countries grow rapidly, their ratios will improve—but they may produce more emissions in the short run. If that occurs, more attention will need to be paid to research and development so that emissions intensity of new investment can be brought below levels that are now cost-effective in developed countries. The good news is that by improving economic freedom, there is a good chance that new technologies will actually be used once they are developed.

Improving Economics and Emissions

The current global environmental initiative to reduce emissions is failing. It appears unlikely that policymakers will convince developing countries to do something they have no inclination to do, which is to sign up for mandatory greenhouse gas caps that they rightly perceive will have large economic costs.

A successful policy would reconcile desire for development with reduction of carbon intensity. To achieve this, policymakers could focus U.S. and international programs to change the fundamental economic conditions in developing countries that simultaneously inhibit economic progress and keep greenhouse gas emissions high.

Improving economic freedom is necessary for the functioning of traditional aid programs that support investment in cleaner energy technologies. Otherwise, these projects are fighting a losing battle against an inhospitable economic and regulatory environment and will, as they have in the past, remain white elephants that exist only while they are paid for by donor countries.

Raising the level of economic freedom will be sufficient for most desirable outcomes as the clear association between economic freedom and energy efficiency suggests. A necessary condition is to get the institutions right that would allow for the inflow of the FDI and diffusion of new technology to take place. Until that happens, developed countries can provide the necessary financial support on the condition of demonstrated market reform.

Improved efficiency will have beneficial affects on GDP and carbon per dollar of GDP. Whether it lowers emissions overall is not the subject of this paper, but at least helping developing countries with growth may make them trust U.S. policymakers more if Kyoto-style emissions limits prove to be essential.

Notes

1. The Copenhagen Consensus Project, founded by "skeptical environmentalist" Bjorn Lomborg and run by some of the world's best known economists, recently considered GHG-emission reductions a "bad" policy investment (especially as compared with combating disease, lowering trade barriers, and dealing with chronic water problems). This study is available at www.copenhagenconsensus.com. The World Summit on Sustainable Development (WSSD) reaffirms the need to have a balanced economic development, social development, and environmental protection. In addition, it also reaffirms poverty eradication and preservation of the environment as the overarching objectives of sustainable development (United Nations 2002).

2. A1 IMAGE and B2 MESSAGE are two representative scenarios from the forty scenarios developed by IPCC using different forecast assumptions of the state of the world. The A1 storyline is based on a rapid and successful economic development, whereas the B2 scenario takes into account increased environmental and social sustainability concerns.

3. If purchasing power parity exchange rates are used instead of market exchange rates then the differences in

intensities will change and will be closer together. However, the convention established by IPCC and other agencies is to use market exchange rates, and hence this is done in this paper.

4. The energy intensity differences could also result from differences between the structure of developed and developing countries' economies.

5. Z. Zhang (2003) points out that the shift in the structure of economies from energy-intensive to less-energy-intensive caused real energy intensity to decline over the past two decades. Fisher-Vandan et al. (2003) suggest that the main reasons for improvement in energy use in China are increasing energy prices, research and development expenditures, reform in the ownership structure of the enterprise, and structural shifts at the industrial level.

6. The authors would like to thank Neil Emerick for providing electronic versions of the Freedom Index.

7. The Economic Freedom Index contains thirty-eight variables, including eighteen survey-based variables obtained from survey data published in the International Country Risk Guide and the Global Competitiveness Report, which cover a variety of aspects of economic freedom and are weighted into an overall index for each country.

8. Economic Freedom of the World, Annual Report, 2001.

9. Energy per GDP, carbon per GDP, and Freedom Index for the United States are 31,695, 0.17, and 7.8 respectively (source: EIA).

10. This is a very high percentage for cross-sectional data of this type.

11. Gross national income per capita was included as a separate explanatory variable in the regression model discussed in the next section. The explanatory power (R-square) decreased from 0.36 to 0.32.

12. The *Financial Times*, (June 28, 2004), reported that the European Union will refuse "market economy" status to China. The European Commission believes that China has a long way to go, and the report identifies four major challenges: reduce government influence on the economy; implement transparent and non-discriminatory company law; implement effective and transparent property rights laws; and build an independent and market driven financial sector.

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