A Global Analysis of the Impact of Human Concentration on Species Fragility

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Abstract

Increased size of human population and associated human activities adversely affect other species' abundance, contributing to loss of biodiversity and increased species fragility in a given area. However, the relationship between the spatial distributions of a fixed-size human population on species fragility is not well documented and a generalized finding is lacking. There is significant belief that concentrating humans in densely populated cities has ecological benefits. However, this assumed relationship has scant empirical support. In this study, we explore empirically the impact of human dispersion on species fragility. Using data on 108 countries compiled and published by the International Conservation Union, World Resources Institute, United Nations, and World Bank along with data from the Oak Ridge National Laboratory on population distribution, a generalized linear model is fitted on species fragility against endemic species, population density, a population dispersion index (Gini coefficient), protected area, and per capita gross domestic product. The results suggest that the percentage of endemic species is a positive and significant predictor of the percent of ecologically imperiled species in a country. However, neither human population density or the Gini coefficient measure of human population concentration is statistically related to species fragility.

Introduction

It seems quite clear that the sheer number of humans (or any species) has a variety of ecological consequences (Cincotta and Engelman 2000; Kerr and Currie 1995; Thompson and Jones, 1999). A successful species directly 'crowds out' other species by appropriating habitat (Odum 1971). As the population of a prey species increases, so, too, does the population of any predator and/or symbiotic species, albeit with a temporal lag. In turn, a boom in the numbers of a predator species leads to a reduction in the numbers of the prey species and population cycles among predator/prey species are well-documented.

However, while a link between the *spatial distribution* of humans (or human activity) and ecological outcomes has been conjectured, empirical support is lacking. For example, it has been suggested that intensively-managed timber, as a human activity, reduces the imperative to cut from 'natural' forests, thus leaving greater acreage intact in undisturbed ecosystems (Bowyer, 2001; South, 1999; Wallinger, 1993). The implicit suggestion is that *in the aggregate* there are ecological advantages (in terms of biodiversity enhancement, reduced soil disturbance, reduced ecosystem fragmentation, and the like) to more intensive human processing of a relatively smaller number of acres in planted trees than less intensive human processing of a relatively larger number of acres of naturally generated trees, for a given timber harvest level.

Analogously, certain proponents of so-called smart growth advocate policies that encourage, if not require, higher densities of humans in cities as a means of reducing the putative ecological harms caused by urban sprawl. For example, one Smart Growth principle is Compact Building Design. As indicated on an Environmental Protection Agency (EPA) website: (http://cfpub1.epa.gov/sgpdb/glossary.cfm?type=topic):

> Compact Building design refers to the act of constructing buildings vertically rather than horizontally, and configuring them on a block or neighborhood scale that makes efficient use of land and resources, and is consistent with neighborhood character and scale. ***Compact building design reduces the footprint of new construction***, thus preserving greenspace to absorb and filter rain water, reduce flooding and stormwater drainage needs, and lower the amount of pollution washing into our streams, rivers and lakes. (emphasis added).

Similarly, albeit in a different context, additional claims are made on another EPA web site (www.epa.gov/smartgrowth/topics/environmental_protection.htm) about the environmental impact of how humans organize themselves:

> Development patterns and practices also indirectly affect environmental quality since urban form can influence the travel decisions that people make. Conventional patterns of development, characterized by very low densities, singular land uses, and little or no public transportation, foster a greater reliance on motor vehicles. As development grows more dispersed, people must drive further to reach their destinations…..In turn, this auto-dependence leads to more and longer vehicle trips, which are associated with the auto-related air emissions and greenhouse gases that contribute to global climate change. Ultimately, air pollution and climate change can also adversely affect water quality and habitat.

There are two strong assumptions that form the foundation for this smart growth philosophy:

(1) not only does the sheer number of human beings matter, how you distribute the human population, generally speaking, matters also. In this regard, the analogy to the intensively-managed forestry mentioned previously is virtually perfect, as indicated in this passage from the SmartGrowth.org website (www.smartgrowth.org/about/issues/issues.asp?iss=4):

> As we build, we replace our natural landscape - - forests, wetlands, grasslands with streets, parking lots, rooftops, and other impervious surfaces. The effect of this conversion is that stormwater, runoff which prior to development is filtered and captured by natural landscape, is trapped above impervious surfaces and runs off into streams, lakes, and estuaries, picking up pollutants along the way. Runoff can be reduced through clustering of development, thereby leaving larger open spaces and buffers. ***Although compact development generates higher***

> ***runoff and pollutant loads within a development, total runoff and pollutant loads are offset by reductions in surrounding undeveloped areas***. (emphasis added)

(2) the claimed environmental impacts are of significant consequence.

The possibility that concentration/dispersion of the human population matters independently of the level of human population can be illustrated by example. Consider two countries, A and B, that are identical in every respect, including size of human population, land area, percent of human population living in urban areas, number and characteristics of ecological niches, species diversity, and so on. In country A, the urban population is confined completely within a single city of 100 square miles; in city B the urban population is distributed equally among 100 cities, each confined within a one square mile area. The critical question is whether the ecological impact of the otherwise identical human urban populations is the same across countries A and B.

There are good reasons to believe that the impacts would not be identical. Depending critically on the precise location of both cities and ecologically fragile species, it seems likely that the impervious surface of the single urban area in A would destroy a smaller number of species located in unique, geographically small, ecological niches than the equivalent area of impervious surface distributed in smaller parcels in B, that happen to coincide with a larger number of those unique, geographically small, ecological niches. Yet, in fact, such location issues may be of empirically trivial importance given that both countries require identical amounts of food, water, and other resources to sustain their respective populations of humans. These life-sustaining resources are drawn from the entire country, not just the specific location in which the population is physically housed. Thus, use of fertilizers and pesticides to boost agricultural harvests will be identical in the two countries, with identical impacts on their respective species' ecological fragility.

There can be no doubt that, at an on-the-ground level of analysis, specific location decisions are critical to species fragility. Concrete poured at specific location X may destroy the last remaining population of a rare flower but have a negligible ecological impact if poured at specific location Y. But questions about the site-specific impact of humans on species fragility are fundamentally different than questions about whether, *in the aggregate*, the number of ecologically fragile species is influenced by the size-distribution of a fixed population of humans. Exactly where that existing population is physically located may indeed have ecological implications; however, these site-specific implications are quite separable, in theory, from the ecological implications of different size-distributions of the human population.

A significant intellectual foundation for the belief that the structural configuration of a fixed-size population has ecological implications was provided by Liu et al. (2003) and Keilman (2003). They argue that the intensity of resource use, and thus the aggregate environmental impact, is greater when a fixed population of human beings is distributed in smaller households than in larger households. There may be spatial implications of alternative household dynamics, but this need not necessarily be the case. Two or more households can occupy the same space as a single household - - e.g., a residential house that is re-made into separate apartments. The result is that analysis of different household dynamics is not the same as analysis of different spatial distributions of a fixed population of humans. Urbanization as a specific form of habitat loss that causes biodiversity loss has also been widely acknowledged (McKinney 2002, Riley et al. 2003, and Turner et al. 2004), but the empirical importance of such losses has yet to be documented.

Employing a cross-sectional analysis of the 49 continental states in the U.S., Brown and Laband (2005) investigated whether the structural organization of humans has an empirically significant *aggregate* impact, defined in terms of the ecological fragility of plant and animal species. They constructed Gini coefficient measures of inequality in the dispersion of human population in each state, using 4 indicators: (1) population, (2) the number of households, (3) night-time light distribution, and (4) distribution of roads. They failed to find evidence of a relationship between the distribution of human activity and the distribution of the number of ecologically fragile species (using NatureServe listings of species in each state that are at-risk of extinction).

Research Question

In this project, we expand the work of Brown and Laband (2005) by conducting a global analysis of the relationship between the structural dispersion of humans and the incidence of species fragility of plants and animals. The specific question to be investigated is whether the incidence of species endangerment (as an indicator of the ecological footprint of man's presence and activities) in a country is related significantly not only to the level (or density) of the human population, but also to the extent to which that the human population is geographically concentrated. That is, does structural dispersion in the human population, *holding population level constant*, influence the severity of the ecological impact of mankind?

Methods and Data

Our model of the factors that influence the percent of ecologically fragile species in a country is presented in equation (1):

$$PES = \beta_0 + \beta_1 PEN_i + \beta_2 POPDEN_i + \beta_3 POPGINI_i + \beta_4 PROTECTEDAREA_i \qquad (1)$$

$$+ \beta_5 PCGDP_i + \beta_6 ISLAND_i + \varepsilon_i$$

where

PES_i = the percent of country i species that are considered endangered, found by dividing the number of endangered species of amphibians, reptiles, birds, and vascular plants found in country i by the total number of amphibians, reptiles, birds, and vascular plants found in country i

PEN_i = the percent of country i species (amphibians, reptiles, birds, and vascular plants) that are found only in country i.

$PROTECTEDAREA_i$ = the fraction of country i land area officially designated as protected, found by dividing the total square mileage of protected land in country i by the total square mileage of country i.

$POPDEN_i$ = country i population density in 2000.

$PCGDP_i$ = Gross Domestic Product ($U.S. equivalents) per capita in 2000 in country i.

$POPGINI_i$ = the constructed Gini coefficient measuring concentration in country i's population distribution in 2000.

$ISLAND_i$ = a dummy variable that is assigned a value of 1 for island nations and 0 for non-island nations.

ε_i = the error term.

We expect the percent of ecologically imperiled species in a country to be positively related to the percent of endemic species (McPherson and Nieswiadomy 2005) and to (human) population density (Wilson 1988; Kerr and Currie 1995; McKinney 2001; 2002), and inversely related to concentration of the human population, and to the fraction of the country designated as protected. For a variety of well-understood reasons, we expect island nations to have a larger percent of imperiled species than non-island species (Czech, Krausman and Devers 2000; Frankel and Soule, 1981). However, there is considerable controversy about the relationship between economic well-being and measures of environmental degradation. On one hand, it has been argued that desperately poor people are willing to accept increased environmental degradation as necessary to produce an improved standard of living. However, as their standard of living improves, they are able increasingly to turn their attention away from exploiting the natural environment for food, shelter, and other necessities of life, and toward appreciation of the wonders of nature (existence *per se*). In terms of empirical application, this implies a relationship characterized by an inverted U-shape between measures of economic well-being, such as per capita income, and measures of environmental degradation - - the so-called Environmental Kuznets Curve (EKC).

Others criticize the putative EKC relationship on the grounds that perhaps the reason that richer countries experience diminishing levels of environmental degradation is that they 'export' their environmental harm to other, poorer countries. That is, instead of manufacturing environmentally unfriendly items in their own countries and subjecting themselves to environmental degradation, people living in rich countries merely purchase those goods from manufacturers living in other countries, who then are the ones subject to the environmental problems associated with production. International trade permits global NIMBY (not in my backyard), in which the poorest countries voluntarily become the environmental dumping grounds for the richest countries. Economic well-being for humans inevitably harms the environment, if not locally then globally in the context of spaceship earth. When one species thrives it 'crowds out' others.

Employing cross-sectional analysis, a number of researchers have found empirical evidence that is consistent with the EKC (Cropper and Griffiths, 1994; Grossman and Krueger, 1995; Hettige et al., 1992; Hilton and Levinson, 1998; List and Gallet, 1999; Shafik 1994; Selden and Song, 1994). Although precise interpretation of these empirical findings is problematic (Arrow et al, 1995; Stern et al., 1996; and de Bruyn et al., 1998; Suri and Chapman, 1998; and Rothman, 1998), it seems plausible to suggest that, at least above a certain (albeit unspecified) level of well-being, environmental quality is a normal good, with the implication that as incomes rise, environmental protections will rise. All of these analyses focused on specific pollutants, rather than an indicator of more comprehensive environmental degradation. However, in their analysis of threatened and endangered species of birds and mammals in 113 countries, McPherson and Nieswiadomy (2005) report evidence that is consistent with an EKC.

Country specific data on species (total species, endangered species, and endemic species) are available from the World Resources Institute Earthtrends Environmental Portal (WRI 2003) and from the World Conservation Union (IUCN 2003). The IUCN publishes a Red List that identifies taxa that face a high risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). Information on species endangerment is available for amphibians (181 countries), reptiles (194 countries), birds (194 countries), mammals (189 countries), fish (194 countries), and vascular plants (185 countries). These data are from 2002/2003. However, a number of these countries are island nations. These were excluded from our empirical analysis because an alternative mix of anthropogenic and environmental factors is thought to drive species imperilment on islands (Czech et al., 2000). The data on Gross Domestic Product per capita are available from the World Bank (WB 2003) and WRI.

Endemism is a critical determinant of the overall incidence of species fragility (Brown and Laband, 2005). However, data on endemism (in 1999) was not as prevalent as data on species diversity and species endangerment. For example, data on endemic species of mammals and fishes were unavailable, thus our empirical analysis was limited to four taxa - amphibians, reptiles, birds, and vascular plants. Further, the data on endemic vascular plants was available only for 132 countries.

Population density figures are available from the United Nations Population Division (UNPD 2003). Data on the distribution of population are available from a gridded one kilometer^2 estimation (LandScan) developed by the Oak Ridge National Laboratory, based on census counts adjusted by several indicators, such as land cover, slope, roads, and nighttime lights. The Gini coefficient (GC) is a measure of inequality (Klein 2002). It is based on the Lorenz curve, a cumulative frequency curve that compares skewness in the distribution of a specific variable (e.g. human presence) against a uniform distribution. GC values range from 0 to 1. We computed the GC value for each country by superimposing a world political map on the Oak Ridge gridded population map using ArcGIS software (ESRI 2002). This overlay exercise produced the number of cell counts with corresponding population figures for each country. The GC is calculated from unordered size data as the "relative mean difference" i.e. the mean ratio of the difference between every possible pair of population counts and population values for a country divided by the mean population size (μ) of that country using the following formula as suggested by Dixon et al. (1987), and Damgaared and Weiner (2000):

$$GC = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right|}{2n^2\mu} \qquad (2)$$

$$For \quad this \quad study, it \quad is \quad simplified \quad as:$$

$$GC = \frac{(\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right| * n_i * n_j)}{2 * \sum n_i^2 * (\sum n_i.x_i) / \sum n_i} = \frac{(\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right| * n_i * n_j)}{2 * \sum n_i * (\sum n_i.x_i)}, \tag{3}$$

$where;$

$i = population \quad counts \quad (the \quad number \quad of \quad cells \quad that \quad contain \quad same \quad number \quad of \quad people)$

$j = population \quad values \quad (the \quad number \quad of \quad people \quad (not \quad density) \quad per \quad cell).$

$x_i = specific \quad size \quad population \quad counts \quad in \quad a \quad country$

$xj = corresponding \quad population \quad values \quad in \quad a \quad country$

$ni = total \quad number \quad of \quad population \quad counts \quad in \quad a \quad country$

$nj = total \quad number \quad of \quad population \quad values \quad in \quad a \quad country$

$\mu = mean \quad population \quad size \quad of \quad a \quad country$

$n = total \quad number \quad of \quad countries$

As a measure of concentration the GC has desirable statistical properties (mean and size independence, symmetry, and Pigou-Dalton Transfer sensitivity) and is one of the most accepted and widely-used measures of concentration available (Hart 1971).

Both ordinary least squares models (van Rensberg et al. 2004) and negative-binomial models (Naidoo and Adamowicz 2001) are appropriate for our empirical analysis. We employed the ordinary least squares method to analyze the data after their log transformation in the following form:

$$y_i = \beta_0 + \sum_{j=1}^{p} x_{ij}\beta_j, \quad y_i \in (0 \;\; 1), \; i = 1, 2, \ldots, 108 \; (country), \; j = 1, 2, 3 4, and \; 5 \; , (p = 5). \tag{4}$$

Where, y_i is the ratio of fragile species to total species expressed in percentage, x_i is the vector of independent regressors that include – percentage of endemic species, population density, population dispersion index (GC), percentage of protected area, and per capita GDP.

The data analysis was performed in SAS using the generalized model (GENMOD) procedure. Consistent data on all variables in the model were available for 108 countries. Descriptive statistics are presented in Table 1.

<u>Table 1 about here</u>

Results

Results of the regression analysis are presented in Table 2. As expected, we find that the percent of endemic species in a country is a statistically significant, strongly positive predictor of the percent of species threatened by extinction in that country. Surprisingly, however, we do not observe that human population density influences species fragility. Rather, we find that the impact of population density on species imperilment is influenced by whether or not the country is an island. Although we traced this connection, we were unable to resolve it satisfactorily. Population density is shown to exert a positive and significant impact on species imperilment across our entire sample, with no distinction made between island nations and all other nations (column 1). However, when we include a dummy variable in the model that identifies island nations, the coefficient estimate on that dummy variable is positive and highly significant, while the impact of population density no longer is statistically significant (column 2). Further, when we split our sample into two (non-island countries – column 3, and island countries – column 4), population density is not a statistically significant predictor of species imperilment in either regression. Of particular importance for our analysis, we fail to find evidence of a statistically significant, negative relationship between concentration in a country's human population and the percent of ecologically fragile species in that country. We find no evidence that the extent of protected area in a country or per capita GDP (entered linearly or nonlinearly) is related to the percentage of ecologically fragile species. The former finding is in agreement with Naidoo and Adamowicz (2001); the latter finding is not consistent with the findings of McPherson and Nieswiadomy (2005) or Naidoo and Adamowicz (2001).

Table 2 about here

The coefficient estimates are based on a double log form of the model, so they can be treated as a measure of elasticity. For example, the estimated coefficient on PES (in column 2) suggests that doubling the percent of endemic species is associated with a 29 percent increase in the percent of ecologically fragile species, relative to the sample means.

Discussion

Our findings confirm the critical relationship between species endemism and species imperilment observed previously by Naidoo and Adamowicz (NA 2001) and McPherson and Nieswiadomy (MN 2005) in a global context. However, we fail to observe a statistically significant influence of human population density on species fragility, whereas MN found that population density was a significant predictor of species imperilment for mammals and birds, based on their analysis of 113 countries. Likewise, both MN and NA find that measures of economic prosperity are related to species imperilment; we do not. In separate regression estimations, MN find evidence of a positive but diminishing impact of per capita income on species imperilment for both birds and mammals. In their analysis of 141 countries, NA found a similar response pattern for birds, but failed to find a statistically significant impact of per capita income on imperilment of mammals (127 countries). They did, however, find evidence of a negative but increasing relationship between per capita income and imperilment of amphibians (134 countries), reptiles (101 countries), fish (74 countries), and invertebrates (120 countries).

We suspect that these areas of inconsistency between our findings and those of NA result from the fact that our regression model treats imperiled species in the aggregate whereas NA estimate separate regressions for each of 7 different taxa. We include population density in our models; they do not. Nor are they able to control for endemism in every model. Since NA observe a significant positive but diminishing impact of per capita income on imperilment of birds and a positive (linear) impact for plants, but a negative and increasing effect of per capita income on imperilment of amphibians, reptiles, fish, and invertebrates, it certainly seems possible, if not likely, that an aggregative model will show no effect of per capita income on species imperilment. We also speculate that our failure to observe a significant relationship between human population density and species imperilment while MN observe a significant, positive impact of human population density on species imperilment results, in part, from the fact that MN examine only mammals and birds, whereas we examine vascular plants, birds, reptiles, and amphibians. We would not be surprised to learn that species in the different taxa exhibit differing sensitivity to changes in human population density.

Our objective was to investigate empirically whether the spatial concentration of humans has significant ecological impact - - measured in terms of species imperilment. We examined species imperilment across 4 major taxa: reptiles, amphibians, birds, and vascular plants to find no evidence (across the 108 countries we examined) of a statistically significant impact of the spatial concentration of humans. This result is consistent with the previous findings of Brown and Laband (2005). The implications of our findings for the likely efficacy of current policy initiatives are very great indeed.

Urban sprawl has been painted as an ecological, if not social, evil (Ewing et al., 2002; Burchell et al., 2003; McKinney, 2002). To combat the putative evils of urban sprawl, a significant movement has arisen, under the rubric of smart growth, whose adherents propose redesigning where and how people live, using the power of government as a vehicle for achieving their vision (Filion, 2003; Babbitt, 1999; Cheshire and Sheppard, 2002). Principles of smart growth are being strongly supported by the United States Environmental Protection Agency - - the most visible and politically powerful environmental agency in the federal government - - as well as many citizens groups and municipalities.

One of these principles calls for higher density urban housing and mass transit systems, on the assumption that putting more people into smaller urban areas means less environmental disturbance/distress elsewhere. This is an extraordinarily strong assumption without, so far as we can tell, any scientifically rigorous empirical underpinning. While it is possible that deliberate clustering of humans in high-density urban areas is preferable, from an ecological standpoint, to a more dispersed human population, the only anecdotal evidence we have suggests just the opposite - - the last century of dramatically increased urbanization almost everywhere in the world is associated with significant global environmental degradation. But this also has occurred during a period of rapid population growth, so separating association from causation is problematic. People who live in cities need to be fed, which implies a significant agricultural effort that likely distresses natural systems. The materials that are used to build and maintain the cities require significant extractive industries and power generation. These activities also are associated with environmental degradation. So it is not at all clear whether policies that deliberately encourage a reconfiguration of the human population into densely populated urban areas actually will provide significant environmental benefits.

There simply must be evidence of significant environmental benefits to justify smart growth policies, because we know with certainty that densely populated urban areas are costly in human terms. They are costly in terms of the public monies that are used to subsidize such development (and which therefore reflect foregone opportunities to provide some other public good). They are costly in terms of restricting private choice of residential location. Through their voluntary decisions to purchase homes in suburbs, millions of individuals have demonstrated clearly that they value the opportunity to own a bit of land that they can plant flowers, shrubs, grass, and fences on. This permits more privacy than is available in more densely-populated urban areas. Suburbs have less crime than inner city areas. Without going into excruciating detail, the point to be made is relatively straightforward: a deliberate social policy of encouraging people to live in densely-built urban areas will be costly in human terms -- the litany of social pathologies that are associated with densely-populated areas is well-known by scientists, law enforcement personnel, the people who live in urban areas, and the people who deliberately choose not to live in those areas.

It is possible that the tens of millions of individuals who voluntarily choose to live in suburbia -- contributing to urban sprawl- - would also voluntarily be willing to move to more densely-built housing if they were convinced that there were significant, positive environmental consequences of doing so AND if they cared about those environmental consequences. But current policy in this regard is not being driven, or, for that matter, even informed by science. Data exist that would permit us to evaluate the size and significance of possible ecological impacts of different degrees of concentration of human populations. These findings are of fundamental importance to an informed discussion of the merits of policies that influence how people live their lives and thus their quality of life.

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Table 1: Descriptive statistics of model variables

Variable	N	Mean	Std Dev	Minimum	Maximum
Fragile Species (PFS)	108	2.14768	3.57014	0.11299	22.72727
Endemic Species (PES)	108	13.88986	18.70290	0.03061	88.45061
Population Density (PD)	108	0.17329	0.63133	0.00159	6.47742
Gini Coefficient (GC)	108	0.86771	0.09641	0.58980	0.99897
Per Capita GDP (PCGDP)	108	6,251.11	9,229.68	99.52	37,500.46
Protected Area (PPA)	108	13.19537	12.97853	0.10000	72.30000
Island	108	0.25000	0.43503	0.00000	1.00000

Table 2: Regression Estimation Results

Parameter	(1) Coefficient Estimate	(2) Coefficient Estimate	(3) Coefficient Estimate	(4) Coefficient Estimate
Intercept	-0.4575	-0.2382	-2.5368	-11.7549
	(0.7717)	(0.7350)	(2.3702)	(7.3594)
Endemic Species (PES)	0.3706***	0.2884***	0.2242***	0.5786***
	(0.0537)	(0.0561)	(0.0587)	(0.1839)
Population Density (PD)	0.1446**	0.0720	0.0348	0.1337
	(0.0706)	(0.0702)	(0.0760)	(0.1681)
Gini Coefficient (GC)	-1.7061*	-1.0148	-1.1885	-4.5549
	(1.0426)	(1.0090)	(1.0347)	(3.4667)
Per Capita GDP (PCGDP)	0.0197	-0.0457	0.5804	2.5977
	(0.0663)	(0.0656)	(0.5998)	(1.6900)
$PCGDP^2$			-0.0439	-0.1480
			(0.0385)	(0.1030)
Protected Area (PPA)	0.0036	0.0524	0.1078	-0.0698
	(0.0651)	(0.0634)	(0.0732)	(0.1300)
Island Countries		0.7967*		
		(0.2277)		
N	108	108	81	27
Model F statistic	11.90***	13.05***	5.80***	2.47*
Adjusted r-squared value	0.3376	0.4033	0.2647	0.2539

standard errors are in parentheses

*** Parameter estimate is significant at 1% level.
** Parameter estimate is significant at 5% level.
* Parameter estimate is significant at 10% level.