Institutional, social and economic roots of deforestation: a cross-country comparison

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SUMMARY

The emphasis on pure economic explanations for economic development has recently shifted to cultural, social and institutional factors. An ordinary least squares (OLS) regression equation is used to examine the relationship between deforestation and economic, institutional and social capital variables for 117 countries. Institutional, economic, and social capital variables are significantly related to deforestation, although there is no evidence to support the existence of an environmental Kuznets Curve (EKC). While the results cannot be used to discuss any one country specifically, they do provide insight into the general roles of social and institutional factors in deforestation.

Keywords: deforestation, environmental Kuznets curve, institutions, policy

INTRODUCTION

Determining factors that cause deforestation is of considerable interest to domestic and international policymakers. The development view of deforestation is rooted in the environmental Kuznets curve (EKC). Applied to forestry, it postulates that very poor countries have relatively low rates of deforestation because they lack the resources to exploit the environment; then, as incomes rise, deforestation rates may initially rise as forest exploitation aids economic development. As income continues to grow and more environmental amenities are demanded, a point is reached where further increases in income lead to reduced rates of deforestation, or even reforestation to correct earlier damage (Bhattarai and Hammig 2001; Ehrhardt-Martinez *et al.* 2002; Harbaugh *et al.* 2000). Using cross-country data, neither Cropper and Griffiths (1994) nor Panayotou (1995) found a positive relation between per-capita income and rates of deforestation, while Antle and Heidebrink (1995) did not find an inverse relationship between per capita incomes and rates of deforestation.

Other studies have focused on the immediate observable drivers of deforestation, which include activities such as commercial logging (that may open a forest to agricultural exploitation), lack of clearly defined and enforced property rights to timberlands, population pressure and migration, economic incentives to convert forestland to other uses (e.g., relative prices and discount rates, subsidies or tax breaks), market failure (spillover benefits of preserving forests are not taken into account), and ill-functioning labour markets. All of these factors have been shown to contribute to deforestation (Pearce and Brown 1994; Kaimowitz and Angelsen 1997; van Kooten *et al.* 1999; Foster and Rosenzweig 2002). These are considered proximate causes of deforestation. The ultimate or final cause of deforestation is that "governments wish for it to happen, ... [and] most governments know precisely what they are doing and why they are doing it" (Bromley 1999, pp.283, 279). It may well be that forests represent an inferior form of capital and that a country's social welfare is enhanced by converting some part of it to other uses. Alternatively, those in power may simply exploit forests for private gain (Dauvergne 1997).

Government intentions are not always benevolent. For example, a developing countries' government may permit or encourage forest conversion by peasants to avoid dealing with land reform, thereby maintaining the status quo in which most of the privileges accrue to the ruling elite. Thus, while population growth is a proximate cause of deforestation, the ultimate or final cause may be the government's unwillingness to deal with the institutional changes required to alleviate poverty and bring about a more equitable distribution of income. As long as a particular nation state is driven by a desire to earn rents from harvesting trees, and as long as land hunger (itself often the result of other policy failures) drives governments to open up remote areas, then very little is to be gained by suggesting that nations stop building roads, or that property rights be made more secure, or that population growth be implemented, or that government corruption be rectified, or that the powerful logging interests be reined in. The only way to confront deforestation is to focus on its final cause (Bromley 1999, p.278).

The purpose of this study is to examine the ultimate causes of deforestation as these relate to a countries' social,

cultural and institutional situations, and to the level of economic development. Contrary to previous studies, we do find a link between per capita income and rates of deforestation, although we employ more recent data than the earlier studies. We also investigate whether institutions, culture and social capital play a role in explaining a particular form of environmental degradation, namely deforestation, finding that indeed such a link exists. Although social, cultural and institutional factors are the result of government policy, we do not claim to have discovered a link between government policies and deforestation.[1]

GLOBAL RATES OF DEFORESTATION

Deforestation is defined as the conversion of forest to another land use, usually agriculture. It occurs or has occurred in all countries, but it was concern over tropical deforestation that prompted international efforts to prevent it. In 1985, the International Tropical Timber Organisation (ITTO) was established by the 1983 International Tropical Timber Agreement, which was negotiated with a limited life span under the auspices of United Nations Conference on Trade and Development (UNCTAD). The ITTO became operational in 1987 to administer a trade agreement between the major producers and consumers of tropical wood products that encouraged producing countries to manage forests sustainably. In 1985, the Tropical Forestry Action Plan was initiated by the World Bank, the UN's Food and Agriculture Organisation (FAO) and other international organisations to address deforestation in developing countries. Although a convention on forestry was not signed at the Earth Summit in Rio de Janeiro in 1992, efforts began to develop criteria and indicators for sustainable forest management (SFM).[2] In 1993, a coalition of environmental groups, foresters and timber companies formed the Forest Stewardship Council (FSC) to develop standards for SFM and certify forests that are sustainably managed. Although initially aimed at tropical forests, these efforts were soon pre-empted by the large industrial wood producing nations through the Montreal Process, the Helsinki Process (subsequently becoming the Pan-European Process), and certification schemes that competed with FSC (Cashore *et al.* 2001).

According to the FAO, deforestation occurs when forest canopy cover is reduced to 10% or less. According to this definition substantial forest degradation can occur without actual deforestation taking place. However, the FAO data are the only consistent data available on forest loss (or gain) over time. Global patterns of deforestation are indicated in Table 1. Non-tropical Africa, the Caribbean, the United States, Europe and the former USSR experienced an increase in forest area (defined as land with a canopy cover of 10% or more) between 1990 and 2000, although non-tropical Africa and the Caribbean experienced declines in the first half of the decade. In contrast to northern latitudes, forest cover in the majority of developing countries has declined (Table 1). Tropical forests in particular are felt to be disappearing at a rapid rate (Tables 1 and 2), alarmingly so because they are thought to account for most of the globe's biodiversity, over half of the earth's 10–30 million species (Lovejoy 1997).

MODELING DEFORESTATION

Economic factors

The relationship between development (as represented by per capita income) and the rate of deforestation is expected to reveal the existence of an environmental Kuznets curve (Kuznets 1955). An EKC relation is found if the sign on the per capita GDP variable is positive, and that on GDP-squared is negative with both parameters being statistically significant. The consequent shape of the EKC is an inverse U.

A country's reliance on forest products for generating economic activity and foreign exchange is captured by the forest exports variable. The effect of this variable on deforestation is unclear. On the one hand, as a country becomes more dependent on forest product exports in the trade basket, existing forest resources could be depleted at a faster rate than forests are regenerated; in this case, the relationship is likely to be positive: the greater a country's reliance on forest exports, the more likely deforestation will increase or decrease more slowly. This might be true of less developed countries that rely on forest products to spur economic growth. Dependence on forest product exports could, on the other hand, lead to an increase in forest area if sufficient funds exist along with a desire on the part of citizens to invest in forest regeneration and maintenance. This is the case in Sweden, for example, where forestry is an important export sector and, despite a high level of private ownership of timberlands, investment in forest regeneration occurs for both financial and non-pecuniary reasons (see Wilson *et al.* 1998). Thus, a negative relationship is more likely to occur in more developed countries. It is difficult to predict the sign of the coefficient on forest exports a priori.

Lastly, the high opportunity costs of forestland in other uses must be considered. In many countries, higher expected returns to agriculture result in the conversion of forestland.

[1] Deacon (1995) claims that the link between government policies and deforestation is "exceedingly thin". Using a theoretical general equilibrium framework, he demonstrates that policies to restrict agricultural and/or log exports, subsidise agriculture and/or wood processing, tax timber harvests (thereby causing high grading), and so on, could reduce rates of deforestation rather than increase them as is often claimed. Again, Deacon deals with proximate and not ultimate causes of deforestation, while our concern is with ultimate causes - social, cultural and macroeconomic factors that explain higher rates of deforestation.

[2] For a history of SFM initiatives for tropical regions and an analysis of their success, see Rice *et al.* (2001).

TABLE 1 *Forest area and rates of deforestation, 1981–90, 1990–95, 1990–2000*

Region/country	Forest cover, 2000 (10^6 ha)	Average annual change in forest cover					
		1981–1990		1990–1995		1990–2000	
		Area (10^3 ha)	Rate (%)	Area (10^3 ha)	Rate (%)	Area (10^3 ha)	Rate (%)
Africa	*649.9*	*-4,100*	*-0.7*	*-3,748*	*-0.7*	*-5,264*	*-0.7*
Tropical	634.2	n.a.	-0.7	-3,695	-0.7	-5,295	-0.8
Non-tropical	15.7	n.a.	-0.8	-53	-0.3	+31	+0.2
Asia	*524.1*	*n.a.*	*n.a.*	*-3,328*	*-0.7*	*-651*	*-0.1*
Tropical	288.6	-3,791	-1.2	-3,055	-1.1	-2,427	-0.8
– South Asia	76.7	-551	-0.8	-141	-0.2	-98	-0.1
– SE Asia	211.9	-3,240	-1.4	-2,914	-1.3	-2,329	-1.0
Europe	*161.6*	*n.a.*	*n.a.*	*+389*	*+0.3*	*+424*	*+0.3*
Northern	58.0	n.a.	n.a.	+8	+0.0	+40	+0.1
Western	67.8	n.a.	n.a.	+358	+0.6	+311	+0.5
Eastern	35.8	n.a.	n.a.	+23	+0.1	+73	+0.2
Former USSR	*901.4*	*n.a.*	*n.a.*	*+557*	*+0.1*	*+739*	*+0.1*
Canada	*244.6*	*n.a.*	*n.a.*	*+175*	*+0.1*	*0*	*0.0*
USA	*226.0*	*n.a.*	*n.a.*	*+589*	*+0.3*	*+388*	*+0.2*
Central America and Mexico	*73.0*	*-1,112*	*-1.5*	*-959*	*-1.2*	*-971*	*-1.2*
Caribbean	*5.7*	*-122*	*-0.3*	*-78*	*-1.7*	*+13*	*+0.2*
South America	*885.6*	*n.a.*	*n.a.*	*-4,774*	*-0.5*	*-3,711*	*-0.4*
Tropical	834.1	-6,173	-0.7	-4,655	-0.6	-3,456	-0.4
– Brazil	543.9	-3,671	-0.6	-2,554	-0.5	-2,309	-0.4
Temperate	51.5	n.a.	n.a.	-119	-0.3	-255	-0.5
Oceania	*197.6*	*n.a.*	*n.a.*	*-91*	*-0.1*	*-365*	*-0.2*
Tropical	35.1	-113	-0.3	-151	-0.4	-122	-0.3
Temperate	162.5	n.a.	n.a.	+60	+0.1	-243	-0.1
Global total[a]	3,869.5	n.a.	n.a.	-11,269	-0.3	-9,397	-0.2

Source: FAO (2001b, 1993, 1997) [a] Totals may not tally due to rounding
n.a. = not available or not applicable

TABLE 2 *Annual change in forest cover, 1990–2000 (10^6 ha)*

Domain	Natural forest					Forest plantations			Total forest
	Loss			Gain		Gain			
	Deforestation	Conversion to forest plantations	Total loss	Natural expansion of forest	Net change	Conversion from natural forest	Afforestation	Net change	Net change
Tropical areas	-14.2	-1.0	-15.2	+1.0	-14.2	+1.0	+0.9	+1.9	-12.3
Non-tropical areas	-0.4	-0.5	-0.9	+2.6	+1.7	+0.5	+0.7	+1.2	+2.9
Global total	-14.6	-1.5	-16.1	+3.6	-12.5	+1.5	+1.6	+3.1	-9.4

Source: FAO (2001b)

Given a lack of country-level returns data, an 'agricultural output' variable is used in lieu of actual opportunity costs.

Institutions and social capital

Economists have long been interested in factors that contribute to economic development. The emphasis on pure economic explanations for economic development (monetary and fiscal policies, trade policy) has shifted to focus on the role of cultural, historical, social and institutional factors (North 1990; Woolcock 1997; Landes 1998; Shleifer and Vishny 1998; Fukuyama 1999; Ostrom 2000; Easterly 2001). Particular emphasis has been on the institutional environment as a driver of development. The institutional environment consists of formal rules (constitutions, laws and property rights) and informal constraints (sanctions, taboos, customs, traditions, and norms or codes of conduct) that structure political, economic and social interactions. Informal constraints are commonly referred to as 'social capital', which is "the shared knowledge, understandings, norms, rules, and expectations about patterns of interactions that groups of individuals bring to a recurrent activity" (Ostrom 2000, p. 176). It refers to "features of social organisations, such as networks, norms and trust, that facilitate action and cooperation for mutual benefit" (Putnam 1993, pp. 35–36).

Trust is perhaps the most important component of social capital: "Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time" (Dasgupta 2000, p.329). Trust is related to institutions and affects the costs of transacting: If one's confidence in an enforcement agency falters, one may not trust people to fulfil their agreements and fewer agreements are entered into. There is an element of trust in any transaction where one has to decide (make a choice) before being able to observe the action of the other party to the transaction. One has to assume that the other person is not acting with guile, keeping hidden information that can be used to their advantage at the expense of the other party to the transaction. Trust makes an economy function more efficiently (Fukuyama 1995; 1999, pp.240–42; Portes 1998).

Institutional variables used in this study are based on data from the index of economic freedom (Gwartney *et al.* 2001). The four indices used in this analysis relate to the 'size of government', the 'freedom to use alternative currencies', 'legal structure and property rights' and the 'freedom of exchange in capital and financial markets'. Each index ranges from 0.0 (least economic freedom) to 10.0 (greatest economic freedom). The economic freedom indices correlate positively to measures of social progress, such as income and economic growth, as well as low levels of corruption and high levels of human development.

Government plays a more significant role in the economies of wealthier nations, accounting for a large proportion of GDP. The 'size of government' index is constructed from data on government consumption expenditures as a percentage of total consumption and on government transfers and subsidies as a percentage of GDP. The index is lowest for countries with the greatest government participation in the economy, and is particularly low for countries that account for the majority of wood product exports – Sweden (1.96), Canada (4.53), Finland (3.89), Germany (4.46) and Austria (3.82). The highest score in our sample is associated with Guatemala (9.92), with most nations in tropical regions scoring higher than 8.0, while the U.S. scored 6.47. Since 'size of government' might be considered an index of a mature, developed economy that has the necessary institutions to reduce deforestation and protect forest cover, we expect it to be inversely correlated with deforestation rates.

The right to conduct transactions in alternative currencies, the ease with which one currency can be converted to another, and the ability of financial institutions to provide bank services in other currencies are important and necessary measures of economic freedom. The 'freedom to use alternative currencies' index measures a country's ability to provide its citizens with access to sound money, including more credible currencies. Without such access, gains from trade are difficult to realise, and forest companies are less likely to invest in forest protection as a result. The majority of countries examined received scores near 10.0, but scores of 0.0 were assigned to Brazil, China, Columbia, India and Thailand, while Bulgaria, The Czech Republic, Hungary, Israel, Korea, Mexico, Malaysia, Russia, the Slovak Republic, South Africa, Poland and Ukraine received a score of 5.0. We expect the freedom to use alternative currencies index to be negatively correlated with deforestation.

Unless private property is effectively protected under the law, there exists little incentive to protect forestlands from degradation. The 'legal structure and property rights' index measures a country's legal security of private ownership, including clearly delineated property rights that are protected by law. Luxemberg, Finland, Australia, The Netherlands, Austria, Denmark, Germany and the United Kingdom score highest for this index. We expect deforestation rates to be negatively correlated with this index, as countries with weak property protection are more likely to see citizens liquidating forest stands.

Finally, the 'freedom of exchange in capital and financial markets' index measures the use of markets to allocate capital. Countries with larger shares of bank deposits held in privately owned banks, interest rates determined by the market, stable monetary policy, positive real deposit and lending rates, and few restrictions on foreign capital transactions are given higher ratings. Luxembourg, The Netherlands, the United Kingdom, Denmark, Hong Kong, New Zealand, Switzerland and the United States received the highest economic freedom ratings for this index. Again, a negative relationship between the economic freedom indices and the rate of deforestation is expected, because greater economic freedom makes investments in forestlands more valuable, while lack of economic freedom causes firms to convert trees to cash as quickly as possible.

A dummy variable indicating whether or not a country is committed to democracy and a market economy has also been included as an institutional variable. It consists of OECD member countries, which have largely experienced economic growth and success. It is expected that a negative relationship will exist between this variable and the rate of deforestation. Essentially, this variable has been included in order to capture explanatory effects that may accrue specifically to developed countries. Since both developed and less developed countries have been included in this study, many significant effects could be lost or diluted unless it is possible to make a distinction between the differing groups.

It is our contention that social capital is also important to sustainable forestry. As already noted, trust is an important component of social capital. The concept of trust is captured in this analysis using the 2001 World Bank 'control of corruption' index (Kaufmann *et al.* 2002). This index is based on subjective assessments from a variety of sources related to corruption, widely defined as the exercise of public power for private gain. The scale of this index ranges from approximately –2.5 to 2.5, where higher values correspond to better outcomes. We expect deforestation to be inversely related to the corruption index; less corruption indicates more and later social development, and thus improved environmental quality.

Another important component of social capital is the extent to which citizens are empowered – the extent to which they can influence political decisions concerning the provision of public goods. In countries with higher levels of social capital, there will be more pressure on government and firms to behave in environmentally responsible ways. A country's overall literacy rate is an important measure of empowerment. Higher levels of literacy suggest that a country is more likely to protect scarce environmental resources, such as forests.

Other factors

Lastly, as noted by Bromley (1999) and discussed above, other factors might contribute to deforestation. Agrarian societies are typically characterised by relatively high levels of rural population. Agriculture, not forestry, is the primary contributor to employment in these societies. Thus, it can be expected that those countries that have highly populated rural areas, with high levels of agricultural output, will also have higher rates of deforestation.

The regression model

The data are analysed using the following ordinary least squares (OLS) regression model:

$$D_i = \alpha + \sum_{=} \beta_k X_{i,k} + \mu_i,$$

where D_i is the average annual rate of deforestation (1990–2000) for country i, i=1,…,n countries, α is the intercept term, β_k are the coefficients to be estimated, X_k (k=1,…,K) are the K explanatory variables described in Table 4, and μ_i represents the error terms. White's (1978) correction of standard errors for possible heteroskedasticity and model misspecification is used.

EMPIRICAL RESULTS

Data were collected for 117 countries (Table 3). The dependent variable in the regression analysis is the rate of deforestation, based on the average annual rate of change in forest cover from 1990 to 2000. (For consistency, if deforestation occurs, it is represented by a positive variable, while afforestation is taken to be negative.) Changes in forest cover data were obtained from the FAO (2001b), which defines forest cover change as the net change in forests, including gains and losses in natural forest areas and expansion of forest plantations. Natural forest areas are defined as forests that are made up of indigenous trees, whereas forest plantations are forests created by planting previously cutover sites or land that was not previously forest but in some other use. The dependent variable has been constructed so that a positive value indicates a higher rate of deforestation, while a negative value indicates reforestation.

TABLE 3 *List of countries included in the regression analysis*

Albania	Ecuador	Lithuania	Slovenia
Algeria	Egypt	Madagascar	South Africa
Australia*	El Salvador	Malawi	South Korea
Austria*	Estonia	Malaysia	Spain*
Bahamas	Figi	Mali	Sri Lanka
Bangladesh	Finland*	Mauritius	Sweden*
Belgium*	France*	Mexico*	Switzerland*
Belize	Gabon	Morocco	Syria
Benin	Germany*	Myanmar	Tanzania
Bolivia	Ghana	Netherlands*	Thailand
Botswana	Greece*	New Zealand*	Togo
Brazil	Guatemala	Nicaragua	Trinidad & Tobago
Bulgaria	Guinea-Bissau	Niger	Tunisia
Burundi	Guyana	Nigeria	Turkey*
Cameroon	Haiti	Norway*	Uganda
Canada*	Honduras	Pakistan	UK*
Cen. African Rep.	Hungary*	Panama	Ukraine
Chad	Iceland*	Papua New Guinea	Unit. Arab Em.
Chile	India	Paraguay	Uruguay
China	Indonesia	Peru	US*
Colombia	Iran	Philippines	Venezuela Rep.
Congo, Dem. Rep.	Iraq	Poland*	Vietnam
Congo, Rep.	Ireland*	Portugal*	Zambia
Costa Rica	Israel	Romania	Zimbabwe
Cote d'Ivoire	Italy*	Russia	
Croatia	Jamaica	Rwanda	
Cyprus	Japan*	Saudi Arabia	
Czech Rep.*	Jordan	Senegal	
Denmark*	Kenya	Sierra Leone	
Dominican Rep.	Latvia	Slovak Rep.*	

* indicates OECD-member countries

Export data are from the FAO (2001a). Purchasing power parity GDP data are from the International Monetary Fund (IMF 2001). As noted, data on corruption are from The World Bank (2001), while data on economic freedom are from Gwartney *et al.* (2001). The independent variables and their descriptions, units of measurement and expected relationships, with the average annual rate of forest cover change, are presented in Table 4. Descriptive statistics are presented in Table 5. Variables that proved to be statistically insignificant in all of the preliminary regressions were not included for further consideration in this analysis. This was the case for several institutional variables represented by certain indexes of economic freedom. Foreign direct investment, inflation rates, population growth, an index of sustainability, forest output, agricultural exports, forest-certification status and population density were other variables that were excluded. Final regression results are reported in Table 6.

In the first model of Table 6, the rate of deforestation was regressed against only GDP and GDP-squared. The purpose of this regression was to examine the relationship between deforestation and income growth in order to test whether there is empirical evidence for an environmental Kuznets relation. Both variables are statistically significant

TABLE 4 *Independent variables and expected relationships with the rate of deforestation*

Independent variable	Description	Unit of measurement	Expected sign
Economic			
GDP	PPP weighted GDP per capita, 2000	US$	+ –
GDP^2		%	No expectation
Forest exports	Forest exports as a proportion of total exports, 2000	Index	+
Agricultural output	Agricultural output per capita, 1999.		
Institutional			
OECD	A dummy variable. 1.0 indicates a country is an OECD member.		–
Exchange	Freedom of exchange in capital and financial markets, 1999 (0–10)	Index	–
Property rights	Legal structure and property rights, 1999 (0–10)	Index	–
Currency	Freedom to use alternative currencies, 1999 (0–10)	Index	–
Size	Size of government, 1999 (0–10)	Index	–
Social Capital			
Corruption	2001 Control of Corruption Index (-2.5 .. +2.5)	Index	+
Literacy	A country's overall literacy rate.	%	–
Other Factors			
Rural population	The proportion of the total population that lives in rural areas.		+

TABLE 5 *Descriptive statistics of variables used in the regression analysis*

Variable	Obs.	Mean	St. Dev.
Dependent			
Rate of deforestation	117	-0.0014	99008.6
Economic regressors			
GDP	115	9128.5	9044.78
Forest product exports	111	0.0391	0.0654
Agricultural output	114	100.5	23.05
Institutional regressors (indices)			
OECD	117	0.1880	0.3924
Freedom of exchange in capital and financial markets	114	6.1702	2.3310
Legal structure and property rights	110	5.956	2.6136
Size of government	112	6.6104	2.0541
Social capital regressors			
Control of corruption index	114	0.1046	0.9650
Literacy	116	81	20.073
Other regressors			
Proportion of rural population	116	0.4521	0.2269

TABLE 6 *Regression results*

Independent variable	Model 1	Model 2	Model 3	Model 4
Number of observations	115	99	99	105
Intercept	0.018592*** (5.41)	-0.0087 (-0.48)	-0.0179 (-0.96)	-0.0073 (-0.46)
Economic regressors				
GDP	-3.50e-06*** (-4.67)	-2.85e-06** (-2.19)		
GDP^2	9.04e-11*** (3.51)	5.58e-11** (-2.06)		
Forest exports		0.0240 (1.10)	0.0355 (1.39)	0.0250 (1.15)
Agricultural output		-0.0001 (-1.56)	-0.0001** (-2.06)	-0.0001* (-1.74)
Institutional regressors				
OECD membership (=1 if a member country)		0.0254* (1.79)	0.0188* (1.82)	0.0153 (1.53)
Freedom to exchange in capital and financial markets index		0.0031*** (2.97)	0.0033*** (3.25)	0.0036*** (3.34)
Legal structure and property rights index		0.0008 (0.56)	0.0004 (0.29)	
Freedom to access alternative currencies index		-0.0014 (-1.37)	-0.0014 (-1.42)	-0.0015 (-1.54)
Size of government index		0.0016 (1.55)	0.0022** (2.25)	
Social Capital regressors				
Control of corruption index		-0.0076 (-1.44)	-0.0123** (2.48)	-0.0118*** (-0.286)
Overall rate of literacy		0.00004 (0.25)	-0.0001 (-0.67)	-0.0001 (-0.77)
Other regressors				
Proportion of rural population		0.0119 (0.76)	0.0221 (1.62)	0.0325** (2.46)
R^2	0.2491	0.3707	0.3348	0.3091
F-statistic (degrees of freedom)	18.58*** (2, 112)	3.36*** (11, 86)	3.80*** (10, 88)	4.04*** (8, 96)

a Values in parenthesis are t-statistics based on White's corrected standard errors.
*** significant at 1% level or better;
** significant at 5% level or better;
* significant at 10% level or better.

at 1% or less and have the correct signs, but as indicated by Figure 1, they do not provide the expected support for an estimated EKC relation. As GDP increases during early development, the rate of deforestation declines immediately. There is no evidence of an increase in deforestation followed by a fall in deforestation rates. This is different from the Kuznets relationships found by Bhattarai and Hammig (2001) for countries in Africa, Asia and Latin America, and by Ehrhardt-Martinez *et al.* (2002) for less developed countries.[3] We find that deforestation rates fall to zero as income rises to about $6,000, and, as it rises further, that countries begin to reforest areas previously deforested. Thus, forest area increases, but reforestation rates decline beyond about $19,500 (Figure 1), with deforestation/reforestation rates reaching equilibrium (no change in forested area) in the richest countries. In this sense, there clearly does exist an environmental Kuznets relation.

This result does not change when all of the variables are included in the regression (model 2). The statistical significance of per capita GDP and GDP-squared falls slightly, while the 'freedom to exchange in capital and financial markets' index is statistically significant (at the 1% level), but of the wrong expected sign. This result suggests, contrary to our earlier notion, that freedom to exchange capital actually hastens forest depletion as firms are better able to turn forests into cash. The OECD dummy variable is statistically significant at the 10% level, but also

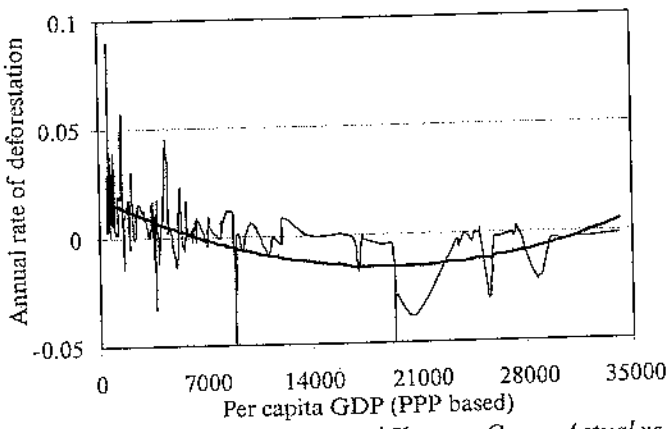

FIGURE 1 *Forest Environmental Kuznets Curve, Actual vs Model 1*

[3] Foster and Rosenzweig (2002) found that, for open economies, the 1980–1995 growth rate of the economy was inversely related to forest growth (implying increasing deforestation as growth increases). We found no relationship between 1990–2000 growth and deforestation (in all regressions this variable was statistically insignificant at the 20% or more level). We also found no affect between measures of the openness of an economy and deforestation rates, nor between forest exports and deforestation.

of the wrong expected sign. This suggests that OECD countries may be somewhat more likely to deforest than other countries. None of the other variables provide a statistically significant explanation of deforestation.

It is only when per capita GDP is removed from the model (models 3 and 4, Table 6) that other institutional variables ('size of government', corruption and possibly 'freedom to use alternative currencies') become statistically significant explainers of deforestation. While these variables are correlated with income, they do illustrate the importance of institutions and social capital in affecting environmental degradation. Countries with permit currency conversion and ones that are less corrupt are less likely to experience deforestation (as expected), while larger governments may hasten deforestation (contrary to what was expected). In models 3 and 4, agricultural output is also an important explainer of the likelihood that a country degrades its forests: the greater a country's agricultural output, however, the less likely the country has degraded its forests in the past decade. Yet, a greater rural population (more workers in agriculture) leads to higher rates of deforestation (as indicated especially in model 4). This suggests that, if agriculture output is adequate, countries may deforest less, but, as the number of people in rural areas increases (meaning more farm workers), deforestation is more likely.

Finally, and surprisingly, neither the degree of literacy nor protection of property rights affects the likelihood that a country will degrade its forests at a higher or lower rate. As expected, forest exports do not affect deforestation because the cases where higher forest exports increase rates of deforestation appear to be offset by those where they result in a greater desire to protect or even expand forests.

CONCLUSIONS

This study examines the effects of economic, institutional and social capital variables on deforestation across 117 countries. The strongest evidence found in this paper pertains to the environmental Kuznets curve. The results do not provide direct support for the notion that, as per capita incomes rise, countries initially increase environmental degradation in an effort to enhance growth, but, beyond some income level, the environment improves because citizens demand higher environmental quality (an income effect). Rather, our results suggest that poor countries have higher rates of deforestation because they are poor, and that deforestation is not used as a tool of development. Rates of deforestation decline continuously as income increases from a low of some $500 per person per year (purchasing power parity basis) to about $6,500, after which countries begin to afforest. The rate of afforestation peaks at some $19,500 per capita after which it declines to zero for the richest countries. In this sense, this study provides evidence for an EKC.

Institutional factors do appear to be important explanatory factors, but their influence is mixed and difficult to explain. There is some, albeit weak, evidence over the decade 1990–2000 that a country's ability to provide stable monetary policy and solid financial institutions with few restrictions on foreign capital transactions indicates economic agents in that country have weaker incentives to manage forestlands, having better ability to liquidate forest assets. Trust, measured as a 'control of corruption' index, appears to be a more important explanatory variable, particularly in the absence of income. That is, countries with less corruption (greater) trust are less likely to liquidate forest assets. Not unexpectedly, countries that have high rural populations are also more likely to deforest than those with lower rural populations.

It is possible to speculate that the level of development may provide the necessary conditions for afforestation, but alone it is not a sufficient criterion to ensure that improvements in environmental quality will occur. The results of this analysis indicate a need for institutional reforms such as greater government involvement and freedom of financial markets, in order to stabilise economies and raise the demand for environmental improvements. Because the analysis presented above is cross-sectional and includes more than 100 countries of differing development status, the results cannot be used to discuss any one country specifically, nor can they be used to provide global-scale policy recommendations. They do, however, provide insight into the general roles of social and institutional factors in deforestation. Further research might use time series data to estimate more accurately an EKC for deforestation. Placing an emphasis on one nation or region, or a number of similar nations or regions may produce results that would be more useful in developing policy implications.

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