Journal of Agricultural and Applied Economics, 36,1(April 2004):49–64

Global Demand for U.S. Environmental Goods and Services

Brock Avery and Fred O. Boadu

This paper reports import demand elasticities for environmental goods and services (EGS) for the world in aggregate and for six world regions. The paper involves a pooled cross-section and time-series estimation procedure and makes per capita demand for EGS a function of economic, political, and structural factors. The results show that per capita incomes, exchange rates, political and economic freedoms, and debt affect the demand for EGS. The results also show that demand for EGS is tied to the particular environmental problem facing a particular region. Exporters of EGS need to disaggregate world markets to better target products.

Key Words: demand elasticities, environmental goods, international trade

JEL Classifications: F18, F14

There is considerable public debate concerning the relationship between trade and the environment. Some have argued that countries may lower domestic environmental standards in an effort to give their domestic firms a competitive edge in a liberalized world trade regime (French). Others see complementarities between trade and the environment and the possibility of adapting cold war-driven technology to develop materials that solve some of the most pressing problems (disease, food and fiber, hunger, peace) facing mankind (National Science and Technology Council). The development and trade in environmental goods and services (EGS) is central in this latter debate. Former Vice-President Al Gore, an early proponent of this view, recommended the establishment of a "Global Marshall Plan" for environmental protection and to promote U.S. EGS industries (Gore). However, the EGS sector of the economy is quite complex and little is known about the market. There is a need for research information as input in public policy making to support U.S. EGS firms in the global marketplace.

This paper reports global demand elasticity estimates for U.S. EGS. Demand elasticity estimates help identify those regions of the world where expenditures of additional marketing resources are most likely to yield the highest benefit in terms of improving the competitive position of U.S. firms in the global EGS market. The next section of the paper defines the EGS market and identifies the key "demand drivers." It also discusses the structure and performance of the market, including brief backgrounds of world regions and their EGS markets. The model, hypothesis, and data sources use the demand drivers previously identified to formulate statistical regional demand equations that are estimated using secondary data. The different demand elasticity estimates are used to draw conclusions for U.S. trade policy and ways of improving the competitive position of firms in the global environmental goods market.

Brock Avery is a Benefits Analyst, Hewitt Associates, Woodlands, TX. Fred Boadu is associate professor, Department of Agricultural Economics, Texas A&M University, College Station, TX. The authors thank Linda Crenwelge, Department of Agricultural Economics, Texas A&M University, for editorial assistance.

Scope of the EGS Market

Defining the EGS Industry

The EGS market, or more generally the 'environmental technology' market, is defined by those environmental technologies that "advance sustainable development by reducing risk, enhancing cost-effectiveness, improving process efficiency, and creating products and processes that are environmentally beneficial or benign" (U.S. Department of Commerce). A European Union (EU) Commission adopts the Organisation for Economic Co-Operation and Development (OECD)/Eurostat definition of the eco-industries, and defines the environmental technology market as "all activities which produce goods and services to measure, prevent, limit, minimize, or correct environmental damage to water, air, and soil, as well as problems related to waste, noise, and ecosystems" (Commission of the European Communities). *The Trade and Industry Outlook Report* identifies water supply and treatment, solid waste management, air pollution control, and environmental cleanup as the four main segments of the industry.

Structure

Measures of the size of the market depend on who is doing the measurement, and especially what is being counted as an environmental good or service. The various measures put the market between $200 and $500 billion (Environmental Business International Inc. [EBI]; EU; OECD). A previous study identified 117,000 U.S. companies engaged in the business of environmental technologies (U.S. Department of Commerce). The industry earned US$196.5 billion in 1999 and supported 1.4 million U.S. jobs (U.S. Department of Commerce/International Trade Administration [ITA]). The ITA has projected the global market to top US$545 billion by the year 2004. EU firms earned about EURO 183 billion and supported 1.6 million jobs (EU). The industry is made up of a few large firms, and a large number of small- or medium-sized enterprises. The structure of the U.S. firms contrasts with the structure of European and Japanese firms, which are typically divisions of well-capitalized conglomerates that operate in other major markets, including the United States (Menes).

Performance

The U.S. domestic market for environmental technologies is very big so only a few firms are engaged in exporting internationally. This may be one of the reasons why little attention has been paid to the international trade issues facing the industry. U.S. firms face increasing competition from foreign investment, technology, and expertise. According to an OECD study, competitive advantage in the EGS industry is based on four factors: technological innovation, quality and service performance, marketing and export strategies, and flexibility in production (OECD). However, scale economies, size and breadth of a firm's abilities, and cost were considered less important (OECD). The factors noted above are probably the most relevant for competing in the developed world. However, in the developing world, firm size, breadth of capability (either singly or through joint ventures), experience in negotiating standards on a facility-by-facility basis, and cost may be more important (U.S. International Trade Commission).

The EGS industries in the United States, Germany, Japan, and elsewhere compete aggressively in third markets, particularly developing countries. The three largest market shareholders are the United States (37%), Western Europe (30%), and Japan (18%). No other country or region holds more than 5% of the market (EU). The competition in the EGS market is in effect a three-way race between the three largest market shareholders. Some of the countries in Asia have been able to find niche markets and are performing well by way of exports.

Americas

U.S. export of EGS to Latin America was about US$9.4 million in 1997 (U.S. Department of Commerce). Mexico is the largest single market, with current sales of about US$3

billion, and is projected to reach US$3.8 billion in 2008 (U.S. Department of Commerce). The two principal environmental problems in Mexico are air and water pollution. Consequently, the major environmental goods in demand in Mexico include air pollution monitoring equipment, technologies for converting fuels, and air pollution control and abatement systems for stationary pollution sources (scrubbers, bag filtering systems, and nitrous oxide control systems), and modernization of water treatment plants (TPCC 1994a). Brazil, Venezuela, Chile, Argentina, and Colombia represent a $4 billion market in air and water pollution control and abatement systems, technologies, and services (TPCC 1994b). The major "demand drivers" in Latin America include the commitment to the production of clean fuels, installation of catalytic converters, improved automobile efficiencies, privatization of regional water companies, municipal and industrial water pollution control equipment, and services (U.S. Department of Commerce).

The European Market

The European market is the largest market for U.S. environmental goods and services (U.S. Department of Commerce). The U.S. exported US$146.7 billion in 1998 and is projected to reach US$158 billion in 2005 (U.S. Department of Commerce). The primary demand drivers are the *Directives* issued by the EU. The key sectors are water, air pollution, solid waste, and hazardous waste recycling. Despite the large size of the market, U.S. firms have to develop strategic approaches to be competitive. Two principal reasons call for a need to strategize. First, these countries are highly industrialized and have developed domestic environmental industries to satisfy demand. Second, the adoption by these countries of a uniform environmental standard, which is widely believed to be heavily Germany-friendly, may significantly raise market entry costs for U.S. firms. It is also possible that a carefully crafted strategy in response to the uniform standards could reduce the cost of doing business in Europe since firms do not need to comply with different standards.

Central and Eastern Europe

U.S. exports of EGS to Central and Eastern Europe was about US$8 billion in 1998 and projected to rise to US$18 billion by 2005 (U.S. Department of Commerce). History and economics are the principal factors driving the demand for EGS in these regions. Historically, over 45 years of Communist neglect of the environment has created a need for an accelerated cleanup program. On the other hand, these countries face major budget constraints that may shift priorities away from environmental cleanup. The process of democratization should strengthen the voice of environmental groups and increase the demand for EGS. The critical demand sectors include water pollution control, waste recycling, and instruments.

Middle East and North Africa

EBI estimated the market size at $5 billion, with a 3.8% annual growth rate. Political instability, combined with a general lack of environmental awareness, is a major impediment to developing markets in this region. The Commerce Department/ITA cites rising air pollution levels in major Israeli cities as an impetus for the rising environmental awareness in that country. Israel is seen as a strong future best prospect, although currently its air pollution control market is only $20 million. The Turkish market presents good opportunities not only for pollution control equipment sales, but also for design, engineering, and contracting services. The major customers are state organizations and infrastructure projects in the tourist regions. The newness of the market masks the potential for its ultimate size. The annual Turkish water and air pollution control market is estimated at $225 million, with Germany holding a 50% share.

Asia and Pacific

Estimates of the size of the EGS market in Asia is about US$21.8 billion and is projected

to reach US$31.5 billion by 2004 (U.S. Department of Commerce). Taiwan, Hong Kong, and Korea are the major markets. There is a strong commitment to improving the environment in these countries as reflected in the open market and procurement policies, a strong regulatory regime, strict enforcement practices, and the significant public investment in environmental cleanup (Delphos). Countries within the Association of Southeast Asian Nations, especially Thailand, Indonesia, Malaysia, and the Philippines, are also major consumers of EGS. The major EGS demand is targeted to the solid-waste handling and disposal services sector, and filtration and purification equipment for water and wastewater.

Sub-Saharan Africa

The EGS market in the African market is projected to experience decent growth, but from a small base. The 1996 market was estimated at US$2.2 billion with a 10% growth rate (EBI). The major EGS sector is the water and wastewater sectors. Almost all the countries in Africa face major budgetary, debt service, and foreign exchange constraints. The economic conditions in these countries make the roles of the World Bank, the African Development Bank, and other donor and bilateral agencies important in their EGS markets.

Model, Hypothesis, and Data Sources

The model used in this study is adapted from a study by Green and Kohli. The authors studied the relation between size of the export market for 102 manufactured products and the gross domestic product (GDP), socioeconomic development, external debt-to-GDP ratios, and proportion of fuel imports in total imports for 82 nations for the years 1970, 1977, and 1981. Our paper uses data covering the 5-year period 1992–1996 to estimate the import demand for EGS. The paper makes the per capita country demand for environmental goods imports a function of eight country-specific characteristics grouped around economic, political, and structural factors as follows:

Economic factors:

(1) real per capita gross domestic product of the country
(2) real exchange rate of the country relative to the US$
(3) debt service payments to exports ratio

Political factors:

(1) index of political rights and civil liberties
(2) index of economic freedom

Structural factors:

(1) percent of population with access to safe water
(2) per capita greenhouse gas emissions
(3) level of a country's economic development

The importance of the economic factors is easily explained. There is a positive income elasticity of demand for a clean environment, whereas a favorable exchange rate regime, that is, a regime that makes U.S. EGS cheaper in overseas markets, is likely to encourage imports. On the other hand, a country facing high debt service payments is unlikely to import environmental goods and services. The political factors are included for two main reasons. First, democratic political regimes make it possible for environmental groups to pressure their governments to protect the environment. Such pressure may lead to increased imports of environmental goods. Second, political and economic reforms have become an important component of foreign aid policies of donor countries. It is of interest to know whether these demands for political reforms influence the demand for environmental goods imports. The structural variables capture the essential conditions in a country that may influence the import demand for EGS in the country. For example, high population growth creates a demand for both potable water and wastewater treatment infrastructure and equipment. Likewise, high per capita greenhouse gas emissions require emission reduction equipment, especially if the country is responding to the requirements under the Kyoto Protocol. The overall level of a country's development is considered a structural variable that captures

the broader problem of poverty and its relation to the demand for EGS.

Probably the major problem in studying the EGS market is the availability of timely information. This is reflected in the date of the data and references used in the study. The information used in this study is the most reliable and accurate on the basis of consultations with the experts at the U.S. Department of Commerce. The dependent variable in this study is the real dollar value (in 1990 constant dollars) of U.S. domestic exports of EGS. Four categories of EGS are studied. These are (1) water pollution control products, which include water filtering or purifying machinery, filtering or purifying machinery and apparatus, parts for filtering and purifying, and oil separation equipment; (2) air pollution control goods, which include dust collection and air purification, electrostatic precipitators, industrial gas cleaning equipment, parts of machinery and apparatus, and catalytic converters; (3) solar energy equipment, which include solar cells in modules or panels, and solar cells not in modules or panels; and (4) monitoring instruments, which include gas or smoke analysis apparatus, exposure meters, and instruments for checking radiation. Statistics on the export of these products have been kept by the U.S. Department of Commerce since 1990, and are organized according to the International Harmonized Commodity Description and Coding System (HS) (U.S. Dept. of Commerce). A detailed explanation and sources of variables are presented below.

Economic size (GDP). The economic size of a nation has been suggested as an important factor influencing the imports of a nation (Douglas, Craig, and Keegan). Since 1991, there has been considerable discussion on what is popularly referred to as the Environmental Kuznets Curve (EKC) that posits a relation between income change in a country and environmental quality. The EKC introduced the idea that contrary to previous thinking, economic growth could actually improve the environmental quality in a country. In its barest essential, the view is that "GDP growth creates the conditions for environmental improvement by raising the demand for improved environmental quality and makes the resources available for supplying it" (Yandle, Vijayaraghavan, and Bhattarai). The authors are quick to note that the validity of the EKC relation is critically dependent on such supportive institutions as government policies, markets, and social structures. Economic size was measured in terms of the per capita GDP in constant 1990 dollars for the years included in the study. The data sources for GDP are *World Resources* (World Resources Institute), *World Tables 1995* (World Bank), *International Marketing Data and Statistics 1995* (Euromonitor 1995b), *European Marketing Data and Statistics* (Euromonitor 1995a), *OECD Main Economic Indicators* (OECD), *United Nations Monthly Bulletin of Statistics* (United Nations 1996), and *Statistical Yearbook for Asia and the Pacific* (United Nations 1995). A plausible hypothesis based on the existing literature is that there is a positive relation between the economic size of a country and imports of EGS.

Exchange rate (EXCH). This variable is measured as the percentage change in the average yearly dollar value of a country's currency. When the value of a country's currency is higher relative to the dollar, the country can import more from the United States. Therefore, a positive relation between the exchange rate and imports of EGS is expected. The data sources for this variable are the *International Financial Statistics* (IMF), the *International Marketing Data and Statistics 1995* (Euromonitor 1995b), and the *Statistical Yearbook for Asia and the Pacific* (United Nations 1995).

Debt service (DEBT). Debt service of a country is measured as the sum of actual payments of principal and interest on loans made in foreign currency. The inference is that nations with heavy foreign debt service payments face problems in importing EGS from the United States since they are under pressure to run a trade surplus to service the debt. The sources for this data are *International Financial Statistics* (IMF) and *World Resources* (World Resources Institute).

Democracy (DEM). Whether democratic regimes are more likely to be concerned about

the environment is an open question. McMillan, Rausser, and Johnson found a positive relation between democracy and economic growth. By extension, it is hypothesized that there exists a positive relation between democracy and the demand for EGS. Also, one may argue that the opportunity in democratic regimes for citizens to question their government about the state of their environment leads to a cleaner environment. Under U.S. law, for example, citizens may bring suit to enforce environmental regulations. Since several countries around the world have initiated reforms to expand citizens' participation in policy making, this variable was included to test the possible relation between democracy and imports of EGS. Since 1972, Freedom House (Freedom House) has compiled indices of political and civil rights. These indices are measured on a scale of 1 to 7, with 1 representing the highest degree of freedom and 7 the lowest.

Economic liberty (ECLIB). The Heritage Foundation's *Index of Economic Freedom* (Johnson and Sheehy) shows that economic liberty defines who gets to participate in a market, and in turn the import opportunities in a country. The study by McMillan, Rausser, and Johnson found that economic liberty has the same effect on growth as democracy. The factors considered in developing the *Index of Economic Freedom* include average tariff rates, tax rates on personal and corporate income, government consumption of economic output, inflation rate, capital flows and foreign investment policy, openness of banking system, wage and price controls, property rights, regulation of opening and operating a business, and black market. Each factor is graded on a scale of 1 to 5, where a score of 1 signifies policies most conducive to economic freedom, and a score of 5 signifies policies least supportive of economic freedom. The factors are weighted equally. A country with a low aggregate score exhibits freer economic policies than a country with a high aggregate score. A positive relation between economic liberty and imports of EGS is expected.

Access to safe water (SAFEWAT). Access to safe water is defined as the percentage of total population with a reasonable means of getting clean water. A higher percentage of the population with access to safe water suggests an ongoing public commitment to economic development, sewage, and wastewater treatment facilities. Such a public commitment to safe water creates an opportunity for U.S. water pollution equipment exporters. It may be the case that developed countries may have already invested in their own production of such equipment and thus do not have a high import demand. In this case, one would expect positive but smaller coefficients than for developing countries that have to import all their equipment and services needs. Generally, however, the higher the access to safe water, the higher the government's emphasis on water purification for its citizens, thus the higher the import demand for EGS. The sources for water pollution statistics are *The Environmental Data Book* (World Bank 1993), the *Human Development Report* (UNDP 1996), and *the World Military and Social Expenditures* (Sivard).

Carbon dioxide emissions per capita (CARBEM). Measured in hundreds of thousands of metric tons of carbon dioxide a country releases into the atmosphere during a period of time, usually 1 year, divided by its total population. The source of carbon dioxide emissions is mainly burning fossil fuels, such as coals, petroleum products, and natural gas. Other greenhouse gas emissions, mainly methane, come from municipal solid wastes and livestock wastes. The combined figure from these two sources in each country is used in this study. The data are compiled by the Carbon Dioxide Information Analysis Center (CDIAC) and represent a complete harmonized global data set of carbon dioxide (CO_2) emissions. The technical notes supporting the reported data do not reveal any weighting of the emissions from various sources. The data were gathered from *World Resources* (World Resources Institute). All countries included in our analysis are participants in the Kyoto Protocol so there was no need to control for participants versus nonparticipants in the Protocol. Countries with high levels of carbon

emissions are more likely to import more EGS.

Socioeconomic development (DEV). The socioeconomic development of a country measures the general well being and is a much broader concept than the GDP measure. Using the best data available, the United Nations Development Program (UNDP) has compiled human development indicators for countries on the basis of three essential elements of human life—longevity, knowledge, and standards of living. We have used this index to measure the overall socioeconomic development in a particular country. This is a single uniform measure published annually by the UNDP. The data source is the UNDP (*Human Development Report*). It is hypothesized that a positive relation exists between DEV and the imports of EGS by countries.

A simple linear relation was assumed between the dependent variable and the independent variables. The mathematical expression of the model is as follows:

$$\begin{aligned}(EGS)it = {} & a_0 + a_1(GDP)it + a_2(EXCH)it \\ & + a_3(DEBT)it + a_4(DEM)it \\ & + a_5(ECLIB)it + a_6(SAFEWAT)it \\ & + a_7(CARBEM)it + a_8(DEV)it \\ & + u_{it},\end{aligned}$$

where $a_0, \ldots, a_8$ are coefficients to be estimated, $i = 1, \ldots, N$ represents selected countries in the world, $t = 1, \ldots, T$ represents time, and u = random error term in country i at time t assumed $N(0, \sigma^2)$. The expected signs for the estimated coefficients are a_1, a_2, a_4, a_5, a_6, a_7, a_8, >0, and $a_3 < 0$ for each country, as well as for various regions of the world (Americas, Western Europe, Eastern Europe, Asia and Pacific, Middle East and North Africa, and Sub-Saharan Africa).

A pooled cross-section time-series estimation technique suggested by Kmenta was used to estimate EGS import demand elasticities for 82 countries grouped into six world demand regions. The Kmenta approach corrects for both autocorrelation and heteroscedasticity in the error terms for the model used in the study. The use of this approach is reasonable because in pooling together countries large and small, it is conceivable that variances of variables may differ across countries. Furthermore, since the data is pooled over time, errors may be carried from one period to the other and lead to imprecise coefficient estimates. The Kmenta method entails transforming the data twice, once to remove autoregression if present, and again to remove heteroscedasticity.

To remove heteroscedasticity, ordinary least squares (OLS) regression is applied to all $T \times N$ observations. These estimates are unbiased and consistent. A correlation coefficient of residuals (rho vector) between time periods is estimated via a first-order autoregressive scheme for each of the i cross-sectional units. To purge the data of the heteroscedasticity, OLS is applied again to the data purged of the autocorrelation. The error variances and covariances are estimated from the regression residuals of the transformed model. Given the difficulties with import data for several of the regions, U.S. export data as reported by the U.S. Department of Commerce was used.

Tables 1 through 5 report estimates of import elasticities for total EGS and for the four environmental goods categories—air pollution, water pollution, instruments, and solar equipment. The estimates represent total world import demand, and the import demand in the six regions of the world as defined by the United Nations. Countries included under each region are shown in Appendix B. All variables were measured in logarithms so the reported estimates represent direct import elasticity measures.

The overall performance of the model is quite satisfactory with an R^2 ranging from a high of 93% to a low of 61%. With a few exceptions, the results confirm the hypotheses in the study. Total environmental goods imports will increase with a rise in incomes in all regions of the world. A 10% increase in growth will lead to about a 3% increase in the demand for all environmental goods. On a regional basis, the highest increases in demand would occur in the developing areas of the world—6% in Asia and the Pacific, about 5.6% in the Middle East and North Africa, about a 5% increase in Sub-Saharan Africa,

Table 1. Estimated Import Demand Elasticities: Total EGS

	World	Americas	Western Europe	Eastern Europe	Asia and Pacific	Mid-East, N. Africa	Sub-Saharan Africa
CONST	1.91**	2.26**	2.10**	1.40*	3.48*	1.14*	1.85**
	(2.23)	(1.83)	(2.03)	(2.68)	(5.37)	(2.89)	(2.11)
GDP	0.33**	0.43**	0.25**	0.44**	0.62**	0.56**	0.51**
	(6.01)	(3.57)	(5.86)	(3.84)	(4.98)	(3.14)	(5.39)
EXCH	0.17*	−0.10**	0.15**	0.20*	0.15**	0.06*	−0.09*
	(2.24)	(3.54)	(3.06)	(2.29)	(4.16)	(2.16)	(1.94)
DEBT	−2.24**	−2.18*			−2.38**	−2.39**	−2.83**
	(2.50)	(2.09)			(3.07)	(2.50)	(2.29)
DEM	2.51**	2.43**	2.83*	2.70**	3.45*	2.69**	3.28**
	(8.92)	(3.16)	(1.91)	(7.02)	(2.11)	(4.37)	(2.42)
ECLIB	3.88**	3.62*	4.11**	4.08**	4.31**	3.32*	3.81**
	(4.01)	(1.99)	(2.51)	(7.26)	(4.14)	(1.96)	(2.19)
DEV	4.72**	5.37**			5.45*	4.87**	5.34**
	(3.60)	(2.42)			(1.79)	(7.23)	(3.43)
R^2	0.80	0.75	0.85	0.89	0.82	0.86	0.93
D-W	1.71	2.03	1.79	1.85	1.70	1.82	1.71
n	410	110	75	55	85	50	35

Notes: *t*-statistics are in parentheses; ** estimated coefficient is significant at the 1% level; * estimated coefficient is significant at the 5% level.

Table 2. Estimated Import Demand Elasticities: Air Pollution Control Products

	World	Americas	Western Europe	Eastern Europe	Asia and Pacific	Mid-East, N. Africa	Sub-Saharan Africa
CONST	1.58**	1.09**	1.99*	0.98*	2.44**	0.34**	0.21*
	(2.45)	(4.64)	(1.89)	(1.90)	(2.49)	(2.90)	(1.88)
GDP	0.54**	0.56**	0.46**	0.74**	0.59**	0.66*	0.43**
	(3.25)	(3.52)	(6.92)	(4.41)	(3.09)	(2.05)	(3.93)
EXCH	0.11*	−0.08**	0.21**	0.17**	0.19**	0.15*	−0.06**
	(2.03)	(2.67)	(6.79)	(2.78)	(2.83)	(2.27)	(2.23)
DEBT	−2.37**	−2.71*			−2.14**	−2.09**	−2.51**
	(7.65)	(2.20)			(2.85)	(4.62)	(4.11)
DEM	2.65**	2.47**	3.03*	2.59*	3.15**	2.59**	2.81**
	(1.87)	(2.89)	(2.38)	(2.12)	(3.39)	(2.56)	(2.60)
ECLIB	4.11**	3.86*	4.13*	4.51*	5.21**	4.08**	4.71**
	(6.75)	(1.85)	(1.99)	(2.37)	(7.21)	(1.65)	(2.68)
CARBEM	2.67*	3.36**	2.55**	3.18**	2.72**	3.13*	0.84*
	(3.29)	(2.41)	(2.85)	(8.02)	(2.79)	(1.86)	(1.71)
DEV	4.78**	5.03**			4.77*	4.87**	5.38**
	(2.43)	(2.50)			(1.93)	(2.83)	(2.52)
R^2	0.83	0.73	0.89	0.88	0.87	0.81	0.67
D-W	1.83	2.02	1.71	1.78	1.83	1.76	1.84
n	410	110	75	55	85	50	35

Notes: *t*-statistics are in parentheses; ** estimated coefficient is significant at the 1% level; * estimated coefficient is significant at the 5% level.

Table 3. Estimated Import Demand Elasticities: Water Pollution Control Products

	World	Americas	Western Europe	Eastern Europe	Asia and Pacific	Mid-East, N. Africa	Sub-Saharan Africa
CONST	1.57**	1.81**	2.16*	0.92**	1.96**	0.61*	0.23*
	(2.63)	(2.53)	(1.88)	(2.84)	(2.83)	(1.69)	(1.70)
GDP	0.51**	0.49**	0.61**	0.59**	0.49**	0.57*	0.46*
	(4.61)	(8.94)	(9.09)	(2.51)	(7.23)	(1.91)	(2.18)
EXCH	0.18**	−0.13**	0.13**	0.25**	0.15**	0.08*	−0.12**
	(2.36)	(3.27)	(4.34)	(3.33)	(3.28)	(2.00)	(3.38)
DEBT	−2.41**	−2.22**			−2.33*	−2.51**	−2.88**
	(1.86)	(2.13)			(1.89)	(2.84)	(2.69)
DEM	2.36*	2.83**	3.25*	2.61**	2.65**	2.77**	3.12**
	(2.09)	(2.95)	(1.93)	(3.34)	(4.45)	(2.35)	(2.61)
ECLIB	3.91*	3.88*	4.12**	4.29**	3.79**	4.04*	4.59**
	(1.90)	(1.95)	(3.04)	(8.35)	(4.54)	(2.24)	(3.96)
SAFE-WAT	7.93*	8.33*		8.07**	7.57**	8.29*	9.04**
	(1.82)	(1.87)		(2.53)	(2.51)	(1.92)	(2.46)
DEV	5.16**	5.02**			5.31*	4.83**	4.96**
	(2.44)	(2.59)			(2.19)	(4.78)	(2.48)
R^2	0.83	0.72	0.69	0.79	0.68	0.77	0.81
D-W	1.84	1.79	1.76	1.87	1.73	1.79	1.80
n	410	110	75	55	85	50	35

Notes: *t*-statistics are in parentheses; ** estimated coefficient is significant at the 1% level; * estimated coefficient is significant at the 5% level.

Table 4. Estimated Import Demand Elasticities: Monitoring Instruments

	World	Americas	Western Europe	Eastern Europe	Asia and Pacific	Mid-East, N. Africa	Sub-Saharan Africa
CONST	1.24*	1.12*	1.97**	0.63**	1.96**	0.55*	0.41*
	(1.78)	(1.80)	(2.55)	(2.66)	(3.03)	(1.80)	(1.94)
GDP	0.55**	0.49**	0.61**	0.52**	0.68**	0.56**	0.65**
	(2.49)	(2.79)	(2.73)	(3.26)	(6.66)	(2.38)	(3.04)
EXCH	0.15**	−0.08*	0.18**	0.11*	0.21*	0.16**	−0.12*
	(2.86)	(1.96)	(2.37)	(2.19)	(2.29)	(2.72)	(2.16)
DEBT	−2.35**	−2.45**			−2.41**	−2.32**	−2.62**
	(4.61)	(3.32)			(5.78)	(3.51)	(2.48)
DEM	2.43*	2.51*	3.16*	2.71**	2.59**	3.48*	3.23**
	(2.10)	(2.14)	(2.20)	(2.81)	(2.76)	(1.94)	(3.91)
ECLIB	4.21*	4.27*	3.77**	4.01**	3.85**	4.23**	3.98**
	(1.90)	(2.00)	(2.69)	(7.03)	(3.96)	(2.61)	(3.38)
DEV	4.81**	5.21*			4.65**	5.38**	5.17**
	(2.59)	(1.96)			(2.56)	(3.51)	(2.52)
R^2	0.76	0.61	0.82	0.89	0.84	0.76	0.86
D-W	1.87	1.85	1.79	1.74	1.89	1.73	1.85
n	410	110	75	55	85	50	35

Notes: *t*-statistics are in parentheses; ** estimated coefficient is significant at the 1% level; * estimated coefficient is significant at the 5% level.

Table 5. Estimated Import Demand Elasticities: Solar Products

	World	Americas	Western Europe	Eastern Europe	Asia and Pacific	Mid-East, N. Africa	Sub-Saharan Africa
CONST	0.78	0.69**	1.28*	0.09*	1.62*	0.48*	0.04*
	(1.08)	(3.07)	(1.90)	(2.34)	(1.88)	(1.76)	(1.95)
GDP	0.61**	0.57**	0.54**	0.37**	0.41**	0.49**	0.32**
	(4.14)	(6.87)	(8.76)	(3.31)	(5.26)	(3.02)	(2.87)
EXCH	0.23**	−0.09**	0.17**	0.16*	0.14**	0.15**	−0.04*
	(2.56)	(3.06)	(5.09)	(2.31)	(3.23)	(2.45)	(1.97)
DEBT	−2.53**	−2.32**			−2.25*	−2.78*	−2.99**
	(5.88)	(4.91)			(2.21)	(1.93)	(3.83)
DEM	2.42**	2.71**	2.33*	2.61*	2.75*	2.55**	2.84**
	(2.87)	(3.00)	(1.93)	(2.21)	(2.16)	(2.51)	(2.91)
ECLIB	4.59**	4.57*	4.31**	5.53*	4.92**	4.83**	5.29**
	(3.00)	(2.11)	(4.19)	(2.35)	(3.14)	(2.61)	(2.77)
DEV	4.84*	4.91*			5.51*	4.74*	5.65**
	(2.00)	(1.96)			(1.92)	(1.91)	(2.95)
R^2	0.77	0.75	0.91	0.66	0.71	0.86	0.75
D-W	1.85	1.69	1.86	1.72	1.93	1.71	1.72
n	410	110	75	55	85	50	35

Notes: *t*-statistics are in parentheses; ** estimated coefficient is significant at the 1% level; * estimated coefficient is significant at the 5% level.

and a 4.3% in the Americas. The estimates for the developing regions contrast with those for Western Europe, where a 10% increase in income leads to only a 2.5% increase in the import demand for EGS from the United States. The results reflect the ability of Western European countries to meet their EGS needs from domestic industry sources. The results also show that for all regions, except the Americas and Sub-Saharan Africa, a favorable exchange rate regime would increase import demand. One explanation for the unexpected results for the Americas and Africa may be the persistent interference in the exchange rate market by the governments in the two regions.

The expanding debt of the developing world has adverse implications for EGS import demand. A 10% increase in the debt of Sub-Saharan Africa, for example, is predicted to lead to about a 28% decrease in the demand for EGS. Since the relation between debt and EGS demand is highly elastic, a solution to the debt crisis of the developing world would significantly help U.S. EGS firms. A consistent source of controversy between the developed and developing world concerns the issue of whether countries should focus on the overall economic development of the country or undertake discrete actions (new environmental regulations, new institutions, bigger budgets, etc.) to protect the environment. The estimates support the position of developing countries who have argued that the overall economic development of a country is the critical factor in the search for strategies to improve the environment.

The regression results show a strong positive relation between the degree of democratic development and the import demand for EGS. This means that giving greater 'voice' to stakeholders would increase the demand for EGS. Of particular interest is the estimate for economic freedom. Reductions in tariff and nontariff barriers to trade will lead to significant increases in EGS import demand. A 10% increase in economic liberty leads to over a 30% increase in EGS demand for all regions of the world. If one associates liberalized regimes with an open world trading regime, then the estimates would seem to refute the popular concern that a liberalized world trade regime would lead to a dirtier world. Slightly lower elasticity estimates were obtained in the case of the political liberty variable. However, even in this case, a 10% increase in liberty leads to over a 20% change in the import demand for EGS for all regions of the world.

The estimates for the individual environmental goods follow the pattern found in the case of total environmental goods. However, the magnitude of the elasticity estimates differs, and seems to reflect the importance of a particular environmental problem in a particular region. For example, in all regions of the world, the income elasticity estimates for air pollution are very high, possibly reflecting the heightened concern over air quality that resulted in the Kyoto Protocol. The carbon emissions (CARBEM) variable to measure air pollution in a country was highly significant in those regions of the world where carbon emissions are high. Thus, the high elasticity estimates for the world (2.67), the Americas (3.36), and Eastern Europe (3.18) contrast with the low but insignificant (1% level) elasticity estimate (0.84) for Sub-Saharan Africa where air pollution is not a major environmental problem.

In the case of water pollution, however, we find the import demand elasticity for Sub-Saharan Africa to be very high (9.04), and statistically significant at the 1% level. For instruments, the estimated import demand elasticity with respect to income (0.68) is highest for the Asia and Pacific region, and highly significant at the 1% level. This reflects the effect of the efforts being made by the newly industrializing nations in that region to take advantage of emerging technologies in the environmental goods market. The estimated import elasticities for solar technologies show that Sub-Saharan African countries could be an important market for U.S. exports. Continuing liberalization of the market, overall economic development, and reduction in debt are among the principal factors influencing the demand for solar products in Africa.

Conclusions

The import demand elasticities reported in this study show that the structural conditions, de-

mands, and priorities in countries differ, and the competitiveness of U.S. EGS industries hinges on a careful segregation of these world markets. The results show a positive and highly significant relation between political liberties, economic liberties, GDP, and overall development and the import demand for EGS by countries around the world. There is a deeper implication of these results for U.S. trade policy in general. The trend in developing nations toward democracy, free markets, and economic growth has significant economic benefits for U.S. environmental goods industries. In this context it may be justifiable to revisit the *Peace, Prosperity, and Democracy Act of 1994,* and also strengthen initiatives such as the *Africa Growth and Opportunity Act,* the *Caribbean Basin Trade and Partnership Act,* and the *U.S.–Asia Environmental Partnership* (USAEP). All these initiatives have sought to institutionalize the relation between democracy, free markets, and economic growth.

The results also suggest a need for examining the overall U.S. trade policies, especially subsidy and tariff policies that may give false signals to other countries about the country's commitment to open and fair trade. A wrong signal to the rest of the world that the U.S. is unwilling to open its markets to imports will work to the disadvantage of environmental technology exporters. It is also important for the U.S. to revisit the proactive approach that brought attention to the EGS market in the early 1990s. One such proactive initiative was the formation of the USAEP in 1992 to promote the adoption of technologies and practices to address environmental issues in Asian countries (http://www.usaep.org/).

The USAEP is a public–private sector partnership led by the U.S. Agency for International Development in collaboration with the U.S. Department of Commerce and the U.S. Environmental Protection Agency. Recently, the USAEP was recognized for undertaking programs that have resulted in "550 direct sales, joint ventures, licensing agreements and infrastructure contracts, or $1.4 billion in U.S. environmental exports leading to the creation of 26,800 jobs, according to SBA guidelines" (http://www.usaep.org/). Since the results from this paper point to positive demands for EGS, it may be useful to explore the possibilities of replicating the USAEP framework to promote EGS exports to other regions of the world.

[Received July 2002; Accepted September 2003.]

References

Commission of the European Communities. *Report From the Commission: Environmental Technology for Sustainable Development.* Brussels, 2002.

Delphos, W.A. *Environment Asia/Pacific: The Executive's Guide to Government Resources.* Washington, DC: Venture Publishing, North America, 1994.

Douglas, S.P., C.S. Craig, and W.J. Keegan. "Approaches to Assessing International Marketing Opportunities for Small- and Medium-sized Companies." *Columbia Journal of World Business* Fall (1982):26–32.

Environmental Business International, Inc. (EBI). *The Global Environmental Market and United States Environmental Industry Competitiveness.* San Diego, CA: EBI, 1995.

Euromonitor. *European Marketing Data and Statistics.* London: Euromonitor, 1995a.

———. *International Marketing Data and Statistics 1995.* London: Euromonitor, 1995b.

Freedom House. "Independent Countries Comparative Measures of Freedom." *Freedom Review* 27,1(Jan-Feb. 1996):10–18.

French, H.F. *Costly Tradeoffs: Reconciling Trade and the Environment.* Washington, DC: Worldwatch Institute, 1993.

Gore, A. *Red Tape to Results: Creating a Government That Works Better and Costs Less.* The Gore Report on Reinventing Government—Report of the National Performance Review. New York: Times Books, Random House, 1993.

Green, R.T., and A. Kohli. "Export Market Identification: The Role of Economic Size and Socioeconomic Development." *Management International Review* 31(1991):37–50.

International Monetary Fund (IMF). *International Financial Statistics.* Washington, DC: IMF, 1996, various issues 1991–1996.

Johnson, B., and T. Sheehy. *Index of Economic Freedom.* Washington, DC: Heritage Foundation, 1995.

Kmenta, J. *Elements of Econometrics.* New York, NY: Macmillan, 1986, pp. 616–25.

McMillan, J.C., G.C. Rausser, and S.R. Johnson.

Economic Growth, Political and Civil Liberties. International Center for Economic Growth. Occasional Paper Number 53. San Francisco: ICS Press, 1994.

Menes, J. As Acting Assistant Secretary for Trade Development, Department of Commerce, in testimony before the House Subcommittee on Environment and Natural Resources, Committee on Merchant Marine and Fisheries, February 25, 1993.

National Science and Technology Council. *A Bridge to a Sustainable Future* (National Environment Technology Strategy). Washington, D.C.: U.S. Government Printing Office, 1995.

Organization for Economic Co-operation and Development (OECD). *Main Economic Indicators.* Paris: OECD, 1996, various issues 1990–1996.

Sivard, R.L. *World Military and Social Expenditures.* Washington, DC: World Priorities, 1993.

Trade Promotion Coordinating Committee (TPCC)/ Environmental Trade Working Group. *Environmental Technologies Export Market Plans for Mexico.* Washington, DC: U.S. Government Printing Office, 1994a.

———. *Environmental Technologies Export Market Plans for Chile/Argentina.* Washington, DC: U.S. Government Printing Office, 1994b.

United Nations, (U.N.). *Monthly Bulletin of Statistics.* New York, NY: United Nations, 1996, various issues, 1992–1996.

———. *Statistical Yearbook for Asia and the Pacific.* Bangkok: United Nations, 1995.

United Nations Development Programme (UNDP). *World Development Report.* Annual editions 1990–1996. New York, NY: Oxford University Press, 1990–1996.

U.S. Department of Commerce. *Database of U.S. Exports and Imports of Merchandise.* Washington, DC: U.S. Government Printing Office, 1995.

U.S. Department of Commerce/International Trade Administration. *The Environmental Technologies Export Handbook 1995.* Washington, DC: U.S. Government Printing Office, September 1995.

U.S. International Trade Commission. *Global Competitiveness of U.S. Environmental Technology Industries: Municipal and Industrial Water and Wastewater.* Washington, DC: U.S. Government Printing Office, March, 1995, pp. 4/1–4/25.

World Bank. *World Development Report.* New York: Oxford University Press,. Various editions: 1987, 1995, and 1996.

———. *World Tables 1995.* Washington, DC: Johns Hopkins University Press, 1995.

———. *The Environmental Data Book—A Guide to Statistics on the Environment and Development.* Washington, DC: World Bank, 1993, pp. 10–13.

World Resources Institute. *World Resources.* Washington, DC: World Resources Institute, 1996, various volumes 1990–1996.

Yandle, B. M. Vijayaraghavan, and M. Bhattarai. *The Environmental Kuznets Curve: A Primer.* Internet site: http://www.perc.org/publications/research/kuznets.html (Accessed December 15, 2003).

Appendix A

Table A1. Department of Commerce (1995) Database of U.S. Exports and Imports Going Back to 1990, Covering Items under These Industrial Classification Codes

	HS Code #
Water Pollution Control	
1. Water filtering or purifying machinery	8421210000
2. Filter or purifying machinery and apparatus	8421290060
3. Parts for filtering and purifying	8421990040
4. Oil separation equipment	8421290020
Air Pollution Control	
1. Dust collection and air purification	8421390010
2. Electrostatic precipitators	8421390020
3. Industrial gas cleaning equipment	8421390030
4. Filtering or purifying machinery and apparatus	8421390090
5. Parts of machinery and apparatus	8421990080
6. Catalytic converters	8421394000
Solar Energy Equipment	
1. Solar cells in modules or panels	8541406020
2. Solar cells not in modules or panels	8541406030
Monitoring Instruments	
1. Gas or smoke analysis apparatus	902710
2. Exposure meters	902740
3. Instruments for checking radiation	903010

Appendix B

Table A2. Countries Included in the Study, Organized by Region

Americas: Canada, Mexico, Guatemala, El Salvador, Honduras, Costa Rica, Bahamas, Trinidad, Jamaica, Haiti, Dominican Republic, Panama, Colombia, Venezuela, Peru, Bolivia, Ecuador, Paraguay, Uruguay, Argentina, Chile, Brazil

Western Europe: Norway, Sweden, Finland, Denmark, Ireland, United Kingdom, Netherlands, Belgium, France, Switzerland, Germany, Spain, Portugal, Italy, Greece

Eastern Europe: Czechoslovakia, Czech Republic, Slovakia, Poland, USSR, Russia, Ukraine, Belorussia, Lithuania, Estonia, Latvia

Middle East and North Africa: Turkey, Israel, Kuwait, Saudi Arabia, United Arab Emirates, Oman, Bahrain, Morocco, Algeria, Egypt

Asia and Pacific: India, Pakistan, Bangladesh, Thailand, Malaysia, Vietnam, Singapore, Indonesia, Philippines, China, South Korea, Hong Kong, Taiwan, Japan, Australia, New Zealand, New Guinea

Sub-Saharan Africa: Ghana, Nigeria, Kenya, Zaire, Zambia, Zimbabwe, South Africa

Source: United Nations Development Program. Human Development Report. Annual editions 1990–1996. New York: Oxford University Press, 1990–1996.