Environmental Intensity of Human Wellbeing in Bhutan: Evidence from Regression Analysis

Dorji Yangka, Curtin University, Australia

The IAFOR International Conference on Sustainability, Energy & the Environment – Hawaii 2018
Official Conference Proceedings

Abstract
A special volume on 'Absolute Reductions' in the Journal of Cleaner Production (Akenji, Bengtsson, Bleischwitz, Tukker, & Schandl, 2016) emphasised the need for a radical socio-technical transformation that can bring material, energy and emissions within the ecological limits. Economic activities are at the heart of consumption of materials and energy and emissions being the waste generated. With regard to the nexus between economic development and environmental impacts, the Environmental Kuznets Curve (EKC) hypothesis is widely used, some studies supporting it while others contrasting it. Now there is an emerging research strands that test EKC by investigating the nexus between the environmental intensity of human wellbeing (EIWB) and economic growth (Knight & Rosa, 2011; Lamb, 2016; Lamb et al., 2014; Steinberger & Roberts, 2010; Sulkowski & White, 2015). This study follows this emerging research strand. Using a regression analysis, the paper attempts to discipline conjecture with data for the case of Bhutan, which hardly appears in the relevant literature. Based on the results of the regression analysis and the EKC theory, the paper discusses if the case of Bhutan inclines towards the treadmill of production theory or the modernisation theory.

Keywords: Bhutan, wellbeing, environment, regression analysis

Introduction

The need for a radical socio-technical transformation that can bring material, energy and emissions within the ecological limits was emphasised in a special volume on 'Absolute Reductions' in the Journal of Cleaner Production (Akenji et al., 2016). Suggesting to consider sustainable development seriously. Sustainable Development requires living within the ecological limits that implies respecting the natural system and not to transgress the planetary boundary (Rockström et al., 2009). Maintaining symboitic relation with nature and balancing material and non-material components of human wellbeing are the key features of Gross National Happiness (GNH), the development paradigm pursued by Bhutan. Furthermore, Bhutan has pledged to remain carbon neutral till perpituity. Not surprisingly, net zero carbon emission is now being seen as the ultimate pathway to hold the global temperature rise below 1.5°C (Rogelj, Luderer, et al., 2015; Rogelj, Schaeffer, et al., 2015).

The goals of Bhutan are complex and challenging - requiring the integration of socio-economic and environmental dimensions which is at the heart of Bhutan's GNH development philosophy that is increasingly associated to Sustainable Development (Allison, 2012; Brooks, 2013; Frame, 2005). However, until now no empirical studies exist for Bhutan on the nexus between economic growth, human wellbeing and environmental pollution vis a vis ecological stress, despite Bhutan wanting to remain carbon neutral as well as to be a middle income country by 2020 within its overarching GNH development philosophy. Thus this paper attempts to fill this gap by using the concept of environmental intensity of human wellbeing (EIWB) (Dietz, Rosa, & York, 2009, 2012; Knight & Rosa, 2011) to discipline conjectures with data. A report on the ecological footprint of Bhutan mentions about the possibility of research area on linking subjective wellbeing and ecological footprint (GNHC, 2014).

The rest of the paper comprises of four sections. A brief literature review is provided in the immediate section below followed by the regression analysis. Thereafter the results and discussions are elaborated with reference to the existing literature surrounding the complex relation between human wellbeing, economic growth and environmental quality. The findings of this research provides an answer to the question on whether Bhutan's development pathway follows the treadmill of production theory or the modernisation theory.

Environment and economic growth

The nexus between economic growth and environmental quality are often explained using the Environmental Kuznets Curve (EKC) hypothesis starting with the works of Grossman and Krueger (1995). The term EKC was first coined by Panayotou in 1993 (Kijima, Nishide, & Ohyama, 2010). In the era of Sustainable development goals (SDG) and climate change, GHG emission is a key environmental issue, which is perhaps the greatest environmental issues being faced by humanity in the 21st century. Encouragingly, the decoupling between economic growth and fossil fuels (the main source of greenhouse gases) is happening around the globe (Newman, 2017).

The relevance of the EKC theory were analysed using regression analysis on time series and cross-sectional data. For instance, Song, Zheng, and Tong (2008) used an Ordinary Least Square estimation for a cubic log-log model to assess EKC in the provinces of China for three environmental degradation such as waste water, solid waste and waste gas. They found EKC for all the three environmental degradation. Pérez-Suárez and López-Menéndez (2015) used polynomial terms of GDP per capita as the independent variable to conduct regression analysis for 108 countries (including Bhutan[1]) to examine the EKC puzzle and found different patterns of EKC, while Bhutan along with other 10 countries showed 'other cubic pattern' of EKC. Al-mulali, Weng-Wai, Sheau-Ting, and Mohammed (2015) used a fixed effect and random effect model to conduct multi-variant regression to examine EKC in 93 countries and showed that the EKC holds for high incomes countries but not for low income countries. Other studies have demonstrated six different relationships besides the inverted U-shaped curve between economic growth and environmental pollution (Yang, Sun, Wang, & Li, 2015), suggesting no consensus on the validity of the EKC theory. Additionally it is also pointed out that there are numerous empirical studies but very few theoretical studies on the EKC (Kijima et al., 2010). Furthermore, it is increasingly acknowledged that there is no single model that fits every country or region, given that every country has different underlying factors that drive the correlation between human development and environmental stress.

Those research highlighted above applied EKC to investigate the relationship between environmental quality and economic growth, with no variables that address social goals or wellbeing. Now there is an emerging research strands that incorporated variable(s) capturing human wellbeing besides the variables on economic growth and environmental quality. These are discussed in the following section.

Environment, economic growth and wellbeing

Applying a regression analysis for a cross-sectional data for 107 countries, Jorgenson (2014) finds that economic development leads to increase in carbon intensity of human wellbeing (CIWB). Similarly, using a regression analysis and a stochastic frontier production model for a cross sectional data for 135 countries, Dietz et al. (2009) showed that increasing environmental impact does not necessarily lead to greater human wellbeing and that the effect of affluence on human wellbeing characterises a diminishing return. Studies also found positive relation between income and carbon emissions measured by both consumption-based approach and territorial approach (Lamb et al., 2014) contrasting EKC hypothesis. A research at province level in China that investigated the effect of economic growth and technological changes on CIWB found that economic growth has a positive effect, while technological innovation has non-linear and negative effect on CIWB (Feng & Yuan, 2016). Vemuri and Costanza (2006) showed that natural capital has a significant and positive impact on life satisfaction making them to propose a National Wellbeing index which adds natural capital variable on the existing Human Development Index. Similarly, using a cross-national data on GDP per capita, subjective wellbeing index and ecological footprint for 105 countries, Knight and Rosa (2011) supported the treadmill of production theory but not the modernisation theory. There are other studies which demonstrated that energy and carbon emissions required for human development is decreasing over time (Steinberger & Roberts, 2010), suggesting that enhancing human wellbeing need not be in lockstep with resource depletion and environmental stress.

[1] This was the only reference the author came across that mentions about Bhutan.

Methodology

In line with the existing literature, a multivariate regression technique is used to investigate the relationship between human wellbeing, environmental impact and economic growth, arguably capturing the three dimensions of Sustainability. The regression analysis is conducted using EViews, a sophisticated data analysis and forecasting tool developed with emphasis on time series analysis (IHS, 2014). To capture the environmental intensity of human wellbeing (EFWB) in Bhutan, the ratio variable between ecological footprint per capita (EFpc) and life expectancy (LE) was used along with GDP per capita (GDPpc) representing economic growth. The details on the choice of these variables are discussed.

The choice of variables

The type of variables used for evaluating the environmental efficiency (or intensity) of human wellbeing vary depending on the data availability and scope of the study. For instance some studies has used CO_2 emission per capita as representing the environmental impact (Feng & Yuan, 2016; Lamb et al., 2014) (Jorgenson, 2014), others have used ecological footprint per capita (Dietz et al., 2009; Knight & Rosa, 2011). Similarly for human wellbeing, life expectancy was used as a proxy variable in some studies (Dietz et al., 2009, 2012), while others have used life satisfaction index (Knight & Rosa, 2011). The choice of variables for this study were limited by the availability of long time series data. Life expectancy and GDP per capita[2] were obtained from the data bank of the World Bank, while the ecological footprint per capita were obtained from the Global Footprint Network (GFN, 2016)[3]. A longer life expectancy represents healthy living which ultimately boils down to physical fitness and good food – perhaps all of us wants to live longer even for a day. Similarly the ecological footprint measures the wholesome consumption level environmental stress exerted by a person onto the natural system. While GPD per capita as a measure of economic growth is well known.

The regression model

In formulating an econometric functional form, inspiration is drawn from David Hendry's four golden rules, namely: 1) think brilliantly, 2) be infinitely creative, 3) be outstandingly lucky and 4) otherwise stick to being a theorist. To explore the relationship between ecological intensity of human wellbeing and economic growth in Bhutan and following the 1st and 2nd golden rules of David Hendry, this study explored the functional form specified in equation (1).

$$EFWB = C + \beta_1 lnGDPpc + \beta_2 (lnGDPpc)^2 + \beta_3 (lnGDPpc)^3 + \beta_4 lnPOP + \varepsilon_t \quad (1)$$

Where, EFWB is the ratio variable between EFPC and LE. C is the intercept. lnGDPpc is the per capita GDP in natural logarithmic form and the polynomial terms of GDPpc are centred by subtracting the mean of lnGDPpc to reduce collinearity (Knight & Rosa, 2011; York, Rosa, & Dietz, 2003). The linear and polynomial terms of GDPpc are being widely used in the EKC literature (Song et al., 2008; Yang et al.,

---

[2] The per capita GDP were available from 1980 onwards only

[3] The ecological footprint were made available upto 2012 only as per the data access provided by GNF.

2015). POP is the population and ε is the error term that captures those unobserved explanatory variables. Finally β_1 to β_4 are the coefficients of the corresponding explanatory variables that are of primary interest in this study, which are to be estimated by regressing equation (1) using EViews.

The above equation attempts to include everything within the available data that is necessary for modeling, but nothing more in line to the Occam's principle (Yang et al., 2015) to avoid under-specification as well as over-specification (Wooldridge, 2016). On regressing equation (1), it was found that the linear and the cubic terms of the GDPpc were statistically insignificant letting us to choose the reduce form model shown by equation (2).

$$EIWB = C + \beta_1(\ln GDPpc)^\wedge 2 + \beta_2 \ln POP + \varepsilon_t \qquad (2)$$

The functional form in equation (2) was treated to comply with Gauss-Markov assumptions for time series regression (Wooldridge, 2016). For instance, tests for the presence of serial correlation and heteroskedasticity were conducted using the Breusch-Godfrey (BG) LM test and Breusch-Pagan-Godfrey (BPG) test respectively (IHS, 2014; Wooldridge, 2016). Fortunately in this study we were outstandingly lucky (David Hendry's 3rd golden rule) – the p values fail to reject the null hypothesis of no serial correlation and homokedasticity. These tests results also suggest that the functional form was specified quite well for the available variables. Furthermore, to avoid spurious regression arising from trending variables, equation (2) was regressed with time trend and the EViews output shows insignificant p value. No collinearity between the independent variables were observed as confirmed by the variation inflation factors which were within the acceptable range of 10 (Dietz et al., 2009; IHS, 2014; Knight & Rosa, 2011). The robustness of equation (2) was also checked through robust least squares method and Autoregressive Conditional Heteroskedasticity (ARCH) method showing no significant differences for the values of the estimated parameters and their associated standard errors.

Results and Discussions

Equation (2) was estimated using the Ordinary Least Squares (OLS) estimation method in EViews and the estimated equation is provided in equation (3) with standard errors in parenthesis.

$$EFWB = 13.51097 + 0.230104 * (\log GDPpc)^2 - 0.873187 * \log(pop) \qquad (3)$$
$$\qquad (0.020551) \qquad\qquad (0.031331)$$

Adjusted R^2 is 0.965284; standard error of regression is 0.030427.

The plot of the estimated equation shows a U-shaped curve as shown in Figure. 1. The estimated equation illustrates that the relation between the EFWB and GDPpc are positive and non-linear and that with population is negative, demonstrating that the findings of this study are partly surprising and the discussions are elaborated in the following subsections.

Discussion on the non-surprising result

The non-surprising part can be referred directly from figure. 1 and the coefficient of the quadratic GDPpc term shown in the estimated equation (3). They show that the stress induced on the ecology for enhancing human wellbeing follows a significantly positive and curvilinear relationship with economic growth. The plot clearly shows a turning point beyond which increase in GDP per capita further intensifies the environmental intensity of human wellbeing, which clearly resonates with the central tenet of the GNH thinking, which seeks to balance ecology, economy and human wellbeing. In other words, after certain threshold growth in per capita GDP increases the ecological stress, clearly contradicting the modernisation theory but supporting the treadmill of production theory aligning with the findings for cross-sectional data (Dietz et al., 2012; Knight & Rosa, 2011). In this study we call it as the 'WE Kuznets curve' that illustrates the relationship between Wellbeing and the Environment vis a vis ecology – respecting the EKC literature and the recent surge in wellbeing research and in particular the happiness kuznets curve proposed by (Sulkowski & White, 2015). The GNH philosophy does not reject GDP, but side-lines GDP as the sole measure of human wellbeing and not surprisingly increasing number of research are showing that there is a threshold value beyond which increasing GDP does not commensurately leverage human wellbeing, thus characterising a diminishing returns.

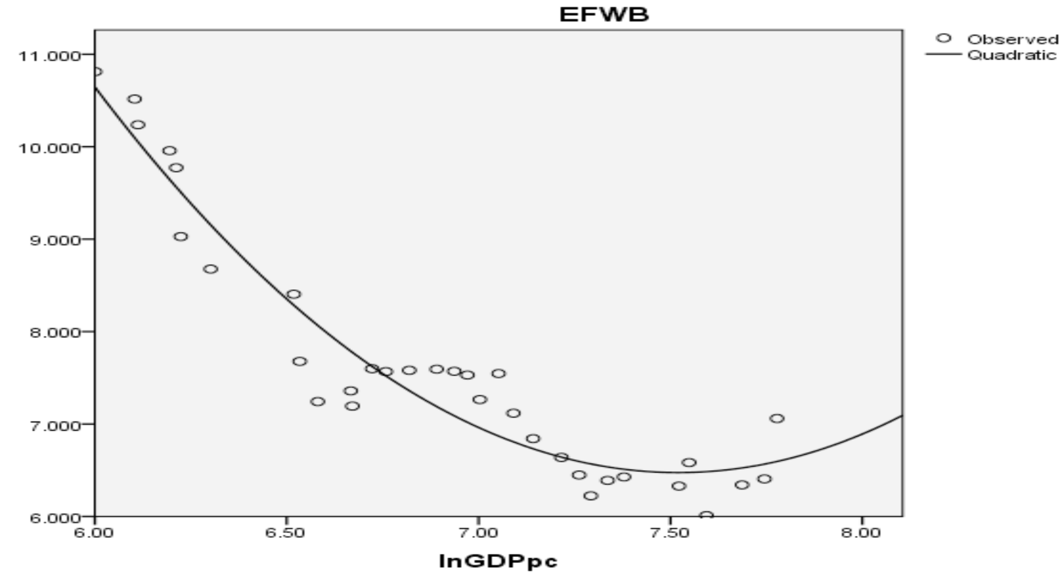

Figure 1: EFWB versus per capita GDP

The turning point shown in Figure.1 is around US$ 2100 (in between estimates), which is slightly lower than that of US$ 2558 found for cross sectional data (Dietz et al., 2012). In a separate research, (Kubiszewski et al., 2013) found that genuine progress indicator does not increase beyond GDP/capita of US$ 7000. In Bhutan, the mean monthly per capita household expenditure in the richest quintile is Nu. 17802, while that in the lowest quintile is Nu. 2468 (RGoB & World Bank, 2017). Now comparing these values to the threshold value in figure. 1, the household expenses of the richest quintile are higher by a factor of 1.6 (assuming US$ 1 equals Nu. 63), whereas the lowest quintile are 4.5 times lower. This finding complements the need for absolute reduction in material (Akenji et al., 2016) by those in the richest quintile for the case here. This indicates that while the poorest could reduce their ecological stress by increasing their income, it is time for the richest to control their relentless expenditure to reduce their ecological footprint. This seemingly paradoxical effect of income on ecological footprint is well explained by the curvilinear relationship shown in figure. 1 – calling for convergence of per capita income to uphold a sustainable and happy society.

Discussion on the surprising result

The first surprising part of the finding is that the graph in Figure. 1 shows an early bend. This earlier bend raises a question - If the prevailing socio-cultural norms adheres itself to the sufficiency concept embedded in the GNH philosophy that attempts to balance material and non-material components of human wellbeing? The earlier bend in case of Bhutan could be explained perhaps by the fact that the majority of the Bhutanese people are dependent on subsistence farming and the natural resources, which has a minimal contribution to the stacking of GDP, while fulfilling the basic needs.

The next surprising part of the finding is that the coefficient of the population is negative, which in statistical terms means negative effect, that is, the growth in population will reduce the ecological intensity of human wellbeing in Bhutan. Is it possible or plausible? This finding may seem spurious to those who hold onto the theory of human ecology, which argues that population is the main driver of ecological and environmental degradation. Also population is one of the main factor in the IPAT and STIRPAT formulation. Furthermore, the finding contradicts the environmental impact of population growth highlighted in the national strategy of Bhutan (NEC, 1998). However, this part of the finding seems to align with the findings of (Toth & Szigeti, 2016) who claimed that it was over-consumption not over-population that is causing overshoot of the Earth. Lamb et al. (2014) also found negative coefficient of population growth on both the territorial-based and the consumption-based per capita carbon emissions. It is argued that such finding may be plausible in Bhutan as well since household size[4] tend to decrease as the per capita income increases - that is, a fewer people in a house, the corollary being size of house (i.e the physical living space) per capita increases, which follows the lines of reasoning posed by Lamb et al. (2014). The household size in Bhutan decreased from 5.3 to 3.2 as we moved from the lowest quintile to the highest quintile (RGoB & World Bank, 2017). Furthermore, it is likely to see strong correlation between the consumption-based carbon emissions and the ecological footprint, which is a consumption based indicator. The other plausible reason could be due to the low population density leading to a higher per capita ecological footprint in Bhutan (GNHC, 2014). Rural Bhutan accounts for 66% of the total population and 64% of total households in 2016 (BLSS, 2017). The average per capita ecological footprint of a rural Bhutanese is 1.86 bha[5], which is higher than that for the urban Bhutanese at 1.74 bha (GNHC, 2014). But urbanisation in Bhutan is striding at a rapid pace and it is expected to reach 77% by 2040 (ADB, 2011). The high per capita ecological footprint could also be attributed to the lower bio-productivity in land-use for production of good and services in Bhutan.

---

[4] Household size means the number of people living in one house; whereas size of house means the physical area of the housing structure.
[5] bha – Bhutan hectare, which is the global hectare (gha) modified to Bhutan's context.

The caveats of this study

This study have some inherent limitations attributable to statistical inferences from the available data sets as vividly commented by (Toth & Szigeti, 2016), 'expecting precise result from a rough data set is a statistical illusion'. Furthermore, the choice of different proxy variables may show a different result. However the availability of data needs to be considered. Our study used 33 years of time series data, while a longer time series data could have a better statistical inferences, especially in reducing the variances. These limitations are widely known in the literature (Pérez-Suárez & López-Menéndez, 2015).

Conclusion

Using established econometrics techniques, this study has attempted to interlink the relationships among the trilemma challenges of Bhutan - integrating wellbeing (i.e GNH), economic growth (i.e. GDP) and ecological footprint (i.e. environmental concerns). This paper contributed to disciplining the conjectures of normative understanding around the trilemma issues in Bhutan through vigorous analysis of the time series data on some of the key variables.

Using Bhutan as a case study, this research contributed to the highly debated issue on the tri-junctures of economic development, human wellbeing and environmental/ecological impact. Within the validity of the time series data, the case study of Bhutan supports the treadmill of production theory against the modernisation theory. To some extent this research can be considered as a formal attempt to place the case of Bhutan into the burgeoning literature on analysing the environmental impact of enhancing human wellbeing in the framework of Environmental Kuznets Curve theory. The U-shaped and curvilinear graphical plot observed in this research also complements the core goal of the GNH development paradigm that seeks for a balanced development. Suggesting the likely convergence between the GNH paradigm and the treadmill of production theory – at least on the concern of environmental degradation front that is caused by economic growth at any cost.

While this study is first of its kind for Bhutan, it shows a promising line of research that may further inquire into the socio-technical structure of the Bhutanese economy.

Acknowledgement

The author would like to thank the Government of Australia for providing the Research Training Programme (RTP) scholarship. He also would like to thank the support rendered by his supervisors, Professor Peter Newman and Dr. Vanessa Rauland, while any errors remain the sole responsibilities of the author.

References

ADB. (2011). *Bhutan Transport 2040 Integrated Strategic Vision*. Retrieved from

Akenji, L., Bengtsson, M., Bleischwitz, R., Tukker, A., & Schandl, H. (2016). Ossified materialism: introduction to the special volume on absolute reductions in materials throughput and emissions. *Journal of Cleaner Production, 132*, 1-12. doi:10.1016/j.jclepro.2016.03.071

Al-mulali, U., Weng-Wai, C., Sheau-Ting, L., & Mohammed, A. H. (2015). Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. *Ecological Indicators, 48*, 315-323. doi:10.1016/j.ecolind.2014.08.029

Allison, E. (2012). Gross National Happiness. *THE BERKSHIRE ENCYCLOPEDIA OF SUSTAINABILITY: MEASUREMENTS, INDICATORS, AND RESEARCH METHODS FOR SUSTAINABILITY*, 180-184.

Brooks, J. S. (2013). Avoiding the Limits to Growth: Gross National Happiness in Bhutan as a Model for Sustainable Development. *Sustainability, 5*(9), 3640-3664. doi:10.3390/su5093640

Dietz, T., Rosa, E. A., & York, R. (2009). Environmentally Efficient Well-Being: Rethinking Sustainability as the Relationship between Human Well-being and Environmental Impacts. *Human Ecology Review, 16*(1), 114-123.

Dietz, T., Rosa, E. A., & York, R. (2012). Environmentally efficient well-being: Is there a Kuznets curve? *Applied Geography, 32*(1), 21-28. doi:10.1016/j.apgeog.2010.10.011

Feng, J., & Yuan, J. (2016). Effect of technology innovation and spillovers on the carbon intensity of human well-being. *Springerplus, 5*, 346. doi:10.1186/s40064-016-1984-0

Frame, B. (2005). Bhutan: a review of its approach to sustainable development. *Development in Practice, 15*(2), 216-221. doi:10.1080/09614520500041963

GFN. (2016). *Global Footprint Network. National Footprint Accounts, 2016 Edition*. Retrieved from: www.footprintnetwork.org

GNHC. (2014). *Ecological Footprint of Bhutan and its Regions*. Retrieved from
Grossman, G., & Krueger, A. (1995). Economic growth and the environment. *The Quarterly Journal of Economics, 110*(2), 353.

IHS, G. (2014). EViews 9 User's Guide I and II. In I. G. Inc. (Ed.).
Jorgenson, A., K. (2014). Economic development and the carbon intensity of human well- being. *Nature Climate Change, 4*(3), 186. doi:10.1038/nclimate2110

Kijima, M., Nishide, K., & Ohyama, A. (2010). Economic models for the environmental Kuznets curve: A survey. *Journal of Economic Dynamics and Control, 34*(7), 1187-1201. doi:10.1016/j.jedc.2010.03.010

Knight, K. W., & Rosa, E. A. (2011). The environmental efficiency of well-being: A cross-national analysis. *Social Science Research, 40*(3), 931-949. doi:10.1016/j.ssresearch.2010.11.002

Kubiszewski, I., Costanza, R., Franco, C., Lawn, P., Talberth, J., Jackson, T., & Aylmer, C. (2013). Beyond GDP: Measuring and achieving global genuine progress. *Ecological Economics, 93*, 57-68. doi:10.1016/j.ecolecon.2013.04.019

Lamb, W. F. (2016). Which countries avoid carbon-intensive development? *Journal of Cleaner Production, 131*, 523-533. doi:10.1016/j.jclepro.2016.04.148

Lamb, W. F., Steinberger, J. K., Bows-Larkin, A., Peters, G. P., Roberts, J. T., & Wood, F. R. (2014). Transitions in pathways of human development and carbon emissions. *Environmental Research Letters, 9*(1), 014011. doi:10.1088/1748-9326/9/1/014011

NEC. (1998). *The Middle Path: National Environment Strategy for Bhutan*. Retrieved from Thimphu, Bhutan:

Newman, P. (2017). Decoupling Economic Growth from Fossil Fuels. *Modern Economy, 08*(06), 791-805. doi:10.4236/me.2017.86055

Pérez-Suárez, R., & López-Menéndez, A. J. (2015). Growing green? Forecasting CO2 emissions with Environmental Kuznets Curves and Logistic Growth Models. *Environmental Science & Policy, 54*, 428-437. doi:10.1016/j.envsci.2015.07.015

RGoB, & World Bank. (2017). *Bhutan Living Standards Survey Report*. Retrieved from Thimphu: http://www.nsb.gov.bt/publication/files/pub2yo10667rb.pdf

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, I., F.S., , Lambin, E., . . . J., F. (2009). A safe operating space for humanity. *Nature, 461*.

Rogelj, J., Luderer, G., Pietzcker, R. C., Kriegler, E., Schaeffer, M., Krey, V., & Riahi, K. (2015). Energy system transformations for limiting end-of-century warming to below 1.5 °C. *Nature Climate Change*.

Rogelj, J., Schaeffer, M., Meinshausen, M., Knutti, R., Alcamo, J., Riahi, K., & Hare, W. (2015). Zero emission targets as long-term global goals for climate protection. *Environmental Research Letters, 10*(10), 105007. doi:10.1088/1748-9326/10/10/105007

Song, T., Zheng, T., & Tong, L. (2008). An empirical test of the environmental Kuznets curve in China: A panel cointegration approach. *China Economic Review, 19*(3), 381-392. doi:10.1016/j.chieco.2007.10.001

Steinberger, J. K., & Roberts, J. T. (2010). From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975–2005. *Ecological Economics, 70*(2), 425-433. doi:10.1016/j.ecolecon.2010.09.014

Sulkowski, A., & White, D. S. (2015). A happiness Kuznets curve? Using model-based cluster analysis to group countries based on happiness, development, income, and carbon emissions. *Environment, Development and Sustainability, 18*(4), 1095-1111. doi:10.1007/s10668-015-9689-z

Toth, G., & Szigeti, C. (2016). The historical ecological footprint: From over-population to over-consumption. *Ecological Indicators, 60*, 283-291. doi:10.1016/j.ecolind.2015.06.040

Vemuri, A. W., & Costanza, R. (2006). The role of human, social, built, and natural capital in explaining life satisfaction at the country level: Toward a National Well-Being Index (NWI). *Ecological Economics, 58*(1), 119-133. doi:10.1016/j.ecolecon.2005.02.008

Wooldridge, M. J. (2016). *Introductory Econometrics: A modern approach*. Boston, USA: Cengage Learning.

Yang, G., Sun, T., Wang, J., & Li, X. (2015). Modeling the nexus between carbon dioxide emissions and economic growth. *Energy Policy, 86*, 104-117. doi:10.1016/j.enpol.2015.06.031

York, R., Rosa, E. A., & Dietz, T. (2003). Footprints on the Earth: The Environmental Consequences of Modernity. *American Sociological Review, 68*(2), 279-300.

Contact email: dorjlhen@gmail.com