Linking forests and economic well-being: a four-quadrant approach

Sen Wang, C.Tyler DesRoches, Lili Sun, Brad Stennes, Bill Wilson, and G. Cornelis van Kooten

Abstract: This paper has three main objectives: (*i*) to investigate whether the four-quadrant approach introduced by J.S. Maini reveals a useful typology for grouping countries by gross domestic product (GDP) and forest cover per capita, (*ii*) to determine if the framework can enhance our understanding of the relationship between forest cover and GDP per capita, and (*iii*) to investigate why countries in the four-quadrant world occupy different quadrants and to determine the principal factors affecting country movement across and within the individual quadrants. The examination reveals that countries can be classified into four broad categories and that GDP and forest cover per capita have a low but consistent level of negative association. After regressing economic, institutional, social capital, and other variables on a country's occupancy and movement in the four-quadrant world, the results suggest that countries in each quadrant share different characteristics and that factors underlying country movement vary according to the quadrant being observed. Overall, countries with less corruption and higher education are likely to experience increases in both forest cover and GDP per capita, while countries exporting a significant proportion of forest products have a reduced probability of increasing both variables.

Résumé : Cet article a trois objectifs principaux : (*i*) examiner si l'approche des quatre quadrants introduite par J.S. Maini révèle une typologie applicable pour le regroupement de pays par produit brut intérieur (PBI) et par couvert forestier par habitant, (*ii*) déterminer si le cadre de travail peut améliorer notre compréhension de la relation qui existe entre le couvert forestier et le PBI par habitant et (*iii*) examiner pourquoi les pays occupent différents quadrants dans le modèle des quatre quadrants et déterminer les principaux facteurs qui influencent le mouvement des pays entre les quadrants et à l'intérieur même de chaque quadrant. L'étude démontre que les pays peuvent être classés en quatre grandes catégories et que la relation entre le PBI et le couvert forestier par habitant est faible et négative mais constante. Les résultats d'une analyse de régression entre la position ou les mouvements d'un pays dans le modèle des quatre quadrants et des variables économiques, institutionnelles, relatives au capital social ainsi que d'autres variables indiquent que les pays à l'intérieur de chaque quadrant ont plusieurs caractéristiques en commun et que les facteurs responsables du mouvement des pays diffèrent selon le quadrant observé. Dans l'ensemble, les pays présentant le moins de corruption et un plus haut niveau d'éducation ont de fortes chances de voir à la fois leur couvert forestier et leur PBI par habitant augmenter, alors que les pays qui exportent une proportion significative de leurs produits forestiers ont une faible probabilité d'accroître ces deux variables.

[Traduit par la Rédaction]

Introduction

Maini (2003) demonstrated that countries can be allocated to one of four quadrants in a two-dimensional schematic where forest cover and gross domestic product (GDP) per capita are plotted on the axes. This categorization results in a meaningful typology where the blocks of countries represent "four realities" representing "a broad clustering of countries in accordance with their priority concerns" (Maini 2003). The framework entails the following generalizations: forest-rich developing countries use forest resources to fuel economic development, forest-rich industrialized countries recognize that forests provide both environmental and economic benefits, forest-poor developing countries depend on the forest for subsistence, often degrading forest ecosystems in the process, and forest-poor developed countries place extraordinarily high value on the environmental services of forest ecosystems. Maini (2003) emphasized that these diverse realities need to be recognized before meaningful international forest policy can be formulated.

Central to the four-quadrant (4-Q) approach are GDP and forest cover per capita, but they are only proxies for economic growth and environmental degradation; they are also variables used to test the widely recognized environmental Kuznets curve hypothesis (EKC). This hypothesis contends that there is an inverted U-shaped relationship between economic growth and environmental degradation (Kuznets 1955; Dinda 2004; Stern 2004). Applied to forestry, the EKC 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 is a driver of

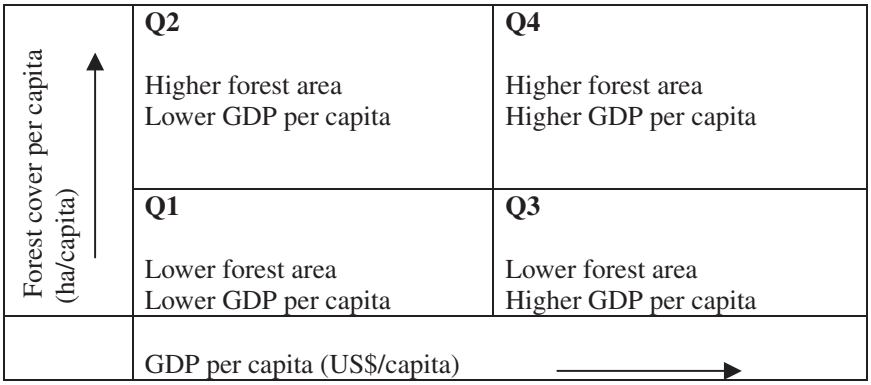
Received 3 October 2006. Accepted 2 March 2007. Published on the NRC Research Press Web site at cjfr.nrc.ca on 12 October 2007.

S. Wang, C.T. DesRoches, L. Sun,[1] B. Stennes, and B. Wilson. Industry, Trade, and Economics Research Program, Pacific Forestry Centre, Canadian Forest Service, Natural Resources Canada, 506 West Burnside Road, Victoria, BC V8Z 1M5, Canada.
G.C. van Kooten. Department of Economics, University of Victoria, P.O. Box 1700 Stn. CSC, Victoria, BC V8W 2Y2, Canada.

[1]Corresponding author (e-mail: lisun@pfc.cfs.nrcan.gc.ca).

 doi:10.1139/X07-044

Fig. 1. The four-quadrant framework.



economic development. Then, 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). Using cross-country data on rates of deforestation, researchers have found conflicting evidence regarding an EKC effect (Mather et al. 1999; Mather and Needle 2000; Bhattarai and Hammig 2001; Meyer et al. 2003). Cropper and Griffiths (1994) and Panayotou (1995) estimated a positive relation between per capita income and rates of deforestation, while Antle and Heidebrink (1995) found an inverse relationship between per capita incomes and rates of deforestation (for incomes above about $1200) and Meyer et al. (2003) found that rates of deforestation fell as income increased, with reforestation occurring in the richest countries. Most of the research involving GDP per capita and forest cover has been done within the EKC framework, often using the ratio of forest cover to total landmass as a proxy for environmental quality. But this approach has found no consistent evidence of a relationship between environmental quality and economic performance.

In the current paper, we employ the 4-Q framework to examine forest cover and GDP per capita from a different angle. Although similar to the EKC insofar as it uses the same variables, unlike this hypothesis, the raison d'être of the 4-Q approach is to examine the possibility of four different realities concerning national forest policies. The 4-Q approach should not be seen as an alternative to the EKC hypothesis but as an alternative contribution to the extant literature on the relationship between environmental quality and economic performance. Our chief objectives are to investigate why countries in the "4-Q world" occupy different quadrants, what factors underlie country movement in the two dimensions, and whether movement within quadrants depends on different drivers.

To accomplish our task, we begin in the following section by outlining the 4-Q approach as an analytical framework. In the next section, we discuss the GDP and forest cover data and conduct cross-country comparisons for three benchmark years (1990, 2000, and 2005). A Goodman–Kruskal gamma (G-K γ) is then calculated to estimate the statistical association between the two key variables. In the next section, we estimate factors underlying country occupancy in quadrants and country movements in the 4-Q world. Based on the economic growth and deforestation literature, we specify three models that employ economic, institutional, social capital, and other regressors. We conclude with a discussion of our findings and their practical policy implications.

Analytical framework

Despite its widely recognized limitations, purchasing power parity adjusted GDP per capita is commonly used as an indicator of economic well-being. Forests are increasingly recognized as playing an important role in economic development for two reasons. First, forests have commercial importance because they provide timber products, nontimber outputs, and fuel. Second, the environmental amenities and ecosystem functions of forests, such as watershed protection and provision of biological diversity, contribute in a less direct way to economic growth as well as provide a diverse set of amenities that people value for their own sake (Intergovernmental Panel on Climate Change 2000; Anielski and Wilson 2005; Sayer 2005). Indeed, forests are central to a nation's water supply, air quality, microclimates, and general environmental health. For these reasons, and to follow Maini (2003), forest cover is integral to the 4-Q framework.

The 4-Q framework is depicted in Fig. 1, where the grid is divided into four quadrants according to levels of forest cover per capita (plotted on the vertical axis), where "forest" is defined as the sum of natural forest plus plantations (Food and Agriculture Organization of the United Nations 2001) and GDP per capita (horizontal axis). In Fig. 2, the 4-Q approach is applied to selected countries in 2005; the quadrants are chosen to be equal in size for illustrative purposes.

Compared with Maini (2003), we reverse the axes to conform to the format used in typical EKC analyses. This enables us to place countries with relatively high levels of per capita forest area but low GDP in the upper left quadrant (Q2) and countries with less forest and higher GDP in the lower right quadrant (Q3). Our approach and that of Maini (2003) coincide with respect to the descriptions of countries in the lower left (Q1) and upper right (Q4) quadrants. Countries located in Q1 are said to be "worst off" in terms of both low levels of forest area and income, while the converse is true of countries in Q4. We can reasonably argue that countries desire an increase in per capita forest cover, an increase in GDP per capita, or both. However, we cannot say that a country with a relatively high level of GDP per capita but low level of forest cover per capita is worse off than a country with higher forest cover but lower income.

Fig. 2. Per capita forest cover and GDP of select countries, 2005 (PPP, purchasing power parity).

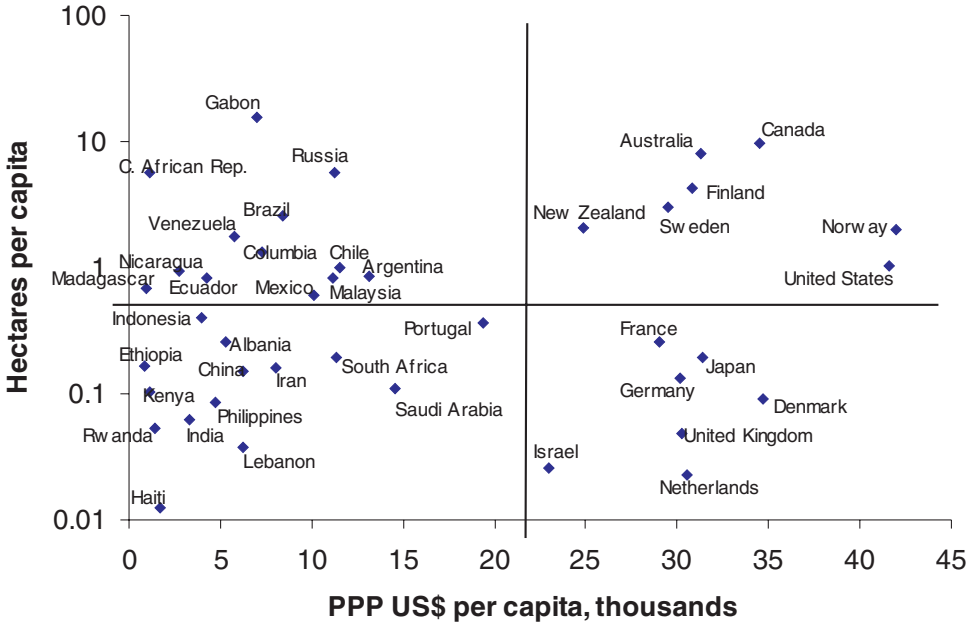


Table 1. Change in the world's population, forest area, and GDP, 1990–2005.

				Annual % change		
Item	1990	2000	2005	1990–2000	2000–2005	1990–2005
World's population (10^6)[a]	5279.5	6085.6	6464.8	1.43	1.22	1.36
World's total forests (10^6 ha)[b]	4077.3	3988.6	3952.0	–0.22	–0.18	–0.21
Forests per capita (ha)[c]	0.77	0.66	0.61	–1.53	–1.56	–1.54
World's GDP (constant, 10^9 US$)[d]	21944.3	28786.3	31811.9	2.75	2.53	2.69
World's constant per capita GDP (US$)[d]	4157.05	4730.85	4979.69	1.30	1.29	1.30

[a]Source: United Nations 2003.

[b]Source: Food and Agriculture Organization of the United Nations 2001, 2006*a*; United Nations 2003.

[c]Total forest cover in 2005 (Food and Agriculture Organization of the United Nations 2006*a*) divided by world population in 2005 (United Nations 2003).

[d]Source: United Nations 2006.

That is, it is not possible to trade-off forest cover against income, so that only Pareto comparisons are relevant. A country is judged "better off" than another country only if it has more per capita income (more forest cover per capita), while forest cover per capita (per capita income) is at least as great, all else being equal. In broad terms, the challenge for countries is to move in a northeasterly direction in the 4-Q space, thereby improving both economic well-being and levels of forest cover.

Global data and the 4-Q applied

As Fig. 1 illustrates, the 4-Q approach requires data for three crucial country-level variables: forest cover, GDP, and population. General global trends in forest cover and GDP per capita over the benchmark years are displayed in Table 1. From 1990 to 2005, the world's total population grew from approximately 5.28 billion to 6.46 billion, indicating an annual growth rate of approximately 1.36%. After experiencing a relatively high annual population growth rate during the 1990s, the rate fell slightly to 1.22% between 2000 and 2005. From 1990 to 2005, the world's combined constant GDP increased at an annual rate of 2.69%, thus increasing by 1.30% on a per capita basis.

In contrast with population and GDP growth, the overall extent of the world's forest cover declined both in aggregate and on a per capita basis. Global forest area declined at an annual rate of 0.22% during the 1990s, slowing slightly to 0.18% between 2000 and 2005. Per capita forest cover fell at an annual rate of 1.54% during the period 1990–2005. Clearly, population pressure was a factor in declining forest cover. However, as indicated in Table 2, rates of decline in forest cover varied from one continent to the next. From 1990 to 2005, all regions of the globe experienced a decrease in forested area. Europe had the lowest level of decline with an approximate annual decline of 0.35% in per capita forest area, while Africa had the highest rate of decline at approximately 3.15%, almost 10 times that of Europe.

Although data on current country-level GDP and population are readily available from, among other sources, the International Monetary Fund for the past five decades (International Monetary Fund 2005), reliable data on forest cover are available from the Food and Agriculture Organization of the United Nations only for 1990, 2000, and 2005

Table 2. Per capita forest cover and change over time, 1990–2005.

	Per capita forest cover (10^3 ha)			Annual % change		
Continent	1990	2000	2005	1990–2000	2000–2005	1990–2005
Africa	1.129	0.817	0.699	–3.182	–3.072	–3.146
Asia	0.175	0.149	0.147	–1.550	–0.361	–1.155
Europe	1.429	1.429	1.357	–0.003	–1.026	–0.345
North America	1.473	1.280	1.366	–1.391	1.309	–0.499
Oceania	0.250	0.215	0.213	–1.467	–0.242	–1.060
South America	3.116	2.550	2.216	–1.984	–2.763	–2.245

Table 3. Measure of association between per capita forest cover and GDP for the 137 countries (1990, 2000, and 2005).

		GDP per capita		
		Below median	Above median	Total countries
Per capita forest cover	Above median	b = 29	d = 38	67
	Below median	a = 23	c = 47	70
	Total	52	85	137
γ_{2005} = –0.219				
Per capita forest cover	Above median	b = 31	d = 37	68
	Below median	a = 28	c = 41	69
	Total	59	78	137
γ_{2000} = –0.102				
Per capita forest cover	Above median	b = 36	d = 32	68
	Below median	a = 31	c = 37	68
	Total	67	69	136[a]
γ_{1990} = –0.146				

[a]Because of a missing value in 1990, there are 136 countries for that year.

(see Food and Agriculture Organization of the United Nations 1995, 2001, 2006*a*).[2] We use GDP per capita measured in purchasing power parity US$.

The choice of demarcation lines for the four quadrants is central to the approach, even though it is somewhat arbitrary. This does not constitute a barrier to employing the 4-Q approach, but it does qualify the interpretation of the empirical results. Our choice of demarcation lines is simply meant to facilitate the subsequent analysis. Arguably, natural choices for establishing the demarcation lines include the mean or median values of forest cover and GDP per capita. Such values set a relative standard by using the data of countries included in the analysis. During the 15 years under investigation, the per capita forest cover of the 137 countries in the data set fell from a mean value of 0.77 ha in 1990 to 0.66 ha in 2000 and further down to 0.61 ha in 2005, while the average GDP per capita rose from $4157.05 in 1990 to $4730.85 in 2000 and to $4979.69 in 2005. Not surprisingly, the median values of per capita forest cover and GDP follow the same trend but are significantly lower for the same benchmark years. For example, in 1990, the median values of per capita forest cover and GDP per capita were 0.35 ha and $3547, respectively. We select demarcation lines set at the 1990 median values for both variables and use these for all three benchmark years.

For 1990, the 137 countries constituting our sample (see Appendix A) are divided into the four quadrants as follows: 31 countries in Q1, 36 in Q2, 37 in Q3, and 32 in Q4.[3] As expected, by 2005, the countries in general moved towards the right (representing a rise in income) and downwards (representing a drop in forest cover). After 15 years, 23 countries are in Q1 and 47 in Q3, the lower quadrants. In terms of per capita forest cover, although the number of countries above the median is similar for all three benchmark years, Gambia, Ghana, Guatemala, Kazakhstan, and Kenya slipped from above to below the median between 1990 and 2005. In terms of a decline in GDP and forest cover per capita, Burundi, Congo Democratic Republic, Guinea-Bissau, Kyrgyzstan, Tajikistan, and Zimbabwe experienced a decline in both over the 15-year period. Countries like Canada, the United States, Australia, Sweden, and New Zealand stayed in Q4 throughout. If the demarcation lines are permitted to vary over time, movements of countries between quadrants are less common, as expected.

To verify the existence of correlation between forest cover and GDP per capita in the 4-Q framework, we use Goodman-Kruskal's gamma (G-K γ), which, in the case of 2×2 tables, is equivalent to Yule's Q, a statistic developed on the basis of pair-by-pair comparisons (Cohen and Holliday 1982; Loether and McTavish 1993; Anderson and Finn

[2] Forest cover data are also available for 1980 (Food and Agricultural Organization of the United Nations 1985) but are not used here because of the greater consistency among the 1990, 2000, and 2005 data.
[3] Because of a missing value in 1990, there are 136 countries for that year.

Table 4. Variables and expected relationship with country movement in the 4-Q space.

Independent variable	Description	Units	Expected sign (+, –)
Forest exports	Forest product exports as a proportion of total exports in 1000s of US$ for 1990 and 2005. Forest product and total export sources, respectively: Food and Agriculture Organization of the United Nations Statistics Division 2007; World Bank 2006	%	+ GDP, ? forest cover
Agricultural output	Agricultural production indices: food production per capita, 1990 and 2005. Units: % of the 1999–2001 average food production per capita. Source: Food and Agriculture Organization of the United Nations 2006*b*[a]	Index	+ GDP, – forest cover
OECD	Dummy variable; 1 indicates OECD membership	1 or 0	+
Regulatory quality	Ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Source: Kaufmann et al. 2006	Index	+
Rule of law	Extent to which agents have confidence in and abide by the rules of society and in particular the quality of contract enforcement, the police, and the courts as well as the likelihood of crime and violence. Source: Kaufmann et al. 2006	Index	+
Control of corruption	Including both petty and grand forms of corruption as well as "capture" of the state by elites and private interests. Source: Kaufmann et al. 2006	Index	+
Education	The 2006 education index includes primary, secondary, and tertiary gross enrollment. Source: United Nations Development Programme 2006	Index	+
Tropical	Dummy variable based on table 14 in Food and Agriculture Organization of the United Nations 2001; 1 indicates a country with 50% or more forest cover in tropical or subtropical regions as defined by the FAO	1 or 0	_

[a]These data are directly available from earthtrends.wri.org.

1996). We use the G-K γ to avoid potential confusion between Yule's Q and our 4-Q notation:

$$[1] \qquad \gamma = (ad - bc)/(ad + bc)$$

where $-1 \leq \gamma \leq 1$, with –1 representing a perfect negative association and +1 a perfect positive relationship. In eq. 1, a and d denote pairs of values showing positive association, while b and c are pairs showing negative association; a measure of association can then be calculated by converting forest cover and GDP per capita into dichotomous forms.

In Table 3, the 137 countries in the sample are divided into four groups using, again, the 1990 median values of forest cover and GDP per capita as the demarcation lines, with the four cells a, b, c, and d corresponding to the four quadrants in Fig. 1. As shown in Table 3, the statistical association between per capita forest cover and GDP is –0.146 for 1990, –0.102 for 2000, and –0.219 for 2005. This suggests that (*i*) there is a low negative association between per capita forest cover and GDP at the country level and (*ii*) the linear relationship between the two has been consistently negative over the 15-year study period. However, the G-K γ must be interpreted with caution. For one, statistical association does not imply causality.[4] Moreover, the γ calculation assumes a linear relationship between forest cover and income levels.

At this point, some general observations concerning the 4-Q framework can be made. First, it is clear that the demarcation lines have no impact on the relative position of countries. Second, the four quadrants need not be equal in size. Third, it is possible that the 4-Q framework provides useful information through its categorization of countries. Fourth, the movements of countries *within* quadrants over time can be less than, equal to, or more significant than the movements of countries between quadrants. Thus, to understand country movements over time, focusing only on countries that switch quadrants would ignore all other potentially important dynamics.[5] This suggests that if we are interested in the underlying factors associated with country movement, it is essential to consider all movements of countries within the two-dimensional space in general and then disaggregated at the quadrant level.

Modeling the "4-Q world"

We are interested in understanding why countries occupy a particular quadrant, the factors underlying country movements, and whether the quadrants represent a meaningful typology. The approach is unique in that we are not trying to understand forest cover (deforestation) or GDP per capita (economic growth) independently but rather the dependence of country movement on both variables over time. Not surprisingly, there is no theory supporting the association between our combined dependent variable and the explanatory variables. However, modeling country movement in the 4-Q world will gain insight from both growth theory and the deforestation literature.

The economic growth literature finds that investments in human capital (e.g., education, training) contribute significantly to productivity (van Reenen and Sianesi 2003). In addition, there is strong evidence linking institutions to economic growth (Rodrik 2000). As noted by Redek and Sušjan (2005): "Growth is the result of an interplay between capital accumulation, human capital accumulation, productivity growth, technological progress, and numerous other factors which foster economic efficiency and are generally referred to as institutions." Institutions can be understood as "systems of established and prevalent social rules that structure social interactions" (Hodgson 2006) and include such things as language, money, the rule of law, and government policy, all of which can affect economic activity and growth.

Despite a large body of literature on tropical deforesta-

[4] A statistical relationship, however strong or suggestive, can never establish a causal connection: "our ideas of causation must come from outside statistics, ultimately from some theory or other" (Kendall and Stuart 1961, as quoted in Gujarati 1995).

[5] There were 29 countries that switched between 1990 and 2005.

tion, there is no consensus on its causes (Angelsen and Kaimowitz 1999; Kaimowitz and Angelsen 2001; Naidoo 2004; Sayer 2005; Kauppi et al. 2006). In the earlier deforestation literature, industrial logging and "slash and burn" agriculture were seen as the main culprits to tropical deforestation. Other underlying drivers of forest loss and degradation include economic factors (Ferreira 2004), institutional factors and governance quality (Bhattarai and Hammig 2004), demographic factors, population pressure (Hartwick 2005), and poverty. Amacher (2006) highlighted the importance of corruption in forest policy, while Barbier et al. (2005) recognized that corruption promotes land conversion; Bhattarai and Hammig (2004) discussed the role of enhanced educational attainment leading to a reduction in deforestation rates. The complexity of factors causing deforestation as evidenced by the literature should not be underestimated. In response, Rietbergen (1993) and Sayer (2005) assembled research findings suggesting that there are different combinations of various causes and underlying driving forces. Warning that it is inappropriate to adopt single-factor explanations, Palo (1990) proposed a model of "system causality" to describe the highly complex processes involved, distinguishing between agents, driving forces, and accelerating forces of deforestation and forest degradation.

Analogous to the many variables studied in models of economic growth and deforestation, our premise is that countries in the 4-Q world are affected by a variety of factors. Although the complexity inherent to ideas like system causality cannot be modeled with certainty, we expect that countries in the 4-Q world can be adequately modeled through experimentation vis-à-vis the selection of explanatory variables chosen from a broad range, including economic, institutional, social capital, and ecological regressors. The intent is not to include all variables responsible for economic growth and deforestation but to include those having a *joint* influence on deforestation and economic growth and where adequate expectations can be deduced. The data are described in the following subsections.

Data

Economic factors

Export of wood products is expected to impact both GDP per capita and forest cover. Forest exports as a proportion of total exports were calculated by dividing forest product export value into total exports for each of the benchmark years. The country-level forest product export value data come from the Food and Agriculture Organization of the United Nations Statistics Division (2007) and total exports for each of the benchmark years come from the World Bank (2006).[6] In the 4-Q world, a rise in forest product exports as a proportion of total exports is expected to increase income. The effect of the forest product exports variable on deforestation, however, is ambiguous (Meyer et al. 2003). Harvesting trees at an unsustainable rate over time clearly results in a loss of forest cover. On the other hand, a sustainably managed forest where adequate cover is present can easily support a viable export industry.

Similar to the Meyer et al. (2003) study where country-level deforestation is modeled, the agricultural output variable, the Food and Agricultural Organization's food produc-

Table 5. Factors affecting country occupancy in the 4-Q world (stock model).

	Coefficient estimate		Marginal effect				
Explanatory variable	General	Restricted	Q4 (38 countries)	Q3 (47 countries)	Q2 (29 countries)	Q1 (23 countries)	Mean
Forest exports (2005)	0.008** (0.004)	0.008** (0.004)	0.001** (0.005)	0.006* (0.004)	–0.001** (0.001)	–0.001** (0.000)	27.994
Agricultural output (2005)	0.014 (0.017)	—	—	—	—	—	101.415
Control of corruption (2005)	0.551**(0.308)	0.487** (0.215)	0.070** (0.032)	0.036 (0.022)	–0.074** (0.034)	–0.032** (0.016)	–0.129
Education (2005)	0.068*** (0.015)	0.070*** (0.012)	0.010*** (0.002)	0.005** (0.003)	–0.011*** (0.003)	–0.005***(0.001)	77.2
Tropical	0.060 (0.511)	—	—	—	—	—	0.511
No. of observations	137	137					
Log likelihood	–141.487	–141.862					
Wald χ^2	93.62	86.45					
McFadden $\bar{R}^2$	0.236	0.234					

Note: Numbers in parentheses are the Huber/White/sandwich robust standard errors. ***Statistically significant at the 1% level or better; **statistically significant at the 5% level or better; *statistically significant at the 5% level or better.

tion index, is a proxy for the opportunity cost of keeping land under forest cover. More food production per capita represents the likelihood of efficiency gains and is expected to increase GDP per capita. The deforestation literature (discussed above) is quite clear about the relationship between agricultural production and deforestation: a rise in agricultural production is expected to increase the rate of land conversion from forest to agriculture.

Institutions, social capital, and human capital

The distinction between institutions and social capital is a subtle one. As noted, institutions include the formal rules that govern economic activities, while social capital refers to certain norms of behaviour. In our model, we discern two institutional variables that we hypothesize to affect economic growth and deforestation in a positive way, namely, a measure of regulatory quality and an indicator of the rule of law. The "regulatory quality" and "rule of law" indices are measured from 1 to 10 (a higher score is better) (Kaufmann et al. 2006). Regulatory quality represents the ability of the government to formulate and implement sound policies and regulations that permit and promote economic activities in the private sector; rule of law attempts to measure the extent to which agents have confidence in and abide by the rules of society, particularly the quality of contract enforcement (police and courts).

According to Ostrom (2000), social capital is "...the shared knowledge, understandings, norms, rules, and expectations about patterns of interactions that groups of individuals bring to a recurrent activity." The extent of a country's social capital is measured by a control of corruption index (Kaufmann et al. 2006). It measures social relations and perceptions and may therefore be correlated with the two institutional indices and whether a country is a member of the Organization for Economic Cooperation and Development (OECD) (as OECD member countries generally score lower on perceptions of corruption). Lower corruption is associated with greater economic growth and is thought to be important in explaining deforestation (Meyer et al. 2003; Amacher 2006). Rich countries may have an advantage over poorer ones simply because they have better trade, tourism, and other forms of exchange with other rich countries, a type of club effect. To address this issue, we employ an OECD dummy variable indicating whether a country is a member of the OECD club. Members of the OECD are expected to have higher GDP and forest cover per capita.

The educational component of the United Nations' human development index is used as a proxy for human capital. Countries that have higher rates of participation in education are generally thought to have higher economic growth. Moreover, a highly educated population is expected to, vis-à-vis democratic means, ensure the regeneration of its country's natural resources.

Additional regressors

We also postulate that, given the nature of forest activities in tropical regions, this might serve to enhance rates of deforestation. In particular, tropic ecosystems are characterized by a large variety of tree species, only a few of which are commercially viable. Tropical forests generally have less commercial value than forests in northern and southern latitudes, and logging activities serve primarily to open up the forest for peasants seeking to grow agricultural crops. To take this into account, we use a dummy variable for countries with tropical forest cover. We expect an inverse relationship with the dependent variable in the 4-Q world. A summary of factors affecting countries in the 4-Q world is provided in Table 4.

Econometric models

For the empirical analysis, we specify (*i*) a stock model, (*ii*) global flow model, and (*iii*) a quadrant-specific flow model. Together, these estimate country occupancy and country movements in the 4-Q world.

Stock model

The stock model includes all of the variables discussed above at their stock values. The objective of this model is to provide insights into factors that determine a country's occupancy in a particular quadrant: do the four blocks of countries share different characteristics? We define the dependent variable as an ordered ranking derived from forest cover per capita and GDP per capita levels in 2005. Four possible rankings (1, 2, 3, and 4) correspond to the four quadrants and are estimated using the ordered logit model.[7]

With a logistic distribution, we have the following probabilities of observing the dependent variable:

$$\text{Prob}(y = 4) = 1 - \Lambda(\mu_3 - \beta' X)$$

$$\text{Prob}(y = 3) = \Lambda(\mu_2 - \beta' X) - \Lambda(\mu_1 - \beta' X)$$

$$\text{Prob}(y = 2) = \Lambda(\mu_1 - \beta' X) - \Lambda(-\beta' X)$$

$$\text{Prob}(y = 1) = \Lambda(-\beta' X)$$

where β is the vector of parameters to be estimated, μ_i (i = 1 to 3) is the unknown threshold parameters that separate categories, and $\Lambda(.) = e^{\beta X}/(1 + e^{\beta X})$ is the logistic cumulative function. As the marginal effects of the regressors of X on the probabilities are not equal to the coefficients, the marginal effects of changes in the regressors are provided as following:

$$\frac{\partial \text{Prob}[y = 1]}{\partial X} = -\Lambda(\beta' X)[1 - \Lambda(\beta' X)]\beta$$

$$\frac{\partial \text{Prob}[y = 2]}{\partial X} = \{\Lambda(-\beta' X)[1 - \Lambda(-\beta' X)] - \Lambda(\mu_1 - \beta' X)[1 - \Lambda(\mu_1 - \beta' X)]\}\beta$$

$$\frac{\partial \text{Prob}[y = 3]}{\partial X} = \{\Lambda(\mu_1 - \beta' X)[1 - \Lambda(\mu_1 - \beta' X)]$$

[6] Data from 2004 are used when 2005 data are unavailable. World Bank (2006) is available from earthtrends.wri.org/.
[7] An ordered-logit model is appropriate in this case where rankings make up the dependent variable (Greene 2000).

Table 6. Factors affecting forest cover and economic well-being (global flow model).

	Weights on change of GDP per capita and forest cover per capita		
Explanatory variable	0.5 GDP, 0.5 forest	0.8 GDP, 0.2 forest	0.2 GDP, 0.8 forest
Forest exports (1990)	–0.002 (0.002)	–0.002 (0.001)	—
Agricultural output (1990)	—	–0.001 (0.001)	—
Change in forest exports (2005–1990)	–0.004 (0.003)	–0.004* (0.002)	—
Change in agricultural output (2005–1990)	—	—	—
Control of corruption (1996)[a]	—	0.071 (0.048)	—
Education (1999)	0.009** (0.004)	0.005* (0.002)	0.004** (0.002)
Change in education (2005–1999)	—	—	0.007 (0.005)
Tropical	–0.342** (0.158)	—	–0.219*** (0.070)
Constant	0.232 (0.346)	0.222 (0.182)	–0.151 (0.166)
No. of observations	107	107	107
$\bar{R}^2$	0.190	0.140	0.265

Note: Numbers in parentheses are the Huber/White/sandwich robust standard errors. ***Statistically significant at the 1% level or better; **statistically significant at the 5% level or better; *statistically significant at the 5% level or better.

[a]The control of corruption index for 1996 is not statistically different from the 2005 index. Therefore, change in control of corruption was omitted.

$$-\Lambda(\mu_2 - \beta'X)[1 - \Lambda(\mu_2 - \beta'X)]\}\beta$$

$$\frac{\partial \text{Prob}[y = 4]}{\partial X} = \{\Lambda(\mu_2 - \beta'X)[1 - \Lambda(\mu_2 - \beta'X)] - \Lambda(\mu_3 - \beta'X)[1 - \Lambda(\mu_3 - \beta'X)]\}\beta$$

Global flow model

The global flow model uses a simple ordinary least squares regression to examine country movements across the two-dimensional space. The dependent variable is the sum of unit-free GDP per capita percentage change between 1990 and 2005 and forest cover per capita percentage change between the same years. To provide a range of results, different weights (0.5/0.5, 0.8/0.2, and 0.2/0.8) are attached to the GDP and forest cover variables, respectively. Unlike the stock model, the global flow model includes both stock and flow values for all regressors. Both the initial level of each independent variable and their change over time are expected to affect country movements.

Quadrant-specific model

Finally, the flow model measures the influence of independent variables on country movement in each of the four quadrants. The objective is to determine whether drivers behind forest cover and economic performance differ among blocks of countries —— to account for quadrant-specific factors that influence country movement over time. Again, stock and flow variables are included in this ordinary least squares regression. The same independent variables and regressors as in the global flow model are used, but only an equal weighting of income and forest cover (0.5/0.5) is assumed.

Results

Initial analyses demonstrated the OECD membership, rule of law and regulatory quality variables to be highly correlated with the control of corruption index and, based on this and regression analyses not shown here, were dropped from further consideration. The choice to maintain the corruption index was primarily because it has recently received increased attention in relation to the formulation of forest policy (Amacher 2006).

Stock model

Results of the stock model are provided in Table 5. The restricted model was achieved by removing the most insignificant variables, one at a time, until all remaining variables were statistically significant at the 25% level. Forest product exports, control of corruption, and the education variables are all significant at 5% or better in the restricted model. As expected, countries with higher forest product exports, better control of corruption, and higher enrolment and literacy rates have a higher probability to occupy Q3 and Q4. The marginal effects of the regressors are also displayed in Table 5. For example, an increase in the control of corruption variable by one unit means that the probability of a country occupying Q4 increases by 7%. Similarly, the likelihood of a country occupying Q3 increases by 3.6%. The probability of a country occupying Q1 and Q2 when the control of corruption regressor rises by one unit decreases by 3.2% and 7.4%, respectively.

Global flow model

Results of the global model (all variables significant at the 25% level) are provided in Table 6, and they indicate that the only explanatory variable statistically significant at the 10% level or better in all three weighted global flow models is the education index. A unit increase in this variable will increase the dependent variable by approximately 0.9% in the 0.5/0.5 weighted model, 0.5% in the 0.8/0.2 model, and 0.4% in the 0.2/0.8 model. Also significant in both the 0.5/0.5 and 0.2/0.8 models is the tropical variable, which is inversely related to the dependent variable. The change in forest product exports between 1990 and 2005 is significant in the 0.8/0.2 model where a unit increase in export change results in a slight decrease in weighted GDP and forest cover.

Quadrant-specific model

Finally, the quadrant-specific flow model results provided in Table 7 support the earlier regression estimates and pro-

Table 7. Factors affecting forest cover and economic well-being (quadrant specific).

Explanatory variable	Q4	Q3	Q2	Q1
Forest exports (1990)	–0.005*** (0.002)	—	—	0.028 (0.020)
Agricultural output (1990)	—	—	–0.013*** (0.004)	–0.014 (0.011)
Change in forest exports (2005–1990)	–0.008** (0.003)	0.010 (0.008)	–0.001 (0.001)	—
Change in agricultural output (2005–1990)	—	—	—	—
Control of corruption (1996)	0.388*** (0.105)	—	—	0.842* (0.414)
Education (2005–1999)	–0.061** (0.023)	0.014 (0.010)	—	0.018* (0.010)
Change in education (2005–1999)	—	0.071** (0.030)	—	—
Tropical	–0.739** (0.263)	0.428 (0.266)	—	—
Constant	5.283** (1.935)	–0.521 (0.896)	1.521*** (0.437)	–0.958 (1.342)
No. of observations	19	32	31	24
$\bar{R}^2$	0.756	0.310	0.324	0.498

Note: Numbers in parentheses are the Huber/White/sandwich robust standard errors. ***Statistically significant at the 1% level or better; **statistically significant at the 5% level or better; *statistically significant at the 5% level or better.

vide some additional insights. Again, only variables significant at the 25% level are included. Not surprisingly, the results estimate that countries in Q4 improve their position when the control of corruption index improves. The forest exports and change in forest exports variables have an inverse relationship with the dependent variable. Recall from the stock model that an increase in forest exports enhanced the probability of a country occupying Q3 and Q4. Although forest exports increase a country's probability of occupying a better-off quadrant, these variables will hinder positive country movement in Q4. This finding is interesting and could have a possible explanation in the resource curse[8] literature (Sachs and Warner 2001).

Countries primarily endowed with tropical forests in Q4 are also less likely to improve their situation. This is likely because, as suggested earlier, forests tend to be less productive in providing commercial timber and with logging activities expected to be less sustainable compared with those in nontropical countries. Further, it turns out that education has a negative influence on improvements in forest stock per capita and per capita income. This result does differ from our expectations but is likely an artefact of the small differences in the education levels of citizens of opulent countries.

The model predicts that countries in Q3 are positively affected by improvements in educational attainment, indicating that education increases income and the desire for more environmental amenities associated with forests. For countries in Q2, improvements in income and forest cover are adversely affected by agricultural output, likely because increases in agricultural output reduce forest stock more than they enhance income (if at all). Finally, improvements in per capita income and forest cover in countries occupying the worst-off quadrant (Q1) are positively affected by both control of corruption and better education, as found in the earlier regressions.

Discussion and conclusion

This study found Maini's (2003) 4-Q framework to be a meaningful typology insofar as it provides a unique means for classifying countries and enhancing our understanding of the relationship between forest cover and GDP per capita. Modeling the 4-Q world also allowed for examination of quadrant occupancy and an investigation into the principal factors affecting country movement across and within individual quadrants. From the 4-Q approach, our results depict an important role for social and human capital in bringing about economic and environmental well-being. In particular, we identified the importance of control of corruption and education in raising per capita GDP and forest cover, especially in the worst-off countries. In this regard, our findings echo those of Meyer et al. (2003) who, at least in terms of control of corruption and deforestation, found an inverse relationship. Moreover, the findings are consistent with Amacher's (2006) argument that corruption is among one of the most relevant variables in the design of effective forest policy. Clearly, investments in social and human capital are an important precursor to economic development and sustainable forestry.

With respect to the influence of forest exports on countries in the 4-Q world, the results are mixed. This is not altogether surprising because our expectation about this variable was also undecided. The stock model predicts that an increase in forest exports enhances the probability of a country occupying the two better-off quadrants, while the quadrant-specific model estimates an inverse relationship with country movement in Q4. These findings suggest a need for further investigation.

The tropical forest dummy variable has an inverse relationship with the dependent variable of the global model and the quadrant-specific model. We deem this result to mean that tropical forests tend to be less productive in providing commercial timber and that logging activities are generally less sustainable when compared with those in nontropical countries. Further, it turns out that education has a negative influence on improvements in the dependent variable for countries in Q4. This result differs from our expectations and likely hints at the small differences in the education levels for those in wealthy countries.

Of course, the results of our analysis carry certain limitations. As discussed above, there is a subjective element to choosing the demarcation lines that mark quadrant bounda-

[8] The resource curse is an inverse relationship between growth of GDP per capita and the proportion of natural resources exported expressed as a percentage of GDP.

ries. By establishing quadrants using the median values, the resulting broad groups of countries facilitated subsequent analysis. It should be clear that the four quadrants must not be interpreted as "air-tight" entities or that demarcation lines are permanent.

Future research needs to examine a variety of questions. What are the main trade flows of forest products among countries in the four quadrants? Why are countries in some quadrants more likely to supply forest products than those in other quadrants? Clearly, rich countries with adequate forest cover have the means to supply those with inadequate timber resources. Why do rich countries (in Q4) do the supplying and not poorer countries (in Q2) that are equally plentiful in forest resources? What is the relationship between economic development and forest conservation in terms of quadrant space? Finally, because groups of countries are generally affected by different factors, how can this effectively inform national and international policy?

Acknowledgments

The authors thank Cameron Stonestreet, Brian Peter, Alec McBeath, two anonymous reviewers, and the Associate Editor of this journal for valuable comments on earlier versions of the paper. All of the usual disclaimers apply.

References

Amacher, G.S. 2006. Corruption: a challenge for economists interested in forest policy design. J. For. Econ. **12**: 85–89. doi:10.1016/j.jfe.2006.05.002.

Anderson, T.W., and Finn, J.D. 1996. The new statistical analysis of data. Springer-Verlag, New York.

Angelsen, A., and Kaimowitz, D. 1999. Rethinking the causes of deforestation: lessons from economic models. World Bank Research Observer, **14**: 73–98.

Anielski, M., and Wilson, S. 2005. Counting Canada's natural capital: assessing the real value of Canada's ecosystems. Can. Bor. Ini., Ottawa, Ont. Available from www.borealcanada.ca/pr_docs/Boreal_Wealth_Report_Nov_2005.pdf.

Antle, J.M., and Heidebrink, G. 1995. Environment and development theory and international evidence. Econ. Dev. Cult. Change, **43**: 604–625.

Barbier, E.B., Damania, R., and Leonard, D. 2005. Corruption, trade and resource conversion. J. Environ. Econ. Manag. **50**: 276–299.

Bhattarai, M., and Hammig, M. 2001. Institutions and the environmental Kuznets curve for deforestation: a cross-country analysis for Latin America, Africa and Asia. World Dev. **29**: 995–1010. doi:10.1016/S0305-750X(01)00019-5.

Bhattarai, M., and Hammig, M. 2004. Governance, economic policy, and the environmental Kuznets curve for natural tropical forests. Environ. Dev. Econ. **9**: 367–382.

Cohen, L., and Holliday, M. 1982. Statistics for social scientists. Harper and Row Publishers, London, U.K.

Cropper, M., and Griffiths, C. 1994. The interaction of population growth and environmental quality. Am. Econ. Rev. **84**: 250–254.

Dinda, S. 2004. Environmental Kuznets curve hypothesis: a survey. Ecol. Econ. **49**: 431–455. doi:10.1016/j.ecolecon.2004.02.011.

Ehrhardt-Martinez, K., Crenshaw, E.M., and Jenkins, J.C. 2002. Deforestation and the environmental Kuznets curve: a cross-national investigation of intervening mechanisms. Soc. Sci. Q. **83**: 226–243.

Ferreira, S. 2004. Deforestation, property rights, and international trade. Land Econ. **80**: 174–193.

Food and Agriculture Organization of the United Nations. 1985. Forest resources 1980. FAO Forestry Department, Rome.

Food and Agriculture Organization of the United Nations. 1995. Forest resources assessment 1990. FAO For. Dep. Pap. 124. FAO, Rome.

Food and Agriculture Organization of the United Nations. 2001. Global forest resources assessment 2000 — Main Report. FAO For. Dep. Pap. 140. FAO, Rome.

Food and Agriculture Organization of the United Nations. 2006*a*. Global forest resources assessment 2005: progress towards sustainable forest management. FAO For. Dep. Pap. 147. FAO, Rome.

Food and Agriculture Organization of the United Nations. 2006*b*. FAOSTAT online statistical service. FAO, Rome.

Food and Agriculture Organization of the United Nations Statistics Division. 2007. FAOSTAT online statistical service. FAO, Rome.

Greene, W.H. 2000. Econometric analysis. 4th ed. Macmillan Publishing Company, New York.

Gujarati, D.N. 1995. Basic econometrics. 3rd ed. McGraw-Hill Inc., New York.

Hartwick, J.M. 2005. Deforestation and population increase. *In* Institutions, sustainability and natural resources: institutions for sustainable forest management. *Edited by* S. Kant and R.A. Berry. Springer, Dordrecht, the Netherlands. pp. 155–192.

Hodgson, G. 2006. What are institutions? J. Econ. Issues, **40**: 1–25.

Intergovernmental Panel on Climate Change. 2000. Land use, land-use change, and forestry. *Edited by* R.T. Watson, I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo, and D. Dokken. Cambridge University Press, Cambridge, U.K.

International Monetary Fund. 2005. World economic outlook database. Available from www.imf.org/external/pubs/ft/weo/2005/02/data/dbginim.cfm.

Kaimowitz, D., and Angelsen, A. (*Editors*). 2001. Agricultural technologies and tropical deforestation. CAB International, Wallingford, U.K.

Kaufmann, D., Kraay, A., and Massimo, M. 2006. Governance matters V: governance indicators for 1996–2005. World Bank Policy Research, September 2006. World Bank, Washington, D.C.

Kauppi, P.E., Ausubel, J.H., Fang, J., Mather, A.S., Sedjo, R.A., and Waggoner, P.E. 2006. Returning forests analyzed with the forest identity. Proc. Natl. Acad. Sci. U.S.A. **103**: 17574–17579. doi:10.1073/pnas.0608343103. PMID:17101996.

Kendall, M.G., and Stuart, A. 1961. The advanced theory of statistics. Charles Griffin Publishers, New York.

Kuznets, S. 1955. Economic growth and income inequality. Am. Econ. Rev. **45**: 1–28.

Loether, H.J., and McTavish, D.G. 1993. Descriptive and inferential statistics —— an introduction. Allyn and Bacon, Boston, Mass.

Maini, J.S. 2003. International dialogue on forests: impact on national policies and practices. *In* Forest policy for private forestry —— global and regional challenges. *Edited by* L. Teeter, B. Cashore, and D. Zhang. CAB International, Wallingford, U.K. pp. 9–15.

Mather, A.S., and Needle, C.L. 2000. The relationships of population and forest trends. Geogr. J. **166**: 2–13.

Mather, A.S., Needle, C.L., and Fairbairn, J. 1999. Environmental Kuznets curves and forest trends. Geography, **84**: 55–65.

Meyer, A., van Kooten, G.C., and Wang, S. 2003. Institutional, social and economic roots of deforestation: a cross-country comparison. Int. For. Rev. **5**: 29–37. doi:10.1505/IFOR.5.1.29.17427.

Naidoo, R. 2004. Economic growth and liquidation of natural capi-

tal: the case of forest clearance. Land Econ. **80**: 194–208. doi:10.2307/3654738.

Ostrom, E. 2000. Social capital: a fad or a fundamental concept? *In* Social capital: a multifaceted perspective. *Edited by* P. Dasgupta and I. Seralgeldin. World Bank, Washington, D.C. pp. 172–214.

Palo, M. 1990. Deforestation and development in the third world: roles of system causality and population. *In* Deforestation or development in the third world? Vol. 3. *Edited by* M. Palo and J. Salmi. Finnish Forest Research Institute, Helsinki. pp. 155–172.

Panayotou, T. 1995. Environmental degradation at different stages of economic development. *In* Beyond Rio: the environmental crisis and sustainable livelihoods in the third world. Chap. 2. *Edited by* I. Ahmed and J.A. Doeleman. Macmillan, London, U.K. pp.13–36.

Redek, T., and Sušjan, A. 2005. The impact of institutions on economic growth: the case of transition economies. J. Econ. Issues, **39**: 995–1027.

Rietbergen, S. (*Editor*). 1993. The Earthscan reader in tropical forestry. Earthscan, London, U.K.

Rodrik, D. 2000. Institutions for high-quality growth: why they are and how to acquire them.. Stud. Comp. Int. Dev. **35**: 3–31.

Sachs, J.D., and Warner, A.M. 2001. The curse of natural resources. Eur. Econ. Rev. **45**: 827–838.

Sayer, J. (*Editor*). 2005. The Earthscan reader in forestry and development. Earthscan Publishers, London, U.K.

Stern, D.I. 2004. The rise and fall of the environmental Kuznets curve. World Dev. **32**: 1419–1439. doi:10.1016/j.worlddev.2004.03.004.

United Nations. 2003. World population prospects: the 2002 revision —– population database. United Nations, New York.

United Nations. 2006. National accounts main aggregates database. Available from unstats.un.org.ezproxy.library.uvic.ca/unsd/snaama/selectionbasicFast.asp.

United Nations Development Programme. 2006. Human development report 2006: beyond scarcity: power, poverty and the global water crisis. Palgrave MacMillan, New York.

van Reenen, J., and Sianesi, B. 2003. Education and economic growth: a review of literature. J. Econ. Surv. **17**: 157–200.

World Bank. 2006. 2006 world development indicators online. World Bank, Washington, D.C.. Available from publications.worldbank.org/ecommerce/catalog/product?item_id=631625.

Appendix A

List of the 137 countries used in the analysis (numbers in parentheses indicate the quadrant (in Fig. 1) that the country occupied in 2005): Albania (3), Algeria (3), Angola (2), Argentina (4), Armenia (3), Australia (4), Austria (4), Azerbaijan (3), Bangladesh (1), Belarus (4), Bolivia (2), Bosnia and Herzegovina (4), Brazil (4), Bulgaria (4), Burkina Faso (2), Burundi (1), Cambodia (2), Cameroon (2), Canada (4), Central African Republic (2), Chad (2), Chile (4), China (3), Colombia (4), Congo Democratic Republic (2), Congo Republic (2), Costa Rica (4), Côte d'Ivoire (2), Croatia (4), Czech Republic (3), Denmark (3), Dominica (3), Ecuador (4), Egypt (3), El Salvador (3), Eritrea (2), Estonia (4), Ethiopia (1), Finland (4), France (3), Gabon (4), Gambia (1), Georgia (2), Germany (3), Ghana (1), Greece (3), Guatemala (3), Guinea (2), Guinea-Bissau (2), Haiti (1), Honduras (2), Hungary (3), India (1), Indonesia (4), Israel (3), Italy (3), Iran (3), Ireland (3), Jamaica (3), Japan (3), Jordan (3), Kazakhstan (3), Kenya (1), Kuwait (3), Kyrgyzstan (1), Laos (2), Latvia (4), Lebanon (3), Libya (3), Lithuania (4), Macedonia (4), Madagascar (2), Malawi (1), Malaysia (4), Mali (2), Mauritania (1), Mauritius (3), Mexico (4), Moldova (1), Mongolia (2), Morocco (3), Mozambique (2), Myanmar (2), Nepal (1), Netherlands (3), New Zealand (4), Nicaragua (2), Niger (1), Nigeria (1), Norway (4), Oman (3), Pakistan (1), Panama (4), Papua New Guinea (2), Paraguay (4), Peru (4), Philippines (3), Poland (3), Portugal (4), Romania (3), Russia (3), Rwanda (1), Saudi Arabia (3), Senegal (2), Sierra Leone (2), Singapore (3), Slovakia (4), Slovenia (4), South Africa (3), South Korea (3), Spain (4), Sri Lanka (3), Sudan (2), Swaziland (4), Sweden (4), Switzerland (3), Syrian Arab Republic (3), Tajikistan (1), Tanzania (2), Thailand (3), Togo (1), Trinidad and Tobago (3), Tunisia (3), Turkey (3), Turkmenistan (4), Uganda (1), Ukraine (3), United Arab Emirates (3), United Kingdom (3), United States (4), Uruguay (4), Uzbekistan (1), Venezuela (4), Vietnam (1), Yemen (1), Zambia (2), Zimbabwe (2).