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ANALYSIS

The role of human, social, built, and natural capital in explaining life satisfaction at the country level: Toward a National Well-Being Index (NWI)

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Abstract

This paper investigates the contributions to life satisfaction of four basic types of capital: human, social, built, and natural. Life satisfaction data were available for respondents from fifty-seven countries from the World Values Survey over the decade of the 1990s. Data on proxies for human, social, built, and natural capital were available for 171 countries, using data from the 1998 United Nations Human Development Report [United Nations Development Programme, 1998. Human Development Report 1998. Oxford University Press, New York.], Freedom House (1999) [Freedom House, 1999. News of the Century: Press Freedom 1999. Freedom House, http://freedomhouse.org/pfs99/pfs99.pdf, September 30, 2003.], and Sutton and Costanza (2002) [Sutton, P., Costanza, R., 2002. Global estimates of market and non-market values derived from nighttime satellite imagery, land cover, and ecosystem service valuation. Ecol. Econ., 41:509–527.]. Regression models show that both the UN Human Development Index (HDI — which includes proxies for both built and human capital) and an index of the value of ecosystem services per km^2 (as a proxy for natural capital) are important factors in explaining life satisfaction at the country level and together can explain 72% of the variation in life satisfaction. We did not find a proxy for social capital that was a significant predictor in the regression models. This was due to the inadequacy of available proxy variables for social capital at the national scale and intercorrelation with other variables. We discuss data limitations and a range of other problems with the existing limited data along with methods to overcome some of these limitations to improve future analyses. We propose a National Well-Being Index (NWI) based on our findings and describe a path to improve it over time.

Keywords: Life satisfaction; National well-being; Environment; Quality of life; Ecosystem services

1. Introduction

How does one assess the "well-being" of nations and the individuals that make them up? The answer to

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this question is critical to national and international development policy, as the explicit goal of these policies is to "make things better". How one measures "better" is thus obviously a key question. There have been several approaches to this question, including:

(1) traditional economic measures such as Gross National Product (GNP) or Gross Domestic Product (GDP);
(2) the UN's Human Development Index (HDI) which combines an index based on GDP with indices of education and health (UNDP, 1998);
(3) broader "economic welfare" indicators that combine components of GDP with wealth distribution adjustments, and natural, social, and human capital adjustments, such as the Index of Sustainable Economic Welfare (ISEW — Daly and Cobb, 1989) and the more recent Genuine Progress Indicator (GPI — Anielski and Rowe, 1999);
(4) indices based on a broad range of factors such as the Human Welfare Index (HWI), which includes over 87 specific sub-indices, and the Well-Being Index, which combines the HWI with the Environmental Welfare Index (Prescott-Allen, 2001); and
(5) measures of subjective well-being (SWB) derived by interviewing individuals and asking them to evaluate their overall well-being, happiness, or life satisfaction.

1.1. Subjective well-being

Subjective well-being (SWB) analysis studies individuals' own evaluations of their lives using "both cognitive judgments of life satisfaction and affective evaluations of moods and emotions" (Diener and Suh, 1999; Diener et al., 1995a). In the 1960s and 1970s, it became apparent that the common measures of economic well-being did not adequately capture the actual well-being of individuals or nations (Milbrath, 1982; Daly and Cobb, 1989; Cobb and Cobb, 1994; Easterlin, 1974, 1995). Even social indicators were not found to be sufficient to portray individual or national well-being (Milbrath, 1982; Haas, 1999). Much of the research in this field has focused on the individual and what may cause differences in the subjective well-being of different people. However, researchers have also investigated the differences in national levels of mean subjective well-being (Inglehart and Rabier, 1986; Diener et al., 1995a,b; Diener and Suh, 1999).

1.2. Aims of this study

This study aims to combine data on national levels of mean SWB with data on objective measures of built, human, social, and natural capital in order to better explain the determinants of national SWB. This should help to build better objective indices of national well-being that can be extended to countries and for years for which SWB has not been measured. In this study, SWB was simplified to the measure of life satisfaction, or just the cognitive evaluation of one's subjective well-being (Sirgy, 2002). In some other studies, subjective well-being has been defined as a combination of life satisfaction and a measure of happiness, or both the cognitive and affective judgments of subjective well-being (Diener and Lucas, 1999). Our decision to use life satisfaction to represent subjective well-being at the national level is supported by the finding of Diener et al. (1995a) that national predictors of well-being more strongly influence cognitive assessments of well-being (satisfaction) than affective assessments of well-being (happiness).

1.3. Background

Efforts to explain well-being have a long history, but there has been an explosion of interest and activity in recent years. Easterlin (2003) identifies two main strands of prevailing theory in psychology and economics. The dominant theory in psychology has been the "set point theory" (Lucas et al., 2003 is a good recent review). This theory hypothesizes that each individual has a happiness set point determined by genetics and personality to which one returns after relatively brief deviations caused by life events or circumstances. At the international level, this theory would imply that the level of SWB across countries should not be affected at all by factors such as income, health, education, environmental amenities, etc., but should be purely a function of the genetic make-up of the population.

The dominant theory in economics has been that "more is better" (Samuelson, 1947; Varian, 1987).

This theory implies that levels of income across countries should correlate with SWB. Easterlin (2003) argues that "neither the prevailing psychological nor economic theories are consistent with accumulating survey evidence on happiness". He argues that because of hedonic adaptation (people's aspirations adapt to their changing circumstances) and social comparison (people judge their happiness relative to social peers rather than on an absolute scale) that both the "set point" and "more is better" theories fail. Easterlin shows that SWB tends to correlate well with health, level of education, and marital status, and not very well with income. The lack of relationship with income is visible in a graph of life satisfaction versus GDP per capita ($PPP), which illustrates the diminishing returns to satisfaction of increases in GDP per capita (Fig. 1). Easterlin concludes that

"people make decisions assuming that more income, comfort, and positional goods will make them happier, failing to recognize that hedonic adaptation and social comparison will come into play, raise their aspirations to about the same extent as their actual gains, and leave them feeling no happier than before. As a result, most individuals spend a disproportionate amount of their lives working to make money, and sacrifice family life and health, domains in which aspirations remain fairly constant as actual circumstances change, and where the attainment of one's goals has a more lasting impact on happiness. Hence, a reallocation of time in favor of family life and health would, on average, increase individual happiness."

Previous international comparisons of subjective well-being have focused on cultural differences in the acceptance of positive and negative emotion, income, individualism, human rights, societal equality, political stability, and interpersonal trust (Diener and Suh, 1999; Diener et al., 1995a,b; Welsch, 2002; Cummins, 1998; Helliwell, 2003; Oswald, 1997). Diener et al. (1995b) focused on income and the acceptance of positive and negative emotion to explain national differences in SWB. They found that 1) income did not impact SWB, 2) differences in SWB are not due to unfamiliarity with the concept, and 3) the frequency of reporting positive or negative emotions is related to the acceptance of those types of feelings in the culture. Diener and Suh (1999) found that people in wealthy countries report higher levels of SWB than those in poorer countries, but that national wealth is strongly correlated with human rights, equality, fulfillment of basic biological needs, and individualism. Therefore, the effect of each of these variables

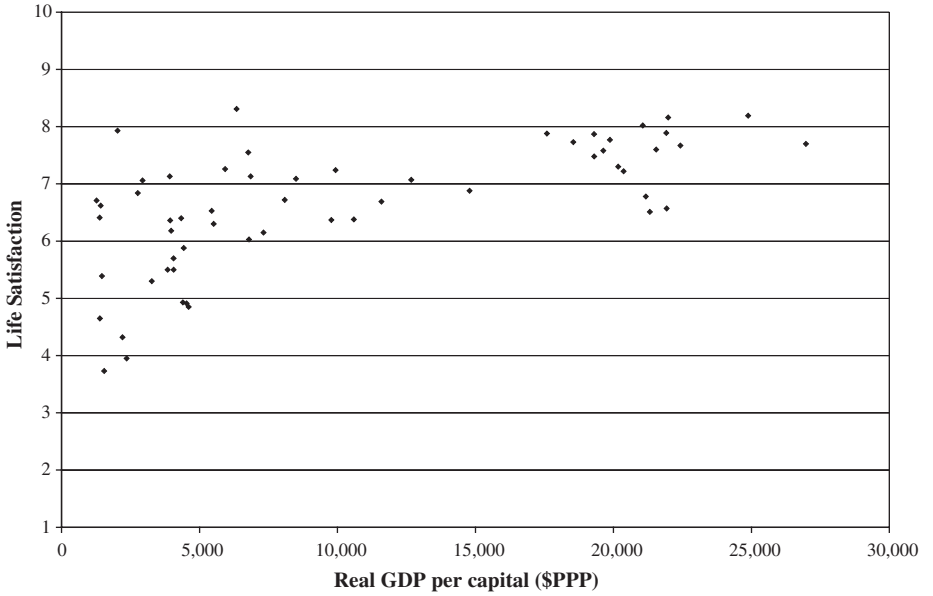

Fig. 1. Life satisfaction versus GDP per capita ($PPP).

individually is difficult to determine. They also found interpersonal trust and political stability to be strongly correlated with higher SWB. Diener et al. (1995a) found SWB to be correlated with high income, individualism, human rights, and societal equality. However, individualism was the only variable to correlate with SWB when other variables were controlled. They found low or inconsistent relationships between SWB and cultural homogeneity, income growth, and income comparison. Welsch (2002) investigated how happiness was impacted by income, rationality, freedom, and pollution. He found that income had a positive impact on happiness and the pollutant nitrogen dioxide had a negative impact on happiness, while rationality and freedom had more indirect effects on happiness. Cummins (1998) found that life satisfaction correlates strongly with national wealth and individualism but that these two variables only accounted for about 35% of the variance across the nations in the study. In conclusion, Cummins gives two suggestions, 1) that life satisfaction is held under homeostatic control since life satisfaction falls into such a narrow range (70 ± 5 percentage of scale maximum), and 2) that one must be cautious in interpreting international rankings of life satisfaction or SWB as implying some desirable population state. Helliwell (2003) based his international comparison on international samples of individual respondents, rather than national average levels of life satisfaction. He found links between life satisfaction and education and social capital but acknowledges that his findings can only show linkages and not establish the existence or direction of causation. Oswald (1997) reviews the happiness and satisfaction literature and finds that in developed nations, happiness is only minimally impacted by economic progress. In addition, Eckersley (2000) examined personal and social life satisfaction measures to determine their possible use in providing "insights into the state and fate of nations." He suggests that subjective measures of social life satisfaction are best used for evaluating national progress because there is evidence that personal life satisfaction is most influenced by personal and intimate aspects of life and is kept under homeostatic control which buffers it against shifts in personal circumstances and social conditions. Eckersley (2000) does acknowledge, however, that most analyses of national subjective well-being have been based on personal well-being questions, not social questions. Due to lack of international data on social life satisfaction, we follow the past trend in analyzing personal life satisfaction averages at the national level. Specifically, our research investigates international comparisons in a new theoretical framework, which incorporates the role of the natural environment, a variable that has been excluded from most other international subjective well-being comparisons.

1.4. Theoretical foundation

We based our work on the expanded model of the ecological economic system elaborated in Costanza et al. (1997a). The core of this model is the set of four basic types of capital: natural, human, social, and built and the notion that there is limited substitutability between these. It hypothesizes that a balance among these four types of capital is necessary to satisfy human needs and generate individual and community well-being (Costanza et al., 1997a). We aimed to test this hypothesis by using data at the national scale on levels of the four types of capital (and more importantly the services they provide) as determinants of SWB as measured by the World Values Survey via surveys of individuals.

2. Data and methods

In our study, we chose to investigate the relative impact of the four types of capital on mean, national-level life satisfaction. We selected single proxy variables to represent each type of capital and used life satisfaction data to represent individual well-being.

2.1. SWB data

The life satisfaction data were obtained from the 1990 and 1995 World Values Surveys (WVS). In 1990, there were 41 countries with life satisfaction data.[1] Forty-two countries had 1995 life satisfaction

[1] Sample sizes were not the same in each country and ranged from 588 respondents in Finland to 2792 respondents in Belgium, but the majority of countries had sample sizes of about 1000 respondents. Standard error of the mean for life satisfaction ranged from a high of 0.088 in Austria to a low of 0.030 in Spain with the majority around 0.062.

data.[2] Twenty-six countries had life satisfaction data for both 1990 and 1995, for those countries, an average value across the two years was used. The national-level life satisfaction averages were calculated as basic means of all respondents from each nation surveyed. The World Values Survey was conducted within each country with domestic funding using either national random, stratified multi-stage random, or quota sampling.[3] All surveys were conducted using face-to-face interviews in the national language with adults over the age of 18 (Inglehart et al., 2000). The life satisfaction question used in the 1990 and 1995 WVS was "All things considered, how satisfied are you with your life as a whole these days?" and it was rated on a scale from 1, dissatisfied, through 10, satisfied.

2.2. Human and built capital data

We represented human and built capital together as the 1995 UN's Human Development Index (HDI) obtained from the United Nations Human Development Report 1998. The HDI is a measure of achievements in human development and is comprised of a longevity index, an education index, and a standard of living index. The longevity index is based on life expectancy. Adult literacy and the combined enrolment ratio are combined into the education index. The standard of living index is based on the adjusted per capita income in PPP$. Index values are used in order to normalize the values of the variables that are included in the HDI, so that all values fall between 0 and 1 (UNDP, 1998). The three indices are averaged to obtain the HDI. Additional details on the calculation of the HDI are available in the technical notes of the Human Development Report, 1998.

We represented the human and built capital variables together because all of the possible human capital variables we tried were highly correlated with all of the possible built capital variables. We tried combinations of the following human capital variables: combined education enrolment ratio, life expectancy, adult literacy, and female adult literacy, with both the real GDP per capita ($PPP) and the adjusted real GDP per capita ($PPP). All combinations were highly correlated, which can confound regression analysis. In fact, regression models were run using the separate human and built capital variables but these models suffered from intercorrelation errors. For example, in a regression using the separate variables, the combined education enrollment ratio was found to have a negative impact on life satisfaction, which was only because of the intercorrelation of this education term with the GDP variable. Confounding errors such as this inhibited the use of the separate human and built capital variables. No other data on human capital were available for a large number of the countries included in the analysis; nor were there any other logical built capital variables to use.

2.3. Natural capital data

The natural capital variable was based on the ecosystem services product (ESP) obtained from Sutton and Costanza (2002). ESP was estimated using the IGBP land-cover dataset and unit ecosystem service values from Costanza et al. (1997b). The amount of each type of land-cover was estimated for each of the countries and multiplied by the corresponding unit ecosystem service values to obtain a total dollar value of ecosystem services per country (Sutton and Costanza, 2002). Using data provided by Sutton and Costanza (ESP values and land area for each nation)[4], we were able to calculate the ESP per square kilometer. For our analysis, we used the log of ESP per square kilometer and then normalized those values as an index between 0 and 1. The original distribution of the ESP variable was highly right-skewed, with a skewness value of 47. The original distribution of the ESP variable also

[2] Sample sizes were not the same in each country and ranged from 95 respondents in Ghana to 6004 respondents in Colombia, but the majority of countries had sample sizes of about 1000 respondents. Standard error of the mean for life satisfaction ranged from a high of 0.219 in Ghana to a low of 0.026 in Colombia with the majority around 0.055.

[3] Inglehart et al. (2000) note that the "populations of India, China, and Nigeria, as well as rural areas and the illiterate population, were undersampled". Stratified multi-stage random sampling was generally used in the 1990 WVS (Inglehart et al., 2000).

[4] Some of the land area values were not included in the dataset provided by Sutton and Costanza and instead were obtained from the CIA World Factbook (2003).

had a large kurtosis value (234), which indicates tails longer than those found in a normal distribution. The distribution of the log of ESP per square kilometer index is significantly better, with a normal bell curve and virtually no skewness or kurtosis, with values of −1.3 and 0.82 respectively.

2.4. Social capital data

The best social capital proxy we could identify is based on Freedom House's press freedom rating for 1995 (Freedom House, 1999). Freedom House assesses the freedom of the press within a nation by focusing on four categories: the laws, political factors, economic factors, and degree of actual violations. The influence of laws and administrative decisions on the content of news media is rated 0 to 15, low numbers meaning greater freedom. Political influence or control over news media content is also rated on the 0 to 15 scale. The influences of economic factors from either government or private entrepreneurs are again rated from 0 to 15. Actual violations against the media, however, are rated on a scale of 0 to 5. All of these categories are assessed for both broadcast and print media. Finally, Freedom House may add between 1 to 5 points to a country's score to reflect the frequency and severity of actual violations against the media. We transformed Freedom House's rating by (100 — Press Freedom rating) to make the score match the direction of positive results of all the other variables in the model. This way, greater freedom is a larger number, just as a larger number represents higher life satisfaction.

2.5. Initial analysis

To begin our analysis, we looked at the bivariate correlations between all of our variables (Table 1). The combined human and built capital, natural capital, and social capital variables were all significantly and positively correlated with life satisfaction. It is also important to point out that there was some intercorrelation between the social capital variable and the other capital variables. The press freedom variable has a highly significant correlation with both the HDI variable (human and built) and the log ESP/km^2 index variable (natural capital). This type of intercorrelation between variables can cause problems in regression analysis.

A review of partial correlations reveals that it is the HDI and press freedom variables that are most intercorrelated. When controlling for HDI, the correlation between press freedom and life satisfaction is reduced to 0.2703 and is barely significant. Similarly, when controlling for press freedom, the correlation between HDI and life satisfaction is reduced to 0.1779 and is not significant. We also conducted some regression analyses with the press freedom variable included but it was not found to be a significant factor. But the HDI variable was found to be significant. Since HDI is the more important variable to include, we decided to exclude the press freedom variable from our regression analysis. The press freedom variable does not add enough unique variation to the description of life satisfaction to warrant inclusion in the analysis, especially since it could cause intercorrelation errors in the regression. Next we used an ordinary-least-squares (OLS) regression model to examine the effect of

Table 1
Bivariate correlations between variables

		Average life satisfaction	HDI	Log ESP/km^2 index	Press freedom
Average life satisfaction	Pearson cor.	1			
	Significance				
HDI	Pearson cor.	.463	1		
	Significance	.000			
Log ESP/km^2 index	Pearson cor.	.358	.071	1	
	Significance	.007	.353		
Press freedom	Pearson cor.	.502	.502	.295	1
	Significance	.000	.000	.000	

Table 2
Basic regression model coefficients for national-level analysis

	Unstandardized coefficients		Standardized coefficients	t-value	Significance
	B	Std. error	Beta		
Constant	1.857	.900		2.063	.044
HDI	3.524	.832	.470	4.234	.000
Log ESP/km^2 Index	3.498	1.021	.380	3.427	.001

Sample size of the regression model was 56.

natural capital and the combined human and built capital on life satisfaction. We present the results of the regression model both before and after deleting six outlier countries.

3. Results and discussion

3.1. Basic regression model

In our basic regression model we did not exclude any countries from the analysis. Overall, our country-level regression model was found to be significant, with an R^2 value of .349. Our independent variables representing natural capital, and human and built capital were able to explain almost 35% of the variability in life satisfaction.[5] Both the natural capital and the combined human and built capital variables are highly significant in the regression (Table 2). The data for all of the countries used in our analysis is presented in Table 3.

We employed a number of diagnostic statistics on our basic regression model to test for influential cases and violations of OLS assumptions. Tests of collinearity using tolerance and the variance inflation factor (VIF) showed no signs of collinearity, with a tolerance value close to one and a low VIF value (Draper and Smith, 1981; SPSS, 1999; Berk, 2004). The Durbin–Watson test for detecting serial correlation was conducted and resulted in a non-significant value of 2.169 based on the testing procedures and tables in Draper and Smith (1981).

[5] Using the less optimistic adjusted R^2 value for the basic regression model (.324), we were able to explain about 32% of the variability in life satisfaction.

Fig. 2 shows that a number of countries were consistent outliers in the partial regression plots and in terms of leverage values and Cook's distance statistic. The main outliers were Bangladesh, Ghana, India, Nigeria and China. Since these were almost all of the low income countries from Africa and Asia in the dataset, it made sense to exclude the Philippines from the analysis as well. These countries all have low HDI values (below 0.7) and are not located in Europe or the Americas. In addition, World Values Survey documentation noted that many of the low-income countries over sampled the urban, educated population and under sampled the illiterate population (Inglehart et al., 2000). Specifically, the samples from China and India were 90% urban and much of the Nigerian sample was also urban or near urban centers (Inglehart et al., 2000). These sampling issues could have biased the life satisfaction levels from these countries, artificially inflating the values since the sample represents people who have had education and other opportunities that are not available to the entire population. The cultures of the low-income nations may also impact the observed levels of life satisfaction. Perhaps people in these countries are more reliant on social networks, which could not be represented in the models presented here. Therefore, the six countries excluded are likely to have a very different life satisfaction regression equation, one that is probably more reliant on social capital for maintaining high levels of satisfaction. Including them in the analysis here would merely add noise variation.

The only remaining non-European or American countries were South Korea, Japan, and South Africa, which all had higher HDI values and behaved similarly to the rest of the countries in the sample. We also kept all European (including former Soviet Union countries) and North and South American countries in the analysis, regardless of HDI value since they have more similar cultural backgrounds. Fig. 2 shows the observed versus predicted life satisfaction values for the 56 countries with life satisfaction data. The regression line for the 50 countries shown in blue diamonds is shown, along with the R^2 for that subset of countries. The six African and Asian outlier countries are also shown and labeled.

Table 3
Data for the countries used in the regression models

Country	Life satisfaction values[a]	Human development Index	Log (10) ESP/km^2 index	Press freedom index	Predicted life satisfaction values	Sample size and year
Colombia	8.31	.850	.67	52	6.98	6025 — 1997
Switzerland	8.19	.930	.61	90	7.54	1400 — 1989
Denmark	8.16	.928	.63	91	7.56	1030 — 1990
Ghana	7.93	.473	.69	38	3.66	96 — 1995
Canada	7.89	.960	.74	82	8.12	1730 — 1990
Ireland	7.88	.930	.65	85	7.63	1000 — 1990
						1009 — 1996
Sweden	7.87	.936	.69	90	7.79	1047 — 1990
Netherlands	7.77	.941	.61	82	7.62	1017 — 1990
						987 — 1996
Finland	7.73	.942	.72	85	7.90	588 — 1990
						1542 — 1995
USA	7.70	.943	.59	88	7.58	1839 — 1990
						1127 — 1996
Norway	7.67	.943	.69	92	7.85	1239 — 1990
Belgium	7.60	.933	.29	93	6.76	2792 — 1990
Australia	7.58	.932	.47	93	7.19	2048 — 1995
						1510 — 1996
Mexico	7.55	.855	.53	46	6.66	1531 — 1990
						1093 — 1998
United Kingdom	7.48	.932	.73	78	7.85	1484 — 1990
Italy	7.30	.922	.51	70	7.22	2018 — 1990
						1149 — 1997
Brazil	7.26	.809	.64	70	6.53	1782 — 1992
						1000 — 1996
Chile	7.24	.893	.57	70	7.11	1500 — 1990
						1017 — 1997
Germany	7.22	.925	.42	82	7.03	2101 — 1990
Dominican Rep.	7.13	.720	.81	65	6.15	417 — 1996
Uruguay	7.13	.885	.51	75	6.89	1000 — 1996
						1079 — 1995
Argentina	7.09	.888	.46	71	6.79	1002 — 1991
Portugal	7.07	.892	.50	84	6.93	1185 — 1990
						1500 — 1995
China[b]	7.06	.650	.46	17	4.68	1000 — 1990
						1211 — 1995
Spain	6.88	.935	.45	77	7.19	1510 — 1990
Philippines	6.84	.677	.61	54	5.28	1200 — 1996
France	6.78	.946	.41	73	7.18	1002 — 1990
Venezuela	6.72	.860	.67	51	7.05	1200 — 1996
						2769 — 1995
Nigeria[c]	6.71	.391	.61	31	2.73	1001 — 1990
						1249 — 1996
Korea, Rep. of	6.69	.894	.58	72	7.13	1251 — 1990
						2040 — 1996
India[d]	6.62	.451	.46	51	2.91	2500 — 1990
						1054 — 1995
Japan	6.57	.940	.63	80	7.68	1011 — 1990
						1153 — 1997
Poland	6.53	.851	.44	71	6.40	938 — 1989
Austria	6.51	.933	.50	82	7.29	1460 — 1990

Table 3 (*continued*)

Country	Life satisfaction values[a]	Human development Index	Log (10) ESP/km^2 index	Press freedom index	Predicted life satisfaction values	Sample size and year
Bangladesh	6.41	.371	.74	51	2.90	1525 — 1996
						2935 — 1996
South Africa	6.40	.717	.43	70	5.20	2736 — 1990
						1007 — 1995
Slovenia	6.38	.887	.38	63	6.59	1035 — 1992
Czech Rep.	6.37	.884	.35	79	6.47	930 — 1990
Peru	6.36	.729	.66	43	5.88	1211 — 1996
						1907 — 1997
Turkey	6.30	.782	.54	27	6.04	1030 — 1991
Croatia	6.18	.759	.52	44	5.79	1196 — 1995
Slovakia	6.15	.875	.40	45	6.53	463 — 1990
Hungary	6.03	.857	.55	62	6.74	999 — 1990
Romania	5.88	.767	.45	50	5.68	1103 — 1993
Macedonia, FYR	5.70	.749	.49	66	5.62	995 — 1997
						1021 — 1996
Estonia	5.50	.758	.65	75	6.10	1008 — 1990
						1009 — 1996
Lithuania	5.50	.750	.47	71	5.58	1000 — 1990
Azerbaijan	5.39	.623	.49	31	4.50	2002 — 1996
						1200 — 1996
Latvia	5.30	.704	.52	71	5.30	903 — 1990
						2092 — 1996
Belarus	4.93	.783	.38	33	5.65	1015 — 1990
						2040 — 1995
Russian Fed.	4.91	.769	.74	45	6.43	1961 — 1991
						1072 — 1997
Bulgaria	4.85	.789	.38	61	5.72	1034 — 1990
Georgia	4.65	.633	.49	30	4.60	2593 — 1996
Armenia	4.32	.674	.61	43	5.25	2000 — 1997
Ukraine	3.95	.665	.48	58	4.86	2811 — 1996
Moldova, Rep. of	3.73	.610	.39	53	4.16	984 — 1996
Mean	***6.60***	*.80*	*.55*	*64.32*	***6.26***	
St. deviation	***1.11***	*0.15*	*0.12*	*19.66*	***1.33***	

[a] Most of the low-income countries under sampled the illiterate population and over sampled the urban and educated population (Inglehart et al., 2000).

[b] China's sample is 90% urban and essentially excludes the illiterate population (Inglehart et al., 2000).

[c] Data collection in Nigeria was stratified to be 40% urban and 60% rural. In 1990, they sampled in urban areas and within 100 km of urban centers. In 1995, they sampled within 10 km of Southern urban towns and within 50 km of Northern urban towns (Inglehart et al., 2000).

[d] India's sample was stratified to be 90% urban and 10% rural and to have 90% of the respondents be literate (Inglehart et al., 2000).

3.2. Revised regression model

In our revised regression model, we use the same variables but exclude the six outlier countries, Bangladesh, Ghana, India, Nigeria, China and the Philippines. The resulting R^2 was 0.724,[6] which is a substantial improvement over our basic regression model (Table 4). Both the natural capital variable and the human and built capital variable are highly significant in the model.

Table 5 presents predicted life satisfaction values for 172 countries that had data for the natural capital and human and built capital variables used in the revised regression model. The predicted life satisfaction values were calculated using the revised regression model. In addition, Fig. 3 is a map of these predicted life satisfaction values by country. The

[6] Adjusted R^2 was 0.712.

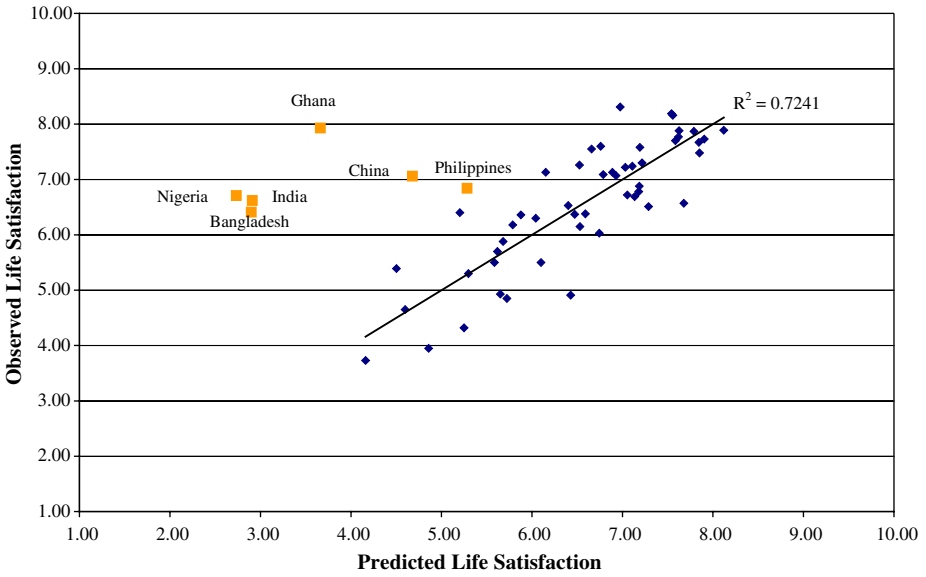

Fig. 2. Observed versus predicted life satisfaction.

map clearly shows that North America, Europe, Australia, and parts of South America have higher predicted life satisfaction values, represented by the darker colors, while countries in Africa and Asia have much lower predicted life satisfaction levels.

Although we cannot conclude causal implications from this type of regression model, we can identify relationships between life satisfaction and the four types of capital. First, it is very interesting to note that our natural capital variable is very important to the regression model and is not intercorrelated with the other capital variables. It appears that natural capital has a unique relationship with life satisfaction that is not encompassed by any of the other variables.

Table 4
Revised regression model coefficients for national-level analysis

	Unstandardized coefficients		Standardized coefficients	*t*-value	Significance
	B	Std. error	Beta		
Constant	−2.220	.799		−2.781	.008
HDI	8.875	.884	.777	10.038	.000
Log ESP/km^2 index	2.453	.739	.257	3.319	.002

Sample size of the regression model was 50.

The importance of natural capital was also seen in the significant bivariate correlation between natural capital and life satisfaction. This suggests that a natural capital variable should be included more often in analyses of life satisfaction, both at the individual and social level. Additional and more focused research may be able to show what role natural capital plays in contributing to people's life satisfaction.

The combined human and built capital variable, HDI, was the most important factor in this regression model, as seen in the comparison of the standardized betas and the *t* values from the regression equations (Tables 2 and 4). Although income or wealth is not the only factor found to influence life satisfaction, it is usually found to be one of the major factors (Diener et al., 1995a; Cummins, 1998; Diener and Suh, 1999). In this instance, income or wealth is also combined with human capital, which represents health and to some extent, human rights and equality. In addition, a nation's wealth is also strongly correlated with fulfillment of basic biological needs, individualism, interpersonal trust, and political stability (Diener and Suh, 1999). The combination of all of these aspects of life reasonably makes up a large portion of the variance in life satisfaction. It is worthwhile to highlight how much better the HDI is as a predictor of life satisfaction in comparison to GDP as presented in Fig. 1 at

Table 5
Predicted life satisfaction values

Country	Predicted life satisfaction	Country	Predicted life satisfaction	Country	Predicted life satisfaction
Bahamas	8.15	Czech Rep.	6.47	Nicaragua	4.44
Canada	8.12	Russian Fed.	6.43	Namibia	4.43
Finland	7.90	Poland	6.40	Swaziland	4.30
Antigua and Barbuda	7.87	Kuwait	6.38	Moldova, Rep. of	4.16
United Kingdom	7.85	Luxembourg	6.37	Viet Nam	4.12
Norway	7.85	Dominican Rep.	6.15	Cape Verde	4.12
Sweden	7.79	United Arab Emirates	6.13	Congo	4.08
New Zealand	7.74	Ecuador	6.12	Papua New Guinea	4.06
Japan	7.68	Estonia	6.10	Tajikistan	4.01
Malta	7.68	Jamaica	6.08	Equatorial Guinea	3.93
Singapore	7.66	Lebanon	6.07	Egypt	3.77
Hong Kong	7.66	Turkey	6.04	Morocco	3.74
Ireland	7.63	Cuba	6.04	Ghana	3.66
Netherlands	7.62	Korea, Dem. People's Rep. of	5.89	Cameroon	3.62
Barbados	7.59	Peru	5.88	Iraq	3.62
USA	7.58	Croatia	5.79	Myanmar	3.60
Denmark	7.56	Bulgaria	5.72	Laos, People's Dem. Rep. of	3.48
Switzerland	7.54	Romania	5.68	Zimbabwe	3.39
St. Kitts and Nevis	7.45	Belarus	5.65	Comoros	3.32
Seychelles	7.43	Macedonia, FYR	5.62	Kenya	3.16
Greece	7.35	Lithuania	5.58	Cambodia	3.04
St. Vincent	7.30	Sri Lanka	5.55	Haiti	2.91
Trinidad and Tobago	7.30	Indonesia	5.49	India	2.91
Austria	7.29	Guyana	5.49	Bangladesh	2.90
Brunei Darussalam	7.29	Samoa (Western)	5.46	Congo, Dem. Rep. of the	2.88
Costa Rica	7.28	Iran, Islamic Rep. of	5.40	Lesotho	2.86
Italy	7.22	Paraguay	5.37	Pakistan	2.79
Australia	7.19	Syrian Arab Rep.	5.36	Nigeria	2.73
Spain	7.19	Latvia	5.30	Uganda	2.67
France	7.18	Philippines	5.28	Malawi	2.65
Korea, Rep. of	7.13	Saudi Arabia	5.27	Cote d'Ivoire	2.61
Israel	7.13	Tunisia	5.26	Tanzania, U. Rep. of	2.50
Cyprus	7.12	Armenia	5.25	Zambia	2.38
Chile	7.11	Kazakhstan	5.24	Togo	2.34
Panama	7.11	Oman	5.23	Senegal	2.34
Dominica	7.07	South Africa	5.20	Angola	2.32
Venezuela	7.05	Sao Tome and Principe	5.15	Benin	2.32
Germany	7.03	Uzbekistan	5.14	Gambia	2.28
Colombia	6.98	Jordan	5.10	Madagascar	2.24
Fiji	6.97	Albania	4.95	Guinea-Bissau	2.23
Portugal	6.93	Botswana	4.95	Central African Republic	2.06
Uruguay	6.89	Libyan Arab Jamahiriya	4.94	Sudan	2.00
Bahrain	6.88	Ukraine	4.86	Nepal	1.91
Grenada	6.82	Mongolia	4.81	Bhutan	1.82
Malaysia	6.80	Kyrgyzstan	4.78	Yemen	1.64
St. Lucia	6.80	Guatemala	4.76	Burundi	1.55
Mauritius	6.79	Vanuatu	4.69	Mauritania	1.53
Argentina	6.79	China	4.68	Mozambique	1.53
Belgium	6.76	Algeria	4.68	Guinea	1.51
Hungary	6.74	Gabon	4.66	Djibouti	1.49
Belize	6.71	Solomon Islands	4.62	Chad	1.40

(continued on next page)

Table 5 (*continued*)

Country	Predicted life satisfaction	Country	Predicted life satisfaction	Country	Predicted life satisfaction
Suriname	6.69	Turkmenistan	4.62	Eritrea	1.14
Mexico	6.66	Georgia	4.60	Ethiopia	1.14
Slovenia	6.59	El Salvador	4.58	Sierra Leone	1.10
Thailand	6.59	Bolivia	4.57	Mali	0.75
Qatar	6.57	Azerbaijan	4.50	Burkina Faso	0.64
Slovakia	6.53	Honduras	4.46	Niger	0.21
Brazil	6.53				

the beginning of the paper. By incorporating the human capital variables, the HDI has a linear relationship with life satisfaction while the GDP does not.

The lack of a significant relationship between the social capital variable, press freedom, and life satisfaction in the regression equations is interesting. It has been shown on the personal level that social interactions with family and friends are very important to life satisfaction (Cummins, 1996), and therefore we had expected similar importance at the national level. However, as mentioned above, our social capital variable is also highly correlated with the combined human and built capital variable, HDI, and its relationship with life satisfaction is altered when one controls for HDI.

Other social capital variables including political rights rating, civil liberties rating, and corruption perceptions index, were also investigated but none had a better linear relationship with life satisfaction than press freedom, and all had significant bivariate correlations with HDI. In addition, the corruption perceptions index was not available for a large enough sample of countries to be useful in the model. The lack of a clear linear relationship of these other social capital variables with life satisfaction may have been a function of the scale on which they were measured; Freedom House only provides a 1 through 7 rating for political rights and civil liberties.

Even more importantly, the problem is that the type of social capital variables available at the national level are probably not the most appropriate. The social capital variables that are available generally do not impact individuals in their daily lives and therefore are more likely to have an impact on social life satisfaction rather than personal life satisfaction. To look at personal life satisfaction at the national scale, variables on the importance of friends and family would be a better proxy for social capital. We did investigate a survey question on the importance of family but could not incorporate it into the model because it was only available for a small number of countries. The lack of a good proxy for friends and family might also explain the outliers we identified. All of the outlier countries are noted for their strong extended families and close social networks (relative to Europe and the US). Thus, a good measure of the strength of friend and family social relations might explain the outliers and improve the overall results. In addition, a good proxy for social capital may improve the predicted life satisfaction values for the African and Asian countries presented in Table 5 and Fig. 3.

As interest grows in social capital at the national level, the availability of useful indicators of national social capital may improve and allow for the investigation of the relationship with life satisfaction without interference from other variables.

4. Caveats to methods

Here we would like to address some common criticisms of aggregated data analyses such as this one. Two common criticisms are that 1) the analysis suffers from the ecological fallacy[7] and 2) the data are subject to the modifiable areal unit problem (Openshaw, 1983; Larson, 1986; Fotheringham and Wong,

[7] The ecological fallacy is defined as "a logical fallacy inherent in making causal inferences from group data to individual behaviors" (Schwartz, 1994). This term is not related to the more common term ecology, defined as "the science of the relationships between organisms and their environment, or the study of the detrimental effects of modern civilization on the environment" (American Heritage College Dictionary, 1993).

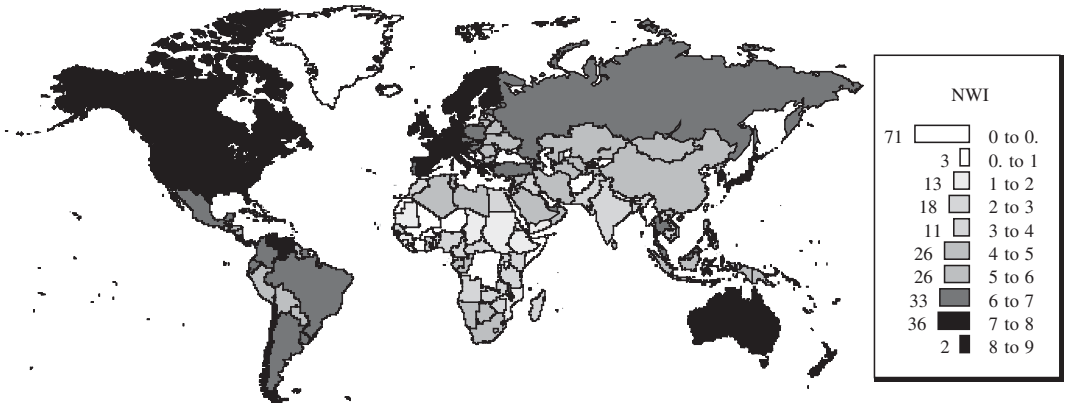

Fig. 3. World map of predicted life satisfaction values.

1991; Amrhein, 1995; Seligson, 2002; Handel, 1981; Hofstede, 2002; Schwartz, 1994). To appease those concerned with the ecological fallacy, we have taken steps to determine that the relationships present in our country level analysis, using mean national-level life satisfaction values, also exist at the individual level. Using the previously identified national-level variables for the combined human and built capital and natural capital, we created a micro-level regression model in which each respondent has a unique life satisfaction value and values for the two independent variables that were defined for that respondent's country of residence. We tested the regression model with all of the same diagnostics as our macro-level model and found no indications of problems, except in the Durbin–Watson test. The regression does have serial correlation, which is a result of the grouping of respondents within countries and with country-level values. Since no other values for the capital variables are available for the individual respondents, no improvement could be made in the model. The use of hierarchical regression modeling was considered but software capable of performing this method of analysis was not available. Therefore, we present the results of the above-described micro-level analysis as the best available. The regression analysis at this individual level was found to be significant and both of the independent variables were also found to be significant (Table 6). We feel that this micro-level analysis provides support for the macro-level associations and conclusions that we are able to draw.

Table 6
Regression coefficients for micro-level analysis

	Unstandardized coefficients		Standardized coefficients	*t*-value	Significance
	B	Std. error	Beta		
Constant	2.506	.049		50.855	.000
HDI	3.427	.046	.206	73.783	.000
Log ESP/km^2 index	2.564	.060	.118	42.448	.000

Sample size for the micro-level regression model was 121,239.

Evidence of the impact of the modifiable areal unit problem on statistical analysis, especially on regression coefficients, has certainly been shown (Fotheringham and Wong, 1991; Amrhein, 1995). In our analysis, we have tried to account for this possible problem by conducting our regression analysis at the level of the individual respondents in each country surveyed, as mentioned above. Our analysis could not be conducted at any other scale or with any other zonal grouping because the data on life satisfaction are only spatially associated with a country. No smaller spatial unit is identified for the respondents in the survey and therefore, no other spatial aggregation of the data is possible.

5. Conclusions

The most important finding from this study is the significant impact that natural capital has on life satisfaction. While the positive effects of the natural environment on stress recovery and health are well-

established, fewer studies have looked at the role of the natural environment in people's self-assessments of life satisfaction. This analysis suggests that people do consider their natural environmental surroundings when evaluating their life satisfaction and therefore, the natural environment should routinely be included in studies of life satisfaction.

We can also conclude that the UN's HDI (as a proxy for built and human capital) is a good starting point for assessing life satisfaction. The HDI alone explains a significant percentage of the variation in life satisfaction, but the HDI could be significantly improved by adding our natural capital index, to create what might be called a National Well-Being Index (NWI). To complete the NWI, a suitable proxy for social capital would have to be included, one that measures the importance of friends and family across countries.

5.1. Future work

Our results indicate that work to create an adequate index of social capital that captures the importance of friends and family at the national scale would likely improve our ability to explain individual life satisfaction. Another interesting follow-up to this study would be to perform a similar regression analysis but use *national* rather than *individual* life satisfaction as the dependent variable. National life satisfaction is also measured using survey methods but rather than asking about satisfaction in one's personal life, it asks about satisfaction with one's country. The Australian Unity Wellbeing Index uses a national satisfaction question with the following wording: "Thinking now not about your own life, but about the situation in Australia generally, how satisfied are you with life in Australia?" (Cummins et al., 2001, 2003). Then, one would be relating national-level capital variables with national-level life satisfaction. This analysis was not possible for this study because there is not yet a widely available database of countries for which this question has been asked.

References

The American Heritage College Dictionary, Third edition, 1993. Houghton Mifflin Company, Boston, MA.

Amrhein, C.G., 1995. Searching for the elusive aggregation effect: evidence from statistical simulations. Environ. Plann. A. 27, 105–119.

Anielski, M., Rowe, J., 1999. The Genuine Progress Indicator — 1998 Update. Redefining Progress, San Francisco, CA.

Berk, R.A., 2004. Regression Analysis: A Constructive Critique. Sage Publications, Thousand Oaks.

Central Intelligence Agency, 2003. The World Factbook. Central Intelligence Agency, Washington DC. http://www.cia.gov/cia/publications/factbook/index.html, April 16, 2004.

Cobb, C.W., Cobb, Jr., J.B., 1994. The Green National Product: A Proposed Index of Sustainable Economic Welfare. University Press of America, New York. 343 pp.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Naeem, S., Limburg, K., Paruelo, J., O'Neill, R.V., Raskin, R., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

Costanza, R., Cumberland, J., Daly, H., Goodland, R., Norgaard, R., 1997. An Introduction to Ecological Economics. St. Lucie Press, Boca Raton, FL.

Cummins, R.A., 1996. The domains of life satisfaction: an attempt to order chaos. Soc. Indic. Res. 38, 303–328.

Cummins, R.A., 1998. The second approximation to an international standard for life satisfaction. Soc. Indic. Res. 43 (3), 307–334.

Cummins, R.A., Eckersley, R., Pallant, J., Davern, M., Misajon, R., 2001. Australian Unity Well-being Index, survey 2: report 2: special report on income and geographic location. Australian Centre on Quality of Life. Deakin University, Melbourne, Australia. 51 pp.

Cummins, R.A., Eckersley, R., Pallant, J., VanVugt, J., Misajon, R., 2003. Developing a national index of subjective well-being: the Australian Unity Wellbeing Index. Soc. Indic. Res. 64 (3), 159–190.

Daly, H.E., Cobb, Jr., J.B., 1989. For the Common Good: Redirecting the Economy towards Community, the Environment, and a Sustainable Future. Beacon Press, Boston. 482 pp.

Diener, E., Lucas, R., 1999. Personality and subjective well-being. In: Kahneman, D., Diener, E., Schwarz, N. (Eds.), Well-Being: The Foundations of Hedonic Psychology. Russell Sage Foundation, New York, pp. 213–229.

Diener, E., Suh, E.M., 1999. National differences in subjective well-being. In: Kahneman, D., Diener, E., Schwarz, N. (Eds.), Well-Being: The Foundations of Hedonic Psychology. Russell Sage Foundation, New York, pp. 444–450.

Diener, E., Diener, M., Diener, C., 1995a. Factors predicting the subjective well-being of nations. J. Pers. Soc. Psychol. 69 (5), 851–864.

Diener, E., Suh, E.M., Smith, H., Shao, L., 1995b. National differences in reported subjective well-being: why do they occur? Soc. Indic. Res. 34, 7–32.

Draper, N.R., Smith, H., 1981. Applied Regression Analysis. John Wiley & Sons Inc., New York.

Easterlin, R., 1974. Does economic growth improve the human lot? In: David, P., Weber, R. (Eds.), Nations and Households in Economic Growth. Academic Press, New York.

Easterlin, R.A., 1995. Will raising the incomes of all increase the happiness of all? J. Econ. Behav. Organ. 27, 35–47.
Easterlin, R.A., 2003. Explaining happiness. Proc. Natl. Acad. Sci. 100 (19), 11176–11183.
Eckersley, R., 2000. The state and fate of nations: implications of subjective measures of personal and social quality of life. Soc. Indic. Res. 52, 3–27.
Fotheringham, A.S., Wong, D.W.S., 1991. The modifiable areal unit problem in multivariate statistical analysis. Environ. Plann. A. 23, 1025–1044.
Freedom House, 1999. News of the Century: Press Freedom 1999. Freedom House. http://freedomhouse.org/pfs99/pfs99.pdf, September 30, 2003.
Haas, B.K., 1999. A multidisciplinary concept analysis of quality of life. West. J. Nursing Res. 21 (6), 728–743.
Handel, W., 1981. The danger of committing the ecological fallacy persists: comment on Grove and Hughes. Soc. Forces 60 (2), 585–588.
Helliwell, J.F., 2003. How's life? Combining individual and national variables to explain subjective well-being. Ecol. Model. 20, 331–360.
Hofstede, G., 2002. The pitfalls of cross-national survey research: a reply to the article by Spector et al. on the psychometric properties of the Hofstede Values Survey Module 1994. Appl. Psychol.-Int. Rev. 51 (1), 170–173.
Inglehart, R., Rabier, J.-R., 1986. Aspirations adapt to situations—but why are the Belgians so much happier than the French? A cross-cultural analysis of the subjective quality of life. In: Andrews, F.M. (Ed.), Research on the Quality of Life. Institute for Social Research, The University of Michigan, Ann Arbor, MI.
Inglehart, R., et al., 2000. World Values Surveys and European Values Surveys, 1981–1984, 1990–1993, and 1995–1997 [Computer file]. Institute for Social Research [producer], Inter-university Consortium for Political and Social Research [distributor], Ann Arbor, MI.
Larson, R.C., 1986. The invalidity of modifiable areal unit randomization. Prof. Geogr. 38 (4), 369–374.
Lucas, R.E., Clark, A.E., Georgellis, Y., Diener, E., 2003. Reexamining adaptation and the set point model of happiness: reactions to changes in marital status. J. Pers. Soc. Psychol. 84, 527–539.
Milbrath, L.W., 1982. A conceptualization and research strategy for the study of ecological aspects of the quality of life. Soc. Indic. Res. 10, 133–157.
Openshaw, S., 1983. The modifiable areal unit problem. Geo Books Regency House, Norwich, England. 41 pp.
Oswald, A.J., 1997. Happiness and economic performance. Econ. J. 107, 1815–1831.
Prescott-Allen, R., 2001. The Wellbeing of Nations. Island Press, Washington DC.
Samuelson, P.A., 1947. Foundations of Economic Analysis. Harvard University Press, Cambridge, MA.
Schwartz, S., 1994. The fallacy of the ecological fallacy: the potential misuse of a concept and the consequences. Am. J. Public Health 84 (5), 819–824.
Seligson, M.A., 2002. The renaissance of political culture or the renaissance of the ecological fallacy? Comp. Polit. 34 (3), 273–292.
Sirgy, J., 2002. The Psychology of Quality of Life. Kluwer Academic Publishers, Boston.
SPSS, 1999. SPSS Base 10.0 Applications Guide. SPSS Inc., Chicago. 426 pp.
Sutton, P., Costanza, R., 2002. Global estimates of market and non-market values derived from nighttime satellite imagery, land cover, and ecosystem service valuation. Ecol. Econ. 41, 509–527.
United Nations Development Programme, 1998. Human Development Report 1998. Oxford University Press, New York.
Varian, H.R., 1987. Intermediate Economics: A Modern Approach. Norton, New York.
Welsch, H., 2002. Preferences over prosperity and pollution: environmental valuation based on happiness surveys. Kyklos 55, 473–494.