EXPLORING ASSOCIATION BETWEEN SUBJECTIVE WELL-BEING AND ECOLOGICAL FOOTPRINT: PANEL DATA ANALYSIS

by

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LIST OF ABBREVIATIONS

Abbreviation	Description
GNH	Gross National Happiness
ESD	Environmentally Sustainable Development
SWB	Subjective Well-Being
EF	Ecological Footprints
GDP	Gross Domestic Product
EKC	Environmental Kuznets Curve
URB	Urbanization Rate
BC	Bio-capacity
ED	Ecological Deficit
OLS	Ordinary Least Square
ECARBON	Carbon Footprint
EGRAZING	Grazing land Footprint
ECROP	Cropland Footprint
EFOREST	Forestland Footprint
EFISH	Fishing land Footprint

EBUILT	Built-up land Footprint
TEF	Total Ecological Footprint
TBC	Total Bio-capacity
PC	Partial Correlation
GAEZ	Global Agro-Ecological Zones model
SR	Stepwise Regression
FEPR	Fixed Effects Panel Regression
CSFR	Cross-sectional Fixed Effects Regression
TSFR	Time-series Fixed Effects Regression

ABSTRACT

One of the important duties of government is to improve people's happiness. The existing literature has a lot of discussion about the factors that affect Subjective Well-being (SWB), such as income, employment, equality education and Health, indeed, the environmental aspects were nearly ignored. This paper aims to explore the relationship between environmental factors and SWB lead to significantly deepen our understanding of SWB and then give some suggestions to governments.

A panel data was collected across 101 countries over the years from 2006 to 2016 from the World Values Survey, World Bank and the global footprint network etc. A series of statistical methods such as partial correlation, simple OLS, stepwise regression and fixed effects panel regression were carried out to examine the spatial-temporal association between SWB and Ecological Footprint (EF).

Our empirical results show that increase of SWB is associated with change of rich level, not with time increase. In PC, the conclusion of TBC having significantly positive influences on SWB leads to pursuing happiness is not conflict with environmental protection. ECROP, EGRAZING, and EBUILT has significantly positive influences on SWB, EFISH has significantly negative influences on SWB. The number of EF factors being significant to SWB are increased with rich levels of countries, generating higher possibility of impacts on SWB. In upper-level countries and top-level

countries, carbon emission is negatively significant related to SWB, so low-carbon daily life is the good way to increase SWB. In three regression comparison, fixed effects panel regression models are alternatives of SWB survey method. Time-series fixed effects panel regression model is the most available among three types regression models. EF is invert u-shaped link to SWB, which is satisfied EKC hypothesis. We propose this study for pursuing the continuous improvement of SWB under the premise of maximization of human development index (higher income, education and health) and minimization of public policy of EF per capita.

We argue that with the continuous improvement of the human development index and the popularity of the concept of ecological protection, the low-carbon circular economy model will be underlying, sustainable development trend from being enforced by the government to people's subjective consciousness. Panel data analysis is an effective way to study this issue.

I. INTRODUCTION

Gross National Happiness (GNH) was pointed out by the 4th King,Jigme Singye Wangchuck of the Kingdom of Bhutan. He says, "GNH measures the quality of a country in more holistic way and believes that the beneficial development of human society takes place when material and spiritual development occurs side by side to complement and reinforce each other." (Karma Ura, 2015). Compared to GDP, GNH is a new metric to measure human spiritual and material development, which is overwhelmingly capturing global attentions. It overcomes the limitation of GDP as a measure of progress that it does not consider natural, human, and social capital depletion. Currently, there is few consensuses about measuring Subjective Well-Being (SWB) in the world. In the same vein, there is no common GNH indexes to value SWB satisfaction between countries. Therefore, SWB in "our world in Data" is a unique alterative of GNH indexes.

SWB means measuring happiness, suffering, and other dimensions of experience (Christopher, 2013). SWB refers to income, jobs, housing conditions, health, work and life balance, education, personal security and social connections (Marko Vladisavljeic, 2019). The general thinking being taken for granted is that rich people are happier than poor people; richer countries tend to have higher average SWB levels (Esteban Ortiz-Ospina&, 2013).

In spite of the number of studies, the components that make up SWB is still a controversial topic, the explanation of the discrepancy of SWB in different countries is super significant to political culture of very single country. D. Ye& argue, "Explaining cross-country differences in SWB is an important issue." (Ng, 2015) Social scientists suggest that the usual strategies of economic prosperity are to measure SWB, like GDP per capita. However, SWB is a multiple-scale interdisciplinary notion of investigation, involving psychology, economics, sociology and so on. How to describe SWB and life satisfaction is a hard question (Esteban&, 2013). This is because life satisfaction is a comprehensive, cognitive assessment of quality of life, attitude about life, and the circumstances surrounding the person (Marko Vladisavljeic, 2019). It is evident that important events with us such as marriage or divorce affect SWB, which is in short-term. Ambience where we live is very important issue for SWB as well, which is a long-term ongoing process. Hence, we are not able to ignore the environmental factors of SWB.

Environmentally Sustainable Development (ESD) is the purpose of environmental research. How do we estimate (ESD)? Ecological footprints (EF) is a vital indicator of measuring environment sustainability. In 1996, an ecological footprint method was proposed by Wackernagel&Rees (Wackernagel&, 2017). This method becomes an important orientation of environment research (York&2003, Marco2008, Alessandro2016, Lanouar2017, Zhao2018, Wang2018, Zhang2019, Mehmet2019, Lin&2019). Accordingly, EF also turns into a key point of our research. This paper examines the predictive power of environmental factors on the cross-country differences in SWB and explores how different dimensions of environmental indices differ in their effects on SWB.

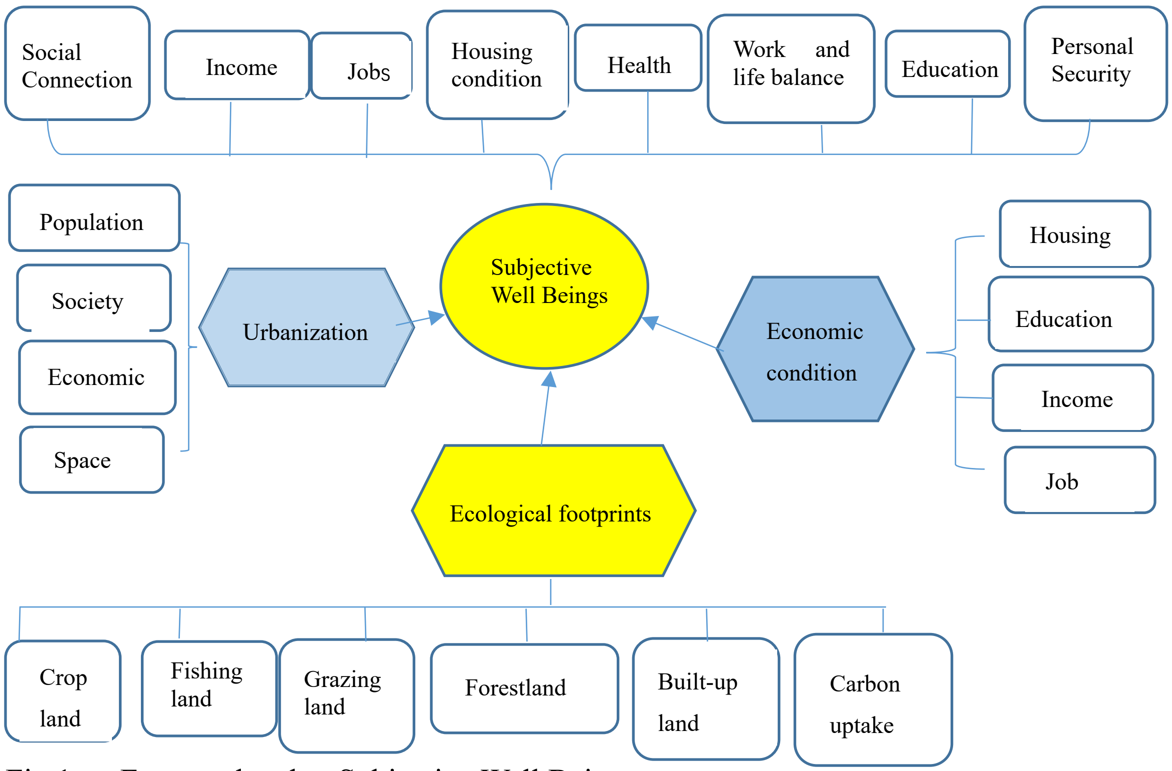

Fig.1 Factor related to Subjective Well Being

Research Motivation

Natural Disasters Caused SWB Reductions Evoking the Concern of Environmental Problems

As waves of rapid economic growth and overwhelming urbanization have swept the globe, most countries have encountered different levels of natural catastrophes because of environmental deterioration. We witnessed many tragedies of SWB reduction. Many scholars, particularly political ecologists, have argued that there is no such thing as a natural disaster, but rather ecological degradation in all forms is the product of social, political, and economic relations. When a dramatic event like a hurricane occurs, the socially disastrous consequences are not, in other word, simply Nature doing its thing. They sought how many people the earth can sustain. From human load to environmental carrying capacity, they attempt to find tools to measure how much pressure we are putting on the planet's resources. Ultimately, they created the concept of EF. EF is a measure of how much area of biologically productive land and water an individual, population, or activity requires to produce all the resources it consumes and to absorb the waste it generates. EF analysis uses prevailing technology and resource management practices. When EF is beyond the bio-capacity, we called it an ecological deficit (or ecological debtor); otherwise, we called it ecological reserves (or ecological creditor). In light of data statistics, there are 136 ecological debtor countries, accounting for about 72% of the world, and 51 ecological creditor countries, representing 28% of the world. The phenomena of ecological deficit are normal, so natural disasters are now the consequence humans must encounter.

Urbanization Aggravates Environmental Impacts While Increasing SWB.

Currently, over half the world's population lives in urban centers and urban population will increase to 66% until 2050 (United Nations 2014). Urban sprawl strongly affects urban environmental quality. For instance, the phenomenon of Urban Heat Island, which means a city's average temperature is higher than the surrounding rural area (Zhao, 2018). Urbanization is a main determinant of environmental degradation (Charfeddine, 2017). First, urbanization leads to "peasant question," which means peasant dispossession, depeasantization, proletarianization and social structure of inequality (Araghi, 2000). Second, urbanization resulted in the problem of the concentration of anthropogenic waste (Clement, 2016), which directly caused the contradiction between rural areas and urban centers. The more resources cities get, the more resources countryside lose. In addition, urbanization has positive effects on carbon emission. Due to intensification of land use, green spaces became fewer; transportation congestion severely worsened, carbon emission aggravated, resulting in urban ecological imbalance.

However, urbanization has been shown to correlate with increases in SWB. First, urbanization offers locational advantages in access to services such as hospitals, recreation centers, and restaurants. Second, affective well-being, which is a part of SWB, has risen due to high education and more work opportunities. Third, high technology application in urban areas is more frequent than in rural areas, result in personal security is higher in cities than countryside and social connections in urban centers is tighter than rural areas. Lastly, thanks to the fact that at-risk-of-poverty rate is twice as high in rural areas than in urban areas, SWB in urban areas is higher than in rural.

Political Economy Influence on Environmental Degradation Is Threating SWB.

Many critical environmental scholars argue that environmental degradation is the result of the current structure of political economy, globally and at more localized scales (Robbins, 2011). There are of course people who argue in favor de-growth as the best forward, but that aside, I think we need to acknowledge at least the voluminous critiques of capitalist globalization's role in environmental degradation. The butterfly effect of human-environment linkages has caught countless scholars' eyes, so they explored the association between economics, politics, and nature for divergent research (Robbins, 2011). Environmental change from political economy is a confluence between ecologically rooted social science and the principles of political economy (Peet&Watts,1996). The overall world has undergone rapid economic growth due to its abundance of natural resources consumption and the transition of their economies from agriculture-based economies to industrial and services-based economies (Lanouar, 2019). In particular, in less developed countries, rapid economic growth leads to environmental degradation, food insecurity and impairment of human well-being. For example, the haze pollution in China is becoming increasingly serious. In 2016 about 254 out of 338 cites could not meet the National Ambient Air Quality Standards of China, accounting for 75.1% (Liu &, 2019). Thus, there is an extensive consensus among policymakers concerning an urgent and optimal economic policy that can help in preserving and protecting the environment of the region. Furthermore, with the increasing awareness of environmental protection among less developed countries' governments, those countries pay attention to environmental issues, the most important of which concerns how to reach higher economic growth and urbanization without compromising the quality of the environment. This question hasn't been solved. There is no common environmental impact assessment standard and ecological environmental evaluation index system to examine the degree of environmental effect from economy. According to the Environmental Kuznets Curve (EKC) hypothesis, environmental degradation has risen from the beginning of economic growth to a turning point. After that, the economic development benefits environmental improvements, which called an inverted U-shaped link (Panayotou, 1993). Previous studies on the association between economic growth and pollution concentrated on carbon dioxide release as a measuring standard of environmental reduction (Salahuddin et al., 2015). In fact, it is evident that carbon dioxide emission is a part of environmental degradation. EF is the more comprehensive indicator to examine the degree of environmental deterioration since it involves not just carbon footprint, but also many aspects such as different land consumptions.

Geographic Influences Determine Human Capabilities And SWB.

The determinist approach was proposed by Nineteenth-century geographer Friedrish Ratzel and the influential researchers William Morris Davis &. It focused on geographic influences determining human capabilities and culture (Robbins, 2011). Kropoptkin pointed out that production is a key social-environmental process and landscape is an object of explanation (Kropotkin, 1888). Ecological deficit means overconsumption of bio-capacity, which is a multi-scale phenomenon, China is the biggest country of ecological deficit. However, by 2014, EF consumption per capital in China was 3.71, which was less than a half of EF consumption per capital in the United States. Canada is the biggest creditor country except for Brazil, but EF consumption per capital is 8.05, which is higher than China. Some thought GDP growth caused the environmental damage. Apparently, China is the top country of GDP, but its GDP per capital is 13440.48 dollars, only a quarter of United States GDP per capital which is 54696.73 dollars. Let's see data of urbanization rate (URB). By 2014, Chinese urbanization percentage was 54.25%, lower than the level of urbanization of the United States, which was 70.38%, not to mention 81.48% in the United States now. Canada was 69.67% in 1961, higher than the current urbanization rate of China. Some believe that the better environment we live in causes the higher of subjective wellbeing, which means making judgments and comparisons with ideals, aspirations, other people, and one's own past happiness. According to the SWB report of 2016, the SWB index of Canada was 7.59, which is located at the top of SWB index list, but the EF consumption per capital is in the top five of the worlds. GDP per capital of the United State is the top ranking, but EF per capital of the United States is in the top six of the worlds, and subjective-wellbeing' s rank is 12th of the world. Ostensibly, China is the most populous countries in the world, which is one of the obvious reasons for environmental problems. Political ecologists have stridently critiqued Malthusian understandings of overpopulation as a driver of environmental degradation.

Problem Statement

There are some limitations in the literature on environmental influences for SWB. Specially, past studies examining association between SWB and EF have several limitations. First, focusing on taking questionnaires method to observe individual wellbeing's situation, lacking quantified statistical analysis. Second, focusing on one special country spectrum, they did not take into account international perspectives and EF impacts between different countries levels. Third, there is few principal components analysis of EF, including carbon footprints, built-up footprints, forestland footprints, cropland footprint, fishing-land footprint, grazing-land footprint. Fourth, there is few a panel data method being taken in research on EF effects of SWB.

Objectives and Research Questions

This study aims to explore Spatial-Temporal correlation between SWB and EF, further put forward some constructive suggestion to enhance human well-being for government. It contributes to address the following questions:

1. Is there any association between SWB and EF per capital in international level?

2. Is there any association between SWB and BC per capital in cross-countries?

3. Is there any association between SWB and factors of EF in cross-countries?

4. How to conduct panel unit root tests?

5. How to establish partial correlation by control variables in research association between SWB and EF based on Panel data?

The research puts forward eight hypotheses to answer the research questions defined above:

Hypothesis:

1. SWB is positively link to EF per capital.
2. SWB is positively relevant to Bio-capacity.
3. SWB is positively relevant to carbon footprint.
4. SWB is positively relevant to cropland footprint.
5. SWB is positively relevant to fishing-land footprint.
6. SWB is positively relevant to grazing-land footprint.
7. SWB is positively relevant to built-up land footprint.
8. SWB is positively relevant to forestland footprint.

II. LITERATURE REVIEW

This work conducted a literature search in the database of Web of Science. 'Subjective well-beings' as a keyword, is published 14339 times on web of Science from 1900 to 2019. Confined to environments, appeared 801 articles. Added EF as a keyword, there were 8 records to match.

SWB Research Review

SWB comes from people's inner world, is an emotional reaction in response to objective materials. "SWB is a multifaceted concept; thus, it is hard to fully understand the mechanisms by which it improves life expectancy." stated Grahame F. Evans and Elsayed Z. Soliman (Evans et al., 2019). In a couple of years, research on SWB is increasing and self-reported data on SWB or life satisfaction is turning into hot spots. Their researches are involved life expectation, mental health and physical health, income, education, community and family life, which summarize three aspects: life satisfaction, affective well-being, and the local environment satisfaction. Life satisfaction, linking to material living conditions, which is up to GDP per capital, includes education, income, unemployment, and housing conditions (Kahneman & Deaton, 2010). It directly contributes to degrees of EF per capital. Affective well-being is related to spiritual well-being including health, personal security, and social connection, work and life balance which depend on the degree of EF per capital indirectly. Current researchers focus on non-material component of people's quality of life (Llosada-Gistau&, 2019). For example, this two articles: "The Subjective Well-being of children in Kinship care"(2019) and "Religious Orientation and Subjective Well-being: The Mediating Role of Meaning in Life"(2019) are related to people's life quality in terms of SWB. On the other hand, they draw primarily on psychology research field, rather than an interdisciplinary perspective. Hence, the SWB research requires assimilating research out of psychology. However, there is few literatures to explore the relationship between sustainability and well-being. From published research of SWB investigation respective, we are pleased to see that there is already having the study on relationship between SWB and GDP, such as "The Asymmetric Experience of Positive And Negative Economic Growth: Global Evidence Using Subjective Well-being Data" (2018). Jan-Emmanuel used Gallup World Poll data from over 150 countries in the world to compare whether SWB push or impede economic growth. This article inspires me start to research SWB on environmental influence. Through web of Science, the only one article is relevant to my research, which used a questionnaire implemented in Flanders (Belgium) to reveal association between individual's ecological footprint to their subjective well-being. Given ignored time series data analyst, the finding is not indisputable. Spatial-temporal exploring association between EF and SWB will benefits to raise well-being in a sustainable development process. That might will turn out more available as well. The article of "Culture and SWB" offered research orientation and research method for this work.

EF Research Review

EF is the general name of all environmental depletion. Sherppa described, "A frequently used measure for the (un)sustainability of an individual behavior is the EF- the number of acres of biologically productive land that are needed for the individual's consumption and activity" (Sherppa,2016). When I am exhausted of seeking EF research on widespread vision, SWB research on EF is like a blossoming flower in deserts, which ignited my research passion. Indeed, quite a few numbers of studies of EF have been carried out to unravel what affects the environment (Mufutau, 2019). York, et al. (2003) indicated the environmental consequences contained three general aspects: human ecology, modernization, and political economy, based on the EF on Earth. Jorgenson (2010) argued that growth of energy consumption was positively relevant to growth in entire urban population, negatively associated with increase in the percentage of a population living in urban slum conditions. Fang (2013) proposed a 3D model with the EF depth and the EF size. Elliott and Clement (2014) conducted cross-sectional and panel regression analyses of carbon emissions at the nationwide in United States, curbing for spatial autocorrelation. They showed urbanization countervail the local level to affect carbon emissions. Charfeddine, L., & Mrabet, Z. (2017) exhibited economic development and social-political factors on ecological footprint using a panel data analysis for 15 MENA countries. Jing Zhao &, (2018) explored “Spatio-Temporal Dynamic Analysis of Sustainable Development in China Based on the Footprint Family”. They created a united criterion for grading the evaluated consequences on global benchmarks to describe the environment of sustainable development deteriorated. Xuemin Liu& (2019) wrote the article “Spatial Spillover Effects of Environmental Regulations on China’s Haze Pollution Based on Static and Dynamic Spatial Panel Data Models.” They identified the relationship between environmental regulations and haze pollutions by dynamic and spatial econometric method including global and local spatial autocorrelation. Also, they used seven socioeconomic drivers to check the spatial spillover impacts on haze pollution, involving economic growth, industrial structure, foreign direct investment, population density, urbanization, transportation, and R&D intensity. Especially they doubted the global footprint network statistics and calculation method. Zhaohua (2018) pointed out fresh water did not contain the traditional ecological footprint accounting in the article “Assessment and prediction of Environmental Sustainability in China Based on a Modified Ecological Footprint Model”.

Quantitative investigation of the interactive coupling relationship is lately employed to analyze effect of urbanization on the EF, such as “International progress and evaluation on interactive coupling effects between urbanization and the eco-environment” (Fang, 2016). This is the first paper to explore effect of Urbanization on the EF.

Arguably, there are similarities about existing EF research besides some distinctions. Similarities involve study approach, data type, variable choice, and research range. They have in common taking advantage of the static or dynamic spatial econometric model skills by panel data in a certain period. Data type is tempo-spatial combined data with long-term or short-term. Variable choice mainly includes population, GDP, carbon emission and urbanization, which have direct effects on factors of environmental degradation. Research range are in relatively big and enclosed fields from macro prospective such as a country, a rally with some countries together. Therefore, if the research of EF were limited to a small space, that would too complicated to achieve. In particular, some factors impact on environmental degradation and climate change should be discovered in long-term process, rather than an environmental temporary action in a short term. It indicates panel data observation should be available and exposed to interior reasons behind ecological deficit. Furthermore, the research of ecological footprints belongs to interdisciplinary topics, which are geography, econometrics, environmental sociology, psychology and ecology. It is important to take a consideration comprehensive and integrated knowledge to enrich EF study. At the same time, EF theory and approach modifies day to day, from a static model to a dynamic 3D model, from an imperfect stage to close to a perfect stage. In addition, they almost utilized a model construction of control variables to reveal related dependent variable changes of EF. The result is reliable by objective data processing.

Global Footprint Network Research

Global Footprint Network (GFN) free offered opened data platform in the world gives rise to attract many scholars' interests. There are 825 publication of GFN in Web of Science. GFN is a public, free network by New York University in the United State. It not only has an integrated and systematic dataset of the globe including EF production, EF consumption, EF per capital, Bio-capacity, ED, but it also covers historical data of EF in a long term from 1961 to 2017. In spite of existing data categorization flaws, its huge dataset with 6671 records of 183 countries, could be open to share the public, which made big contribution of environmental sustainability research. Its sister network of Earth Overshoot Day, also free to provide opened and visual maps to detect energy, city, food, nature and population where we live. Both further promote the environmental research deeply and push more environmental works emergence.

Panel Data Analysis Review

In this study, a main method we used is a panel data, which means we predict the unobserved impacts model by observations from a cross-section of countries over multiple time periods (Ng&,2019). A panel data analysis includes pooled OLS Regression Model, Fixed Effect Regression Model, and Random Effect Regression Model. Pooled OLS Regression Model means it combines variables by pooling, denied the heterogeneity or individuality that may exist among a dataset without considering the cross section and time series nature of data. The fixed effect Model allows for heterogeneity or individuality among a dataset by allowing to have its own intercept value. The term fixed effect is due to fact that although the intercept may differ across countries, but intercept does not vary over time, that it is time invariant. Random effect Model means all countries have a common mean value for the intercept. After estimating the above three models, we shall have to decide which model is good to accept.

Limitation of Previous Research SWB or EF

Literatures of Measuring SWB related to local environment are rarely seen in SWB research (Vladisavljeic, 2019). Similarly, there are some controversies about EF to catch our eyes. For example, what underlying research question does the EF address? How is the research question underlying the EF relevant or irrelevant to policy concerns? (Galli&, 2018) Therefore, several limitations of existing literatures are essential to be proposed. First of all, they took the improvement of EF model seriously, rather than concerning EF concept and its framework analysis. EF is the sum of capital flows and capital stocks, but the EF foregoing research just consider one side (time series or stationarity). Second, Comparison of EF structure between debtor countries and creditor countries is limited. Third，there is few researches on relationship between subjective well-being and EF. We just search two articles published recently, one is "The structure of subjective well-being and its Relation to objective well-being indicators: Evidence from EU-SILC for Serbia" (Marko Vladisavljeic, 2019), which firstly put forwards the idea of the structure of subjective well-being. Another is "Food Insecurity Is More

Strongly Associated with Poor Subjective Well-Being in More-Developed Countries than in Less-Developed Countries”. Frongillo, E. A., Nguyen& (2019) used multilevel linear regression to examine associations between well-being and food insecurity. Subjective well-being belongs to psychology subject, which is applied in food insecurity at first time. They both did not touch environmental fields deeply. Indeed, whether environmental evaluation is good or bad is based on people’s satisfaction surrounding their daily lives. Therefore, the research of SWB satisfaction on environments is a significant value for improving environmental quality. Lastly, they are used quantified analysis to check correlation between variables, like Panel unit root test, Panel Cointegration Model and Panel Vector Error Correction (VECM) Granger causality, rather than qualified identification. A detailed study should be considered data quantification and qualified judgement. Thus, subjective well-being on environmental researches could not leave out qualification examination and data quantification.

Table 1 describe the disparity of related to EF researches.

Table 1 Related to EF Researches Comparison Table

Authors	Article	Depend variables	Control variables	Research work	Research gap
York, Richard et al. 2003.	Footprints on Earth: The Environmental Consequences of Modernity	EF	Population Land area per capita Latitude GDP per capita Percentage urban Political rights Civil liberties State environmentalism	Basic material elements influence the environment and explain the vast majority of cross-national changes in environmental effects. The reason is neo-liberal modernization theory, including political freedom, civil liberties, and state environmentalism. The results suggest societies cannot spoil about achieving sustainability by 142 countries current trend in economic growth.	Data is from cross-section in 1996, no time-series.
Elliott, Jim and Matthew Clement. 2014	Urbanization and Carbon Emissions: A National wide Study of Local Countervailing Effects in the United States	Carbon emissions per capita Carbon emissions per dollar of GDP	Population concentration Land development Systemic position Persons per household Alternative transit use Industrialization Economic output	The study aims to support the framework and show how distinct of urbanization countervail the local level to affect carbon emissions on measures that contribute to far more consistent impacts than household density and alternative transit use.	Panel Data has cross-section of 2001 and time-series from 2001-2006 (short term).
Jorgenson, Andrew et al. 2010	Cities, Slums, and Energy Consumption	Energy consumption	Urban population in percentage of the total population Percentage of the total population residing in urban slum conditions	Results of panel model show that a sample of non-developed countries has two important evidences. From 1990 to 2005, increase of energy consumption positively impact on growth in whole urban population and negatively impact on growth in the percentage of a population living in urban slum atmosphere.	simplicity of the Model and the lack of ecological footprints assessment

Charfeddine, L., & Mrabet, Z. (2017)	The impact of economic development and social-political factors on ecological footprint: A panel data analysis for 15 MENA countries	EF	RGDP Energy use Urbanization Political Institutional index variable Fertility rate Life expectancy at birth	Energy use worsens ecological footprint, whereas real GDP per capita displays an inverted U-shaped relationship with EF in oil-exporting countries. Conversely, EF is U-shaped related to GDP in oil-importing countries. The results show that urbanization, life expectancy at birth and fertility rate benefit to the environmental development in the long term.	The research range: MENA, true correlation of economic growth and environmental degradation has been hidden
Xuemin Liu& 2019	Spatial Spillover Effects of Environmental Regulations on China's Haze Pollution Based on Static and Dynamic Spatial Panel Data Models.	LnERs	lnPM10 ln2GDP lnFDI lnIS lnPS lnUD lnTRA lnR&D	This paper took advantages of the exploratory spatial data analysis to analyze global and local spatial autocorrelation of environmental regulations and haze pollution. It also built static and dynamic spatial panel data models to show the influence of environmental regulations and its spatial spillover impact on haze pollution over 31 provinces of China in 2005-2015.	The panel data of 31 provinces in China was collected. Base on special case, it is hard to generalization.
Frongillo, E. A., Nguyen, H. T., Smith, M. D., & Coleman-Jensen, A. (2019).	Food Insecurity Is More Strongly Associated with Poor Subjective Well-Being in More-Developed Countries than in Less-Developed Countries.	Subjective well-beings	infant mortality gross domestic product economic inequality agricultural value fertility maternal mortality, female schooling, and female participation	The prevalence of food insecurity was vulnerable to SWB over 147 countries.	The Method is worthy to learn, but the topic is not related to environments.

III. DATA AND METHODOLOGY

Data and Its Source

In order to explore the Spatial-Temporal correlation between SWB and EF on 101 countries data (2006-2016), the fixed regression effect model to express SWB changes with the components of EF is employed by a panel data from 2006-2016. In my study, SWB is a dependable variable, GDP per capita, urbanization rate, literacy rate, youth life expectancy, Wage and salaried workers, political stability, voice accountability are control variables, bio-capacity, carbon footprint, cropland footprint, fishing land footprint, built-up land footprint, forestland footprint, grazing-land footprint, EF consumption per capital are independent variables. The EF dataset has been extracted from the global footprint network dataset. Control variables are extracted from the World bank and World Value Survey. Survey SWB are extracted from the Gallup World Poll. All variables are converted into natural logarithms to address normality and homoscedasticity and to interpret the coefficients of the long-term relationship as constant elasticity. The data model and analysis framework are shown as the Figure 2.

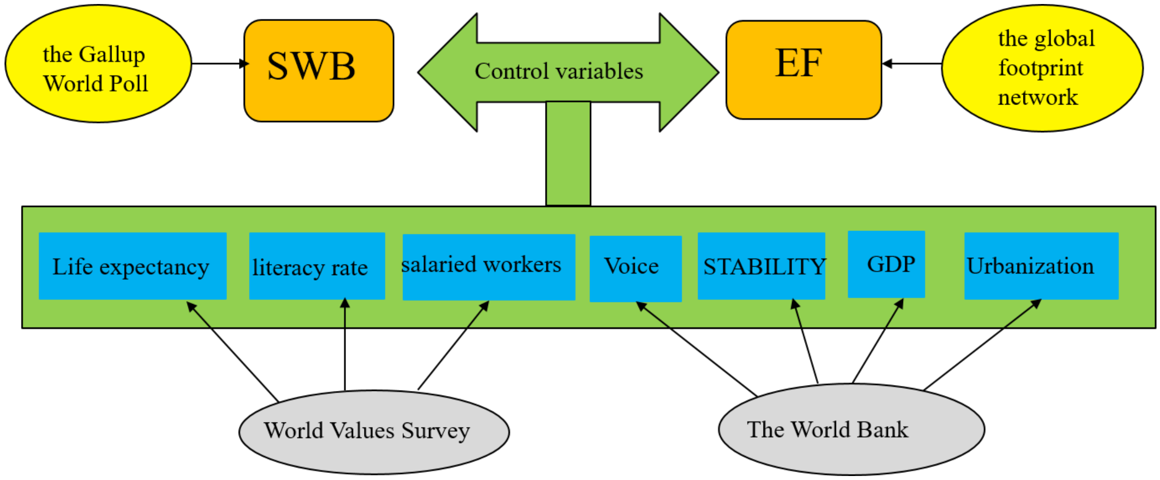

Fig.2 Data source framework

<u>Dependent Variables</u>

SWB

SWB, refers to how people experience the quality of their lives and it includes both emotional reactions and cognitive judgments (Inglehart et al., 2008). The world SWB report 2019 data (Fig3.) are from the Gallup World Poll. It is large-scale repeated cross-sectional survey involving more than 150 countries. The period covered in our research from 2006 to 2016. All samples in the poll are probability based and nationally representative of the resident population aged from15 to older. The typical Gallup World Poll survey wave interviews 1000 individuals using answers to a Cantril Ladder question. Life satisfaction is measured on a 10-point scale.

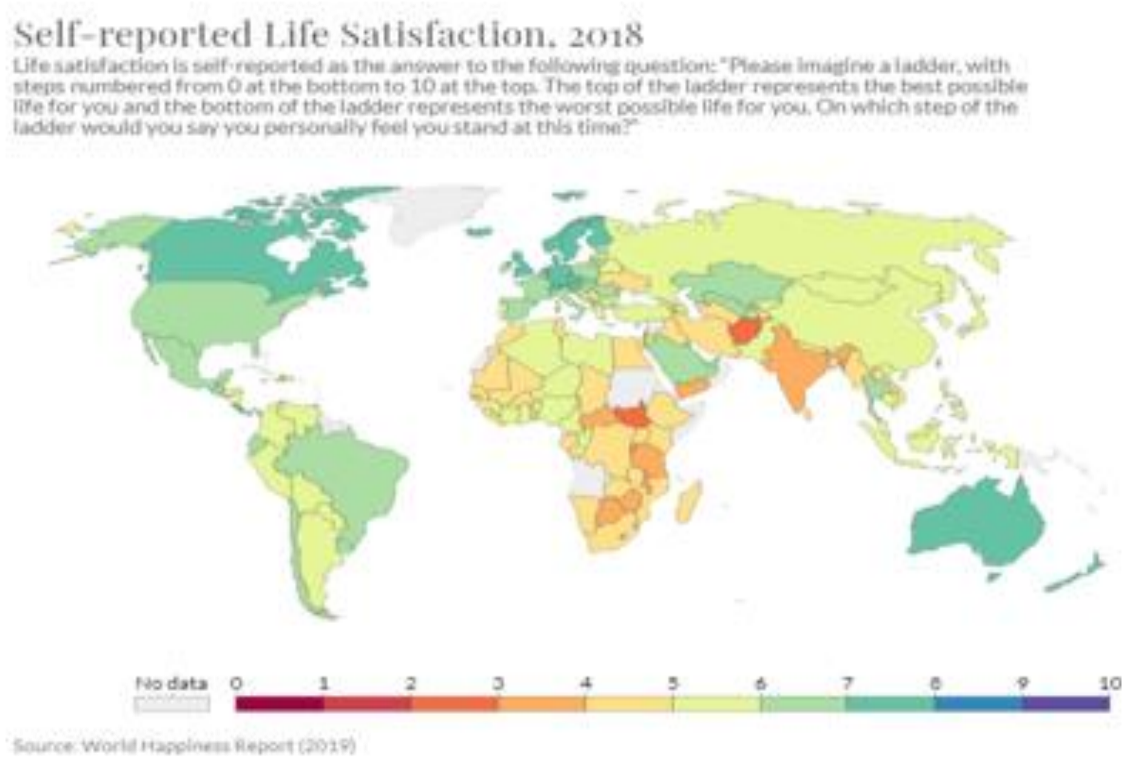

Fig.3 The world SWB report 2019 data map

<u>Independent Variables</u>

EF per capital consumption

EF is one of ways to measure how much lands of human needs to produce all the resources it consumes and to absorb the waste, using current technology and resource management systems. The EF is usually expressed in global hectares. General speaking, EF generally means the Ecological Footprint of consumption. EF is often referred to in short form as Footprint. From structures of EF perspective, EF data consist of cropland footprints, grazing-land footprints, forestland footprints, fishing-land footprints, built-up footprints, carbon footprints. All the data are obtained from global footprint network. Data we research cover 101 countries from 2006 to 2016.

Bio-capacity (BC)

Bio-capacity is the ecosystems' capacity. The nature offers biological materials, which are used by people and to absorb waste material generated by humans in the certain technology levels or development condition. Data of BC are downloaded from global footprint network. Data we research cover 101 countries from 2006 to 2016. Biocapacity is expressed in global hectares.

Factors of EF

The carbon footprint (ECARBON)

The carbon footprint represents the size of forest land needed to contain anthropogenic carbon dioxide emissions. The data of carbon footprint calculate the footprint of carbon dioxide release using some parameters including domestic fossil fuel combustion, electricity consumption, incorporated carbon in traded items and electricity, a country's share of global international transport emissions, and non-fossil-fuel sources (Ewing&, 2010). Data are from global footprint network. Data we research cover 101 countries from 2006 to 2016.

Grazing land footprint (EGRAZING)

Grazing land footprint summarizes the footprint of pasture grass embodied in livestock products (Ewing&, 2010). Data are from global footprint network. Data we research cover 101 countries from 2006 to 2016.

Cropland footprints (ECROP)

Cropland footprints estimated the footprint of cropland incorporated in crop products and in feed products for livestock and fish (Ewing&, 2010). Data are from global footprint network. Data we research cover 101 countries from 2006 to 2016.

Forestland footprints (EFOREST)

Forestland footprints estimates the forest products footprint embodied in primary and secondary forest products (Ewing&, 2010). Data are from global footprint network. Data we research cover 101 countries from 2006 to 2016.

Fishing land footprints (EFISH)

Fishing land footprints estimates the footprint of marine and inland water area embodied in fish and other aquatic products (Ewing&, 2010). Data are from global footprint network. Data we research cover 101 countries from 2006 to 2016.

Built-up land footprints (EBUILT)

Built-upland footprints summarize the footprint related to infrastructure. Data are from global footprint network. Data we research cover 101 countries from 2006 to 2016.

Control Variables

When many factors playing roles in SWB, we must control for these factors to get over the bias of omitted variables. As literature reviews mentioned, we choose GDP per capita, urbanization rate, literacy rate, youth life expectancy, Wage and salaried workers, political stability, voice accountability as control variables.

Life expectancy (HEALTH)

Life expectancy at birth describes the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. Data include the following six sections: (1) United Nations Population Division. World Population Prospects: 2017 Revision or derived from male and female life expectancy at birth from sources such as: (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Program (World bank group).

Youth literacy rate (EDUCATION)

Youth literacy rate is the percentage of people ages 15-24 who can both read and write with understanding a short simple statement about their everyday life. The source is from UNESCO Institute for Statistics (World bank group).

Wage and salaried workers (UNEMPLOYMENT)

Unemployment are those workers who had jobs which defined as "paid employment jobs," where the incumbents hold explicit (written or oral) or implicit employment contracts that give them a basic remuneration that is not directly dependent upon the income of the unit for which they work (World bank group). Data are from International Labor Organization, ILOSTAT database. Data retrieved in April 2019.

Voice and Accountability (VOICE)

Voice and Accountability reflects thinking of the extent to which a country's citizens are able to take part in selecting their government, freedom of idea, freedom of association, and an opened media (World bank group). Percentile value means estimations among all countries (ranges from 0 (lowest) to 100 (highest) rank). Data are from the World Bank.

Political Stability and Absence of Violence/Terrorism (STABILITY)

Political Stability and Absence of Violence/Terrorism estimates thinking of the possibility of political instability and/or politically motivated violence, including terrorism (World bank group). Percentile value means estimations among all countries (ranges from 0 (lowest) to 100 (highest) rank). Data are from the World Bank.

GDP

Gross domestic product (GDP) is perceived as an indicator of assessing the situation of a country. GDP is characteristic as measuring economic performance by amassing the value of all the goods and services produced within a country (Weimann &, 2015). Although economic prosperity is not an end in itself, it contributes to an indicator of people's SWB. That is why we take for granted that people are better off when they are better afford and when they are capable of consuming more. However, we do not think GDP is not panacea, but as our yardstick (Bruno, 2018). Its strength is safe and transparent since the data are produced by market processes without any element of arbitrariness. GDP is measured per capital in buying power Parity constant 2017 US dollars.

Urbanization (UBR)

Urbanization is considered as an important index of cities sprawl and urban populous increasing. The current urbanization system consist of population urbanization, social urbanization, economic urbanization and spatial urbanization (Liu S L&, 2018） Due to exploring interrelationship between SWB and EF, EF involves spatial carrying capacity, GDP includes economic influence on urbanization, we just keep eyes on traditional urbanization, which means the growth of population urbanization. The principal source of urbanization data is the World Bank.

Study Area

Ecological sustainability concentrates on spatial variation and temporal scale. Thus, sufficient samplings benefit us to find out spatial heterogeneity and scale characteristics in association between SWB and EF.

The condition of research countries being selected:

1. The begin year of SWB data is regarded as the first research year, the last year posted SWB data in public is as the end of research year for the sake of SWB data restriction.

2. Study countries depends on countries of SWB from the Gallup World Poll.

Since SWB data in the Gallup World Poll was from 2006, EF data should be compared in the same period. In order to data consistency and comparability, we removed out 82 countries from Global footprints network, remaining the following 101 countries data from 2006-2016 as research samples (Table2). All countries are categorized into rich level I-IV types according to PERGDP from World Bank GNI per capita Operational Guidelines & Analytical Classification. Rich Level I represents poor countries, rich level II and III represent developing countries, rich level IV represents developed countries. Meanwhile, entire research period is divided two periods of 2006-2010 and 2011-2016.

Table 2 Research Countries List

COUNTRY	number	COUNTRY	Number	COUNTRY	Number
Afghanistan	1	Lebanon	34	Estonia	68
Albania	2	Lithuania	35	Ethiopia	69
Angola	3	Luxembourg	36	France	70
Argentina	4	Macedonia	37	Germany	71
Armenia	5	Madagascar	38	Ghana	72
Australia	6	Malawi	39	Greece	73
Austria	7	Malaysia	40	Haiti	74
Azerbaijan	8	Mali	41	India	75
Bahrain	9	Mexico	42	Indonesia	76
Bangladesh	10	Montenegro	43	Israel	77
Belarus	11	Myanmar	44	Italy	78
Belgium	12	Nepal	45	Japan	79
Benin	13	Netherlands	46	Jordan	80
Bhutan	14	Nicaragua	47	Kazakhstan	81
Bolivia	15	Niger	48	Kenya	82
Bosnia and Herzegovina	16	Norway	49	Kuwait	83
Botswana	17	Pakistan	50	Latvia	84
Brazil	18	Panama	51	Sri Lanka	85
Burkina Faso	19	Paraguay	52	Sweden	86
Burundi	20	Peru	53	Switzerland	87
Cameroon	21	Philippines	54	Tanzania	88
Canada	22	Poland	55	Thailand	89
Chad	23	Portugal	56	Togo	90
Chile	24	Romania	57	Tunisia	91
China	25	Russia	58	Turkey	92
Colombia	26	Rwanda	59	Uganda	93
Congo	27	S Korea	60	United Arab Emirates	94
Costa Rica	28	Saudi Arabia	61	United Kingdom	95
Croatia	29	Serbia	62	United States	96
Czech Republic	30	Sierra Leone	63	Uzbekistan	97
Denmark	31	Singapore	64	Venezuela	98
Dominican Republic	32	Slovenia	65	Vietnam	99
El Salvador	33	Spain	66	Yemen	100
		Zimbabwe	67	Zambia	101

Regression Model

In order to examine the eight hypotheses, we model SWB on various dimensions of EF. The regression Model we build is as follows:

$$SWB_{it} = \beta_{0i} + \beta_{1i} \times EF_{si} + \beta_{2i} \times Controls_i + u_{it} \quad (1)$$

where the dependent variable SWB is the subjective well-being level for country i in year t.

The explanatory variables EF_{si} are a set of environmental indices, which measure different type of resources consumption including EF per capital, TBC, ECARBON, ECROP, EFISH, EBUILT, EGRAZING, EFOREST; Controls are variables that may relatively affect SWB including Stability, GDP, Urbanization rate, VOICE, HEALTH, EDUCATION, UNEPLOYMENT; u_{it} is the disturbance term.

Table 3 Hypothesized effects of underlying EF factors on SWB

EF	Hypothesized effects
EF per capital	+
Bio-capacity per capital (TBC)	+
carbon footprint (ECARBON)	+
cropland footprint (ECROP)	+
fishing-land (EFISH)	+
grazing-land (EGRAZING)	+
built-up land (EBUILT)	+
Forestland (EFOREST)	+

IV. DESCRIPTIVE STATISTICS

Introduction

At the beginning, this chapter describe SWB is a continuous Variable with normal distribution. Next it depicts EF related factors and their statistical characteristics. Finally, it illustrated how SWB and EF passed Panel unit root test.

Methods

Normal Distribution includes univariate normal distributions and multivariate normal random distributions. In our study, both SWB and EF belong to univariable. The usual concept of the standard normal variable Z specifies its density $f(x) = 1/\sqrt{2\pi}\ e\hat{}(-x\hat{}2/2)$. In general, $N(m, \sigma)$density is given by

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-m)^2}{2\sigma^2}}$$

By completing the square one can check that the characteristic function$\Phi(t) = Ee^{itZ} = \int_{-\infty}^{\infty} e^{itx} f(x)dx$of the standard normal r. v. Z is given by (Wlodzimierz, 1995)

$$\Phi(t) = e^{-\frac{x^2}{2}}$$

Panel unit root test is the common feature of panel data analysis. The early panel unit root test meant Dickey-Fuller(ADF) tests, the Phillips-Perron tests and the Iwiatkowski et al. (1992) tests. The first-generation panel unit root test that are called the Levin-Lin-Chu (LLC, Levin et al, 2002). Im-Pesaran-Shin (IPS, Im et al, 2003) and the Hadri (2000) are second-generation panel unit root test. They minimized size distortions and increased power. A theoretical description of these tests is presented as follows: The data producing process of the series y, in its difference form, be:

$$\Delta y\_it = \alpha y_{it-1} + \sum_{j=1}^{pi} \beta i_j \Delta y_{it-j} + X'\delta + \varepsilon_{it} \qquad (2)$$

Where $i = 1, 2, 3, \cdots, N$ representing cross-sections and $t = 1, 2, 3, \cdots, T$ meaning time period observations, X_it are the exogenous variables such as individual effects and linear trends, $\alpha = (\rho - 1)$, and ρ_i are the autoregressive coefficients. The LLC assume that the autoregressive coefficients in (2) are identical across the panel (common unit root process), while in the IPS test, they are totally different. In the LLC test, the null hypothesis is the presence of a unit root for all i, and the alternative hypothesis requires that the individual process is stationary for all i, and when the null hypothesis the same, the alternative in the IPS test is illustrated to include a non-zero fraction of individual process as stationary. IPS statistic equation as:

$$t\_IPS = \frac{\sqrt{N}\left(\bar{t} - \frac{1}{N}\sum_{i=1}^{N} E[t_i T | \rho_i = 0]\right)}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} V_{ar}[t_i T | \rho_i = 0]}} \qquad (3)$$

In equation (3), according to the simple Lindberg-Levy theory, the test statistic is asymptotically distributed as N (0,1) as the number of observations is extremely large. Im et al (2003) exhibited values of the mean and variance for standardizing the test statistic.

Results

1.SWB statistical characteristics

The precondition of regression analysis is that dependent variable should meet the normal distribution. The request of normal distribution has two conditions. One is uncertain variable is symmetric about the mean, another is that uncertain variable is more likely to be in vicinity of the mean than far away.

Thus, we conducted normal distribution of SWB when SWB defined as unique dependent variable. By observation of 974 cases during 2006-2016, the result is shown that SWB met the requirement of the normal distributive model, based on the test statistics and the histogram (Fig.4).

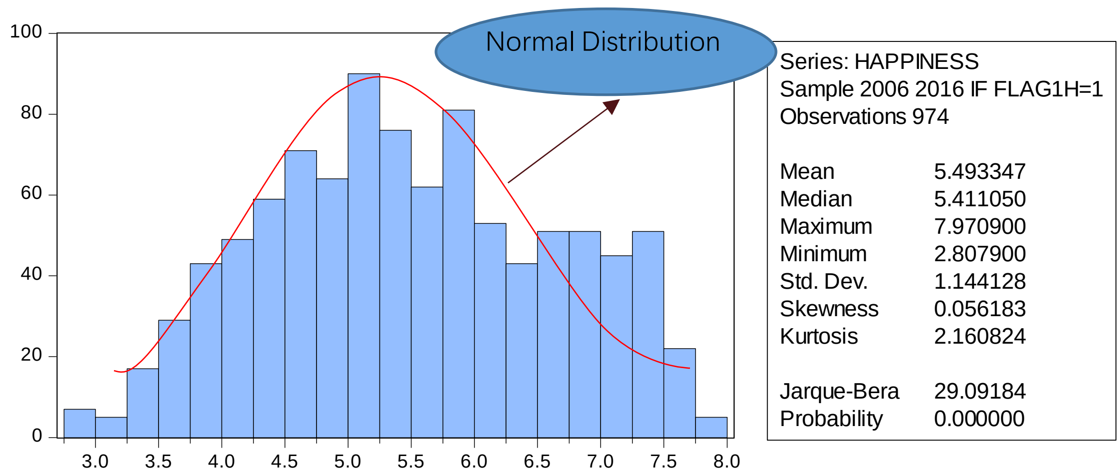

Fig.4 The normal distribution of SWB graph

2 EF related factors and their statistical characteristics

Table 4 depicts the variation of EF and TBC in two different periods. We got the following results:

(1) the overall TEF per capital is positively related to the rich level, the average of TEF increase from 1.115 to 6.065 while rich level goes from 1 to 4.

(2) From the perspective of time, the average of the TEF declines with different period, perhaps due to the popularity of environmental protection campaign in recent years, especially among the countries with higher rich level.

(3) The entire TBC is also positively sensitive to the rich level, the average of TBC increase from 1.39 to 3.211 while rich level goes from 1 to 4.

(4) In the poorest countries, TBC has increased from 1.326 to 1.429 while other countries have reduced over time.

Table 4 Descriptive Statistics for EF and BC classified by rich level

Mean Std. Dev. Obs.		RICHLEVEL 1 Lower	2 L Middle	3 U middle	4 High	All
	2006-2010	1.107	1.509	3.146	6.281	3.491
		0.337	0.516	1.06	2.168	2.539
		66	84	105	129	384
TEF	2011-2016	1.099	1.621	3.135	5.933	3.447
		0.295	0.727	1.024	2.051	2.416
		111	119	149	211	590
	All	1.115	1.575	3.14	6.065	3.445
		0.311	0.649	1.037	2.099	2.461
		186	203	254	340	983
	2006-2010	1.326	2.027	3.256	3.26	2.658
		1.909	4.282	2.823	3.783	3.486
		66	84	105	129	384
TBC	2011-2016	1.429	1.898	2.998	3.179	2.546
		2.103	3.535	2.587	3.684	3.219
		111	119	149	211	590
	All	1.390	1.952	3.105	3.211	2.59
		2.028	3.852	2.685	3.717	3.326
		177	203	254	340	974

3 Panel unit root tests

To keep stability-based time-series data and remove fake regression models, we engaged in unit root tests to examine association between variables. Panel unit root test is a conventional method to examine variable rationality in panel data analysis. The result of panel unit root with SWB variable is shown on Tab 5 P-value is 0, qualified Cross-section records is 99, observation records are 826 cases. The result of panel unit root with TEF variable is shown on Tab 6 P-value is 0, qualified Cross-section records is 99, observation records are 826 cases. The result of panel unit root with TBC variable is shown on Tab7 P-value is 0.0001, qualified Cross-section records is 99, observation records are 826 cases. The result of panel unit root of SWB with Control variable is shown on Tab 8 P-value is 0, qualified Cross-section records is 4, observation records are 4655 cases. According to results analysis, all variables passed unit root tests owing to P-value less than 0.05.

Table 5 The result of panel unit root of dependent variable

Panel unit root test: Summary
Series: SWB
Date: 09/03/19 Time: 11:53
Sample: 2006 2016 IF FLAG1H=1
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-173.355	0.0000	99	826
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-69.3188	0.0000	99	826
ADF - Fisher Chi-square	1013.71	0.0000	99	826
PP - Fisher Chi-square	1340.59	0.0000	99	900

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table 6 The result of panel unit root of independent variable TEF

Panel unit root test: Summary
Series: TEF
Date: 09/03/19 Time: 11:54
Sample: 2006 2016 IF FLAG1H=1
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-14.6983	0.0000	99	826
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.38979	0.0084	99	826
ADF - Fisher Chi-square	262.865	0.0014	99	826
PP - Fisher Chi-square	357.207	0.0000	99	900

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Table 7 The result of panel unit root with TBC variable

Panel unit root test: Summary
Series: TBC
Date: 09/03/19 Time: 11:55
Sample: 2006 2016 IF FLAG1H=1
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.79267	0.0001	99	826
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.05385	0.4785	99	826
ADF - Fisher Chi-square	221.116	0.1246	99	826
PP - Fisher Chi-square	387.289	0.0000	99	900

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table 8 The result of panel unit root of dependent variable with control variable

Group unit root test: Summary
Series: SWB, LNSPERGDP, LNSTEF, LNSUBR
Date: 07/19/19 Time: 16:29
Sample: 1 1171
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 9
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-124.142	0.0000	4	4655
Breitung t-stat	-19.2882	0.0000	4	4651
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-75.9524	0.0000	4	4655
ADF - Fisher Chi-square	987.895	0.0000	4	4655
PP - Fisher Chi-square	899.930	0.0000	4	4673

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Discussion

Why is SWB sensitive to rich level of countries, not to time changing?

By descriptive statistics for SWB as TAB 9, rich level 1-4 means income level of countries from low to high. We divide into two periods such as 2006-2010 and 2011-2016. The graph indicates that SWB is obviously affected by the rich level (the average of SWB changed from 4.1 to 6.5 along with the rich level increasing), nevertheless, SWB is not sensitive to time period, indicating SWB in the same rich level has not changed. For example, the average increase from 5.48 during 2006-2010 to 5.50 in the years of 2011-2016, that means the tendency of SWB is stable over decade. The number of samples in 2011-2016 is more than that of 2006-2010, pointing out statistic data of SWB is more reliable than before, as well as the concern of SWB is increased by human beings. Thus, table3 has demonstrated that an overall increase of SWB is associated with an increase in rich level, not with time increase.

In rich level I and rich level II of TAB 4, TBC are higher than EF value, that means ecological deficits over ten years. Both low level and middle level countries such as India, China, and many of countries in Africa, usually refer to developing countries, which depend on and take advantages of natural resources overload to develop their economy, including fossil fuel, various lands, and carbon release. They pay more attention to GDP development. In contrast, in rich level III and rich level IV, TBC and EF keep balance of ecological reserves over ten years. These two categorized countries such as U.S, Canada, and Australia, usually refers to developed countries, which depend on high science and technology to develop their economy. They concentrate on environmental protection.

Table 9 Descriptive Statistics for SWB classified by Rich level and time period

Mean Std. Dev. Obs.		RICHLEVEL 1I Lower	2 II Middle	3 III middle	4IV High	All
	2006-2010	4.106	4.895	5.550	6.502	5.479
		0.521	0.659	0.840	0.803	1.141
		66	84	105	129	384
PERIOD	2011-2016	4.084	4.934	5.670	6.452	5.503
		0.557	0.698	0.817	0.783	1.147
		111	119	149	211	590
	All	4.093	4.918	5.621	6.471	5.493
		0.543	0.6818	0.827	0.789	1.144
		177	203	254	340	974

Conclusions

SWB is eligible as dependent variables. Increase of SWB is associated with change of rich level, not with time increase. During 2006-2016, in developing countries, they prefer economic development to environmental conservation. In contrast, in developed countries, they concentrate on environmental conservation, instead of economic development. In panel unit root test, all variables including dependent variables and independent variable passed test.

V. PARTIAL CORRECTION ANALYSIS OF ASSOCIATION BETWEEN SWB AND EF

Introduction

Partial correlation is a way to measure its advantages and tendency of a linear relationship between two continuous variables while controlling for the effect of one or more other continuous variables. As the literature review above, SWB was thought to be pertinent to PERGDP, UBR EDUCATION, HEALTH, VOICE, STABILITY, UNEMPLOY traditional seven factors. To focus on the study on EF related factors, we used all these traditional factors as control variables to conduct a partial correlation analysis to expose real association between SWB and EF under removing the effects of the traditional factors.

Methods

In order to get rid of impacts of control variables, we conducted partial correlation in relationship analysis between SWB and EF related factors. Eventually, we used results with ordinary correlation to compare partial correlation results.

Partial Correlation has the following process. First, we estimate a covariance matrix (Σ), then get the correlation matrix (C) through normalizing the off-diagonal entries:

$$C_{ij} = \frac{\Sigma ij}{\sqrt{\Sigma ii \Sigma jj}} \quad (1)$$

We can also obtain the partial correlation matrix with the same way. Next, we peel off diagonal entries of the inverse of the covariance matrix (Θ), the partial correlation matrix (P) by the equation (2):

$$P_{ij} = -\frac{\Theta_{ij}}{\sqrt{\Theta_{ii}\Theta_{jj}}} \qquad (2)$$

$$\beta^*_{ij} = -\frac{\Theta_{ij}}{\Theta_{ii}} = P_{ij}\sqrt{\frac{\Theta_{jj}}{\Theta_{ii}}} \qquad (3)$$

β^*_{ij} means the weight of the partial correlation between i and j (P_{ij}), using the equation (3) to acquire it (Tristan&, 2020).

Results

Table 10 delineates the results of the ordinary Correlation among SWB and its EF related factors including TBC, TEF, ECROP, EGRAZING, EFOREST, EFISH, EBUILT and ECARBON. They all have significantly positive Correlation except EGRAZING.

The result is shown in TAB 11, which is relative different from that of TAB5.3.1. The main changes are the following: (1) The value of correlation is less likely than that without any controls; (2) ECARBON and EFISH have negative effects on SWB; TBC, TEF, ECROP, EFOREST, EGRAZING and EBUILT have positive effects on SWB. (3) TBC, EBUILT, EFISH, ECROP and EGRAZING are significant factors, but TEF, ECARBON and EFOREST are not significant factors. (4) There are significant Correlation among EF related factors.

To show further different effects, we conducted the Partial Correlation Analysis for different rich levels respectively. The results are shown on TAB 12-15. In the lower income countries, we got results are as follows by 170 records: (1) ECROP and EGRAZING have negative effects on SWB; TBC, TEF, ECARBON, EFISH, EFOREST, and EBUILT have positive effects on SWB. (2) TBC, EBUILT, are significant factors and the rest of EF factors are not significant. The results verified that two indexes of EF affected SWB during 2006-2016.

In the middle level countries, based on 203 records, we got the following results. (1) ECROP, EBUILT, EFISH, and EFOREST have negative effects on SWB; TBC, TEF, ECARBON, EGRAZING have positive effects on SWB. (2) TCARBON, EFISH, and ECROP are significant factors and the rest of EF factors are not significant. (3) The above results demonstrate that three indexes of EF affected quality of SWB during 2006-2016.

In the upper level countries, we got the following results according to 254 qualified records. (1) TEF, ECARBON, and ECROP have negative effects on SWB; TBC, EBUILT, EFISH, EGRAZING, and EFOREST have positive effects on SWB. (2) TBC, TCARBON, EFOREST, and EGRAZING are significant factors and the rest of EF factors are not significant. The above findings demonstrate that four indexes of EF affected SWB during 2006-2016.

In the top-level countries, we got the following results by 338 observations. (1) TEF, ECARBON, EFISH, and EFOREST have negative effects on SWB; TBC, EBUILT, EGRAZING, and ECROP have positive effects on SWB. (2) TBC, TCARBON, EBUILT, ECROP, and EGRAZING are significant factors and the rest of EF factors are not significant. That demonstrates that five indexes of EF affected SWB during 2006-2016.

Table 10 Ordinary Correlation Analysis between SWB and other EF related factors

Correlation Probability	SWB	TBC	TEF	EBUILT	ECARBON	ECROP	EFISH	EFOREST	EGRAZING
TBC	0.296	1.000000							
	0.00	-----							
TEF	0.697	0.274338	1.000000						
	0.00	0.0000	-----						
EBUILT	0.415374	0.126363	0.333300	1.000000					
	0.0000	0.0001	0.0000	-----					
ECARBON	0.648374	0.123126	0.967219	0.247478	1.000000				
	0.0000	0.0001	0.0000	0.0000	-----				
ECROP	0.547025	0.195867	0.704221	0.366845	0.617042	1.000000			
	0.0000	0.0000	0.0000	0.0000	0.0000	-----			
EFISH	0.354639	0.093609	0.302487	0.092713	0.235169	0.248084	1.000000		
	0.0000	0.0036	0.0000	0.0039	0.0000	0.0000	-----		
EFOREST	0.314511	0.463544	0.514311	0.307519	0.337254	0.361754	0.139761	1.000000	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-----	
EGRAZING	0.263719	0.569553	0.234343	0.149279	0.119312	0.113155	-0.014573	0.080531	1.000000
	0.0000	0.0000	0.0000	0.0000	0.0002	0.0004	0.6512	0.0123	-----

*this item cannot reject the T test hypothesis and mean grazing and fishing dot have significant Correlation due to 0.6512.

Table 11 Partial Correlation analysis of EF related factors with control variables

Correlation Probability	SWB	TBC	TEF	EBUILT	ECARBON	ECROP	EFISH	EFOREST	EGRAZING
SWB	1.000000								

TBC	0.157837	1.000000							
	0.0000	-----							
TEF	0.003685	0.173946	1.000000						
	0.9093	0.0000	-----						
EBUILT	0.102082	-0.003751	0.029004	1.000000					
	0.0016	0.9077	0.3699	-----					
ECARBON	-0.047705	-0.069730	0.900176	-0.101357	1.000000				
	0.1401	0.0309	0.0000	0.0017	-----				
ECROP	0.067284	0.090206	0.415799	0.225173	0.221843	1.000000			
	0.0373	0.0052	0.0000	0.0000	0.0000	-----			
EFISH	-0.076369	-0.076063	-0.160891	-0.164854	-0.232170	-0.021754	1.000000		
	0.0181	0.0185	0.0000	0.0000	0.0000	0.5012	-----		
EFOREST	0.015663	0.364001	0.483979	0.159141	0.170170	0.182083	-0.103737	1.000000	
	0.6283	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	-----	
EGRAZING	0.163570	0.547359	0.118550	0.083188	-0.092134	-0.002348	-0.151712	0.013088	1.000000
	0.0000	0.0000	0.0002	0.0100	0.0043	0.9421	0.0000	0.6858	-----

***, **, * Significance for T-test at 1, 5, and 10 %, respectively

Table 12 Partial Correlation analysis in low level

Partial Covariance Analysis: Ordinary
Sample: 2008 2016 isrich14=1 Included observations: 170
Partial analysis controlling for: PERGDP UPR EDUNEW HEALTH VOICE STABILITY UNEMPLOY
Date: 09/05/19 Time: 04:08

Correlation Probability	SWB	TBC	TEF	EBUILT	ECARBON	ECROP	EFISH	EFOREST	EGRAZING
SWB	1.000000								

TBC	0.193655	1.000000							
	0.0133	-----							
TEF	0.013587	0.474172	1.000000						
	0.8633	0.0000	-----						
EBUILT	0.283778	0.252039	0.115778	1.000000					
	0.0002	0.0012	0.1411	-----					
ECARBON	0.074695	0.355260	0.022177	-0.117637	1.000000				
	0.3433	0.0000	0.7787	0.1348	-----				
ECROP	-0.011880	0.188493	0.718321	-0.017753	0.029849	1.000000			
	0.8804	0.0160	0.0000	0.8220	0.7053	-----			
EFISH	0.130137	0.083897	0.208808	-0.163077	0.261329	0.118720	1.000000		
	0.0978	0.2870	0.0075	0.0375	0.0008	0.1312	-----		
EFOREST	0.063380	-0.020788	0.208979	0.017231	0.068079	-0.078782	0.558601	1.000000	
	0.4215	0.7922	0.0074	0.8272	0.3879	0.3175	0.0000	-----	
EGRAZING	-0.076453	0.347356	0.663222	0.126212	-0.388138	0.296135	-0.321088	-0.322941	1.000000
	0.3320	0.0000	0.0000	0.1084	0.0000	0.0001	0.0000	0.0000	-----

Table 13 Partial Correlation analysis in middle level

Included observations: 203 Sample: 2011 2016 isrich14=2 Partial Covariance Analysis: Ordinary

Partial analysis controlling for: PERGDP UPR EDUNEW HEALTH VOICE STABILITY UNEMPLOY

Date: 09/05/19 Time: 04:12

Correlation Probability	SWB	TBC	TEF	EBUILT	ECARBON	ECROP	EFISH	EFOREST	EGRAZING
SWB	1.000000								

TBC	0.043371	1.000000							
	0.5461	-----							
TEF	-0.030132	0.564137	1.000000						
	0.6750	0.0000	-----						
EBUILT	-0.098673	0.085237	0.655997	1.000000					
	0.1688	0.2349	0.0000	-----					
ECARBON	0.160462	-0.099455	0.413602	0.208661	1.000000				
	0.0247	0.1655	0.0000	0.0033	-----				
ECROP	-0.267654	-0.126423	0.199159	0.509811	-0.066261	1.000000			
	0.0001	0.0774	0.0051	0.0000	0.3561	-----			
EFISH	-0.154364	-0.343578	-0.223625	0.018114	-0.339356	0.209158	1.000000		
	0.0308	0.0000	0.0016	0.8010	0.0000	0.0033	-----		
EFOREST	-0.067812	0.066110	0.741042	0.752806	0.209588	0.117599	0.009840	1.000000	
	0.3450	0.3572	0.0000	0.0000	0.0032	0.1007	0.8911	-----	
EGRAZING	0.062385	0.952782	0.585054	-0.016843	-0.045825	-0.246731	-0.427275	0.101132	1.000000
	0.3850	0.0000	0.0000	0.8147	0.5236	0.0005	0.0000	0.1584	-----

Table 14 Partial Correlation analysis in upper level

Sample: 2007 2016 isrich14=3 Partial Covariance Analysis: Ordinary Included observations: 254

Partial analysis controlling for: PERGDP UPR EDUNEW HEALTH VOICE STABILITY UNEMPLOY Date: 09/05/19 Time: 04:27

Correlation Probability	SWB	TBC	TEF	EBUILT	ECARBON	ECROP	EFISH	EFOREST	EGRAZING
SWB	1.000000								

TBC	0.148815	1.000000							
	0.0193	-----							
TEF	-0.002226	0.313301	1.000000						
	0.9722	0.0000	-----						
EBUILT	0.024555	0.375001	-0.033906	1.000000					
	0.7010	0.0000	0.5959	-----					
ECARBON	-0.149310	-0.281346	0.766010	-0.311811	1.000000				
	0.0189	0.0000	0.0000	0.0000	-----				
ECROP	-0.017075	0.295859	0.515731	0.153146	0.202332	1.000000			
	0.7895	0.0000	0.0000	0.0160	0.0014	-----			
EFISH	0.004146	-0.037948	0.187333	-0.370957	0.161590	-0.091105	1.000000		
	0.9483	0.5528	0.0031	0.0000	0.0110	0.1534	-----		
EFOREST	0.160357	0.592601	0.423113	0.290850	-0.053480	0.276005	-0.120775	1.000000	
	0.0116	0.0000	0.0000	0.0000	0.4027	0.0000	0.0580	-----	
EGRAZING	0.205427	0.741328	0.106531	0.319907	-0.384012	0.009392	-0.113190	0.209511	1.000000
	0.0012	0.0000	0.0948	0.0000	0.0000	0.8832	0.0758	0.0009	-----

Table 15 Partial Correlation analysis in the top level

Sample: 2007 2014 isrich14=4 Included observations: 338 Partial Covariance Analysis: Ordinary
Partial analysis controlling for: PERGDP UPR EDUNEW HEALTH VOICE STABILITY UNEMPLOY
Date: 09/05/19 Time: 04:32

Correlation Probability	SWB	TBC	TEF	EBUILT	ECARBON	ECROP	EFISH	EFOREST	EGRAZING
SWB	1.000000								

TBC	0.236457	1.000000							
	0.0000	-----							
TEF	-0.108380	0.142386	1.000000						
	0.0488	0.0095	-----						
EBUILT	0.183198	-0.258560	-0.072239	1.000000					
	0.0008	0.0000	0.1899	-----					
ECARBON	-0.140500	-0.006596	0.943555	-0.078991	1.000000				
	0.0105	0.9048	0.0000	0.1516	-----				
ECROP	0.231109	-0.033026	0.268658	0.240530	0.147281	1.000000			
	0.0000	0.5493	0.0000	0.0000	0.0073	-----			
EFISH	-0.106221	-0.034830	-0.277011	-0.194014	-0.359506	-0.027171	1.000000		
	0.0535	0.5277	0.0000	0.0004	0.0000	0.6223	-----		
EFOREST	-0.081761	0.508130	0.346170	-0.137595	0.099494	-0.050786	-0.187872	1.000000	
	0.1377	0.0000	0.0000	0.0122	0.0706	0.3570	0.0006	-----	
EGRAZING	0.233263	0.218608	0.211625	0.040348	0.087369	0.102213	-0.114988	0.085349	1.000000
	0.0000	0.0001	0.0001	0.4644	0.1126	0.0632	0.0365	0.1212	-----

Table 16 Comparison Ordinary Correlation and Partial Correlation

items		SWB-EF factors correlation		
		Ordinary	Partial	relationship
TEF	Coef.	0.7	0.003	No significant influence
	Prob.	0	0.9	
TBC	Coef.	0.3	0.15	Significantly positive influence
	Prob.	0	0	
ECARBON	Coef.	0.65	-0.04	No significant influence
	Prob.	0	0.14	
ECROP	Coef.	0.55	0.07	Significantly positive influence
	Prob.	0	0.04	
EFISH	Coef.	0.35	-0.08	Significantly negative influence
	Prob.	0	0.02	
EFOREST	Coef.	0.31	0.016	No significant influence
	Prob.	0	0.6	
EGRAZING	Coef.	0.26	0.16	Significantly positive influence
	Prob.	0	0	
EBUILT	Coef.	0.42	0.11	Significantly positive influence
	Prob.	0	0.001	

Discussion

1. What is the Partial Correlation (PC) between SWB and EF, compared ordinary correlation? Is there other problem in PC?

According to Table 5.4, PC allows us to see the real partial association between SWB and EF including:

(1) TEF is not significant related to SWB.

(2) TBC has significantly positive influences on SWB.

(3) ECARBON is not significant related to SWB.

(4) ECROP has significantly positive influences on SWB.

(5) EFISH has significantly negative influences on SWB.

(6) EFOREST is not significant related to SWB.

(7) EGRAZING has significantly positive influences on SWB.

(8) EBUILT has significantly positive influences on SWB.

Since coefficients in PC are small, we might purge the impact of multicollinearity between variables. Multicollinearity causes that variance of regression estimates is inflated just as Fig.5 expression (Rogerson, 2020).

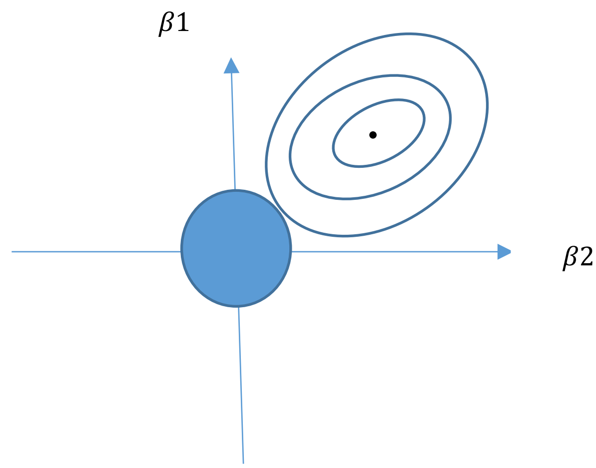

Fig.5 Multicollinearity expression in Geometry

2. Have EF related factors effects on SWB in terms of data from different level countries?

Yes! From poor countries to the most developed countries, the number of factors of EF are increased from 2 to 5. More factors of EF are involved, resources consumption got more, environmental pressures got aggravation, which generate higher possibility of impacts on SWB, but still less than impacts of control variables.

3. What is the relationship between carbon emission and SWB?

Carbon emission is negatively significant related to SWB in upper-level countries and top-level countries, looking at Table 14 and Table 15. Table 14 is the PC analysis for EF related factors impact on SWB with control variables in upper level. ECARBON's coefficient is -0.149, p value is 0.01, less than 0.05. Table 15 is the PC analysis for EF related factors impact on SWB with control variables in top level. ECARBON's coefficient is -0.141, p value is 0.01, less than 0.05. Negative effect of ECARBON is significant relevant to SWB, which matches current situation of developed countries. As matter of fact, ECARBON is the main part of EF, taking up over 70% of

TEF. It is evident that carbon emission is close to environmental quality degradation. Thus, reducing carbon emission is the good way to increase SWB. Low-carbon daily life also might be underlying, sustainable development trend in future.

4.Pursuing happiness is contradicted with environmental conservation?

In context of partial regression analysis, OLS regression analysis and stepwise regression analysis, we no doubt to see that SWB is more likely related to TBC wherever rich level, compared to TEF. In fact, TBC is the consequence of the area available for a given land use type multiplying the yield factor and equivalence factor. The yield factor is the ratio of national average to world average yields. The equivalence factor is to weight different land area in terms of their capacity to produce resources useful for human, based on the Global Agro-Ecological Zones model (GAEZ) (Ewing&, 2010). The GAEZ model divides all land globally into five types, such as very suitable, suitable, moderately suitable, marginally suitable, and not suitable (FAO and IIASA Global Agro-Ecological Zones 2000 FAO Resources STAT Statistical Database 2007). Since area value of one country is fixed, two factors are estimated to constants. TBC literally is inflexible in individual country in a period. This is coincident with previous statistical description of SWB. Compared to TBC, TEF is moveable, calculated human's consumption in different years, which involve impact of trade import and export, as well as population growth. Furthermore, TBC accounts for positive 0.158 of coefficient, just lower than GRAZING coefficient, higher than other EF factors, adding p value of TBC less than 0.05, significantly positive influences on SWB. That reflects two sides of an interaction process. SWB is human's perspectives for nature or surround their milieu. TBC is nature offering based on its capacity. An increase of SWB will bring an increase of TBC, might restricted by advanced technology and environmental conservation depth. Regarding the equation of EF, TBC increasing leads to ED reduction in context of fixed TEF. Those further indicate that the pursuit of SWB growth is not conflict with EF shrinking. The reason is that EF shrinking is to ED reduction or ER increase, not TEF reduction. In other words, TEF increasing is normal, but should be lower speeds of TBC. TEF expansion rests on TBC coordination. Thus, shrinking ED or environmental improvement benefits human pursuing happiness, looking at the Figure (Fig.6). With sufficient sampling size and strong statistical significance ($p<0.001$), the results of regression analysis have a clear correlation between EF and SWB in a long term.

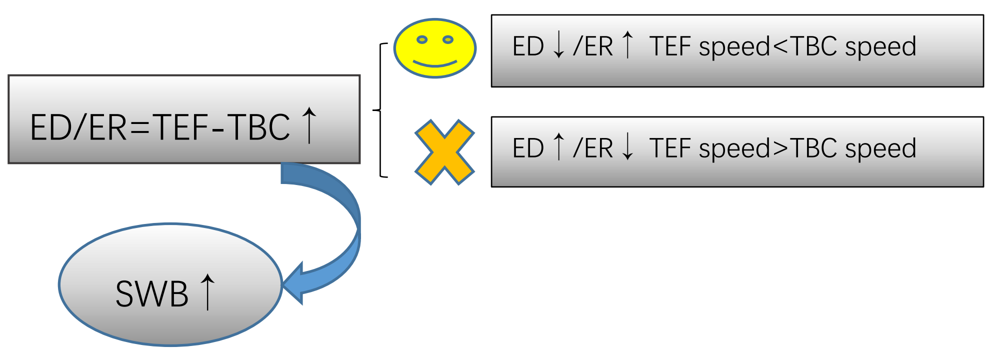

Fig.6 The figure of structure between SWB and EF

Conclusions

In PC, the conclusion of TBC having significantly positive influences on SWB leads to pursuing happiness is not conflict with environmental protection. ECROP, EGRAZING, and EBUILT has significantly positive influences on SWB, EFISH has significantly negative influences on SWB. The number of EF factors being significant to SWB are increased with rich levels of countries, generating higher possibility of impacts on SWB. In upper-level countries and top-level countries, carbon emission is negatively significant related to SWB, so low-carbon daily life is the good way to increase SWB.

VI. THREE REGRESSION ANALYSIS COMPARISON ABOUT ASSOCIATION BETWEEN SWB AND EF

In order to figure out association between SWB and EF related factors to substitute traditional SWB survey, through data observation, we firstly conducted unit root test to make sure variables to pass test, then built simple OLS regression model and detect T-test. Due to not pass T-test, we found out reasons of multicollinearity and endogeneity. Facing multicollinearity, we come up with stepwise regression, the results have biased R-square. Facing endogeneity, we put forward fixed effects panel regression model in cross-section and time-series respectively. Modeling framework is as follows (Fig.7).

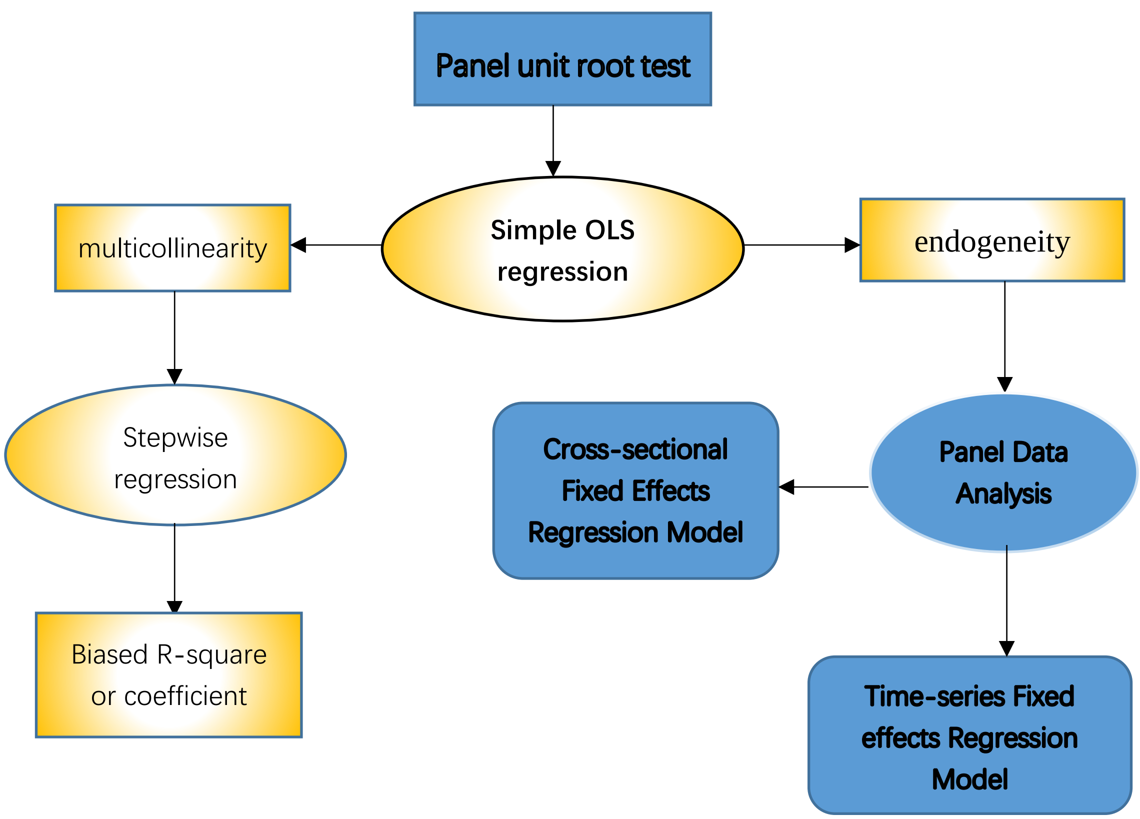

Fig.7 Modeling framework

Introduction

1. simple OLS

In regression analysis, Ordinary Least Squares (OLS) is a basically traditional method for estimating a linear regression between dependent variables and independent variables. In our research, OLS is like a first touchstone to examine whether there is a linear relationship between SWB and EF related factors.

2. Stepwise Regression (SR)

SR are tools that allow some (or all) of the variables to be chosen automatically with different statistical standards. In our research, we decided to use the unidirectional forward and backward SR. That means the model starts no variables, texting the inclusion of each variables with a chosen model-fit standard, adding the variable (if any) whose inclusion offers the most statistically significant meaning of the fit, and repeating this process until none of the rest variables adjust the model (Massimo, 2020)

3. Fixed Effects Panel Regression (FEPR)

Panel regression models can be measured with serial correlation or spatial dependence so that the model control for spatial-temporal dependence and heterogeneity in panels (Lee&, 2015). In our research, we put forward to the use of time differencing and spatial differencing transformations to handle space-time non-stationarity in estimation.

Methods

1. simple OLS

Simple OLS is the estimation of a linear relationship between two variables, Yi and Xi, of the form:

$Y_i = \alpha + \beta X_i + u_i$ i=1, 2,….n

Where Y_i denotes the i^th observation on the dependent variable Y which could be SWB, and Xi denotes the i^th observation on the independent variable X which could be EF related factors. These observations could be collected on countries at a given point in time, in which case we call the data a cross-section. Alternatively, these observations may be collected over for a specific country in which case we call the data a time-series. OLS assumptions involve the disturbances have zero mean and a constant variance, in addition to are not correlated. The explanatory variable X in OLS is nonstochastic.

2. Stepwise Regression (SR)

SR is an automatic variable selection procedure that selects from a couple of candidates the explanatory variables, which are the most related. We used the unidirectional forward methods. Forward selection begins with no variables in the model, examining each variable with a chosen model-fit criterion until none of the remaining variables improves the model to a statistically significant extent (Massimo, 2020).

3. Fixed Effects Panel Regression

In order to eliminate endogenous or exogenous problems, we tried to build panel data regression models. Panel data typically mean "data containing time series observations of a number of individuals" (Hsiao, 2007). They contain independently pooled panels, random effects models, and fixed effects models. Fixed effects models have two-dimensional data, referring to cross-sectional fixed effects models and longitudinal fixed effects models.

Panel data have many strengths over cross-sectional or time-series data, including: (1) more accurate model parameters; (2) more widely available in the international spectrum. (3) more intensive capacity for collecting the complication of human behavior than a single angle. (4) more simplified computation and statistical inference (Hsiao, 2007). (5) minimize the effects of aggregation bias, from aggregating firms into large scale. (6) better measure the impacts that can be detect in neither cross-section nor time-series data. (7) more reliable estimates and test more sophisticated behavioral models with less restrictive assumptions. (8) control for individual heterogeneity.

Results

1. simple OLS

We performed OLS to compare the linear impact of a set of dependent variables for SWB by the principle of least squares. OLS strength is minimizing the sum of the squares of the discrepancy between dependent variables and explanatory variables in context of control variables. Three simple OLS equations were established.

Model1(Table 17) described the liner relationship between SWB and the traditional control variables. The result is that all control variables is significant to SWB.

and the equation can pass the F-test and T-test.

Model 2 (Table 17) is the relationship between SWB and EF related variables without control variables, the results was found out that many variables of EF could not passed T-test.

Model 3(Table 17) is the relationship between SWB and EF related variables in the context of control variables, its results was the same as the second equation, shows that factors of EF could not passed T-test. Although T-test is failure, R-square value is increased from 0.57 to 0.77, demonstrated the model is more suitable than before. Coefficient values of dependent variables are reduced from around 50 to around 16 while coefficient value of control variables is unchanged. P-values of dependent variables is increased from round 0.5 to round 0.7.

However, two points are obtained above models. On one hand, control variables are not able to change the correlation between dependent variables and independent variables; on the other hand, independent variables including TBC, ECROP, EGRAZING, EFOREST, EFISH, EBUILT and ECARBON are positively related to dependent variable of SWB except for TEF (negative impacts).

Therefore, three simple OLS models are not what we want most without pass T-test. Considering two of simple OLS models could not passed T-test, two crucial problems we assumed might existed. On one hand, there was multicollinearity between explanatory variables due to the common tendency of most explanatory variables. Multicollinearity caused big standard errors in OLS models so as to make it hard to gauge the impact of independent variables on dependent variables. On the other hand, there was endogeneity or exogeneity existing, caused that there was a relationship between explanatory variables and the error term in the mode. Endogeneity always induces bias, which influence on models' accuracy.

As far as two possibility existing in OLS models, we could not estimate it very precisely so that we are supposed to attempt other regressions, i.e. stepwise regression and panel regression.

Table 17 Comparison of Five Models with Three Types Regression

Variables Parameters	Simple OLS			Stepwise Regression	Cross-sectional fixed effects Regression	Time-series fixed effects Regression
	Model1	Model 2	Model3	Model 4	Model 5	Model 6
TBC		0.051	0.022	0.023	-0.001	0.022
TEF		-49.81	-16.17	-0.026	0.048	-0.022
EBUILT		56.19	17.40	1.252	2.148	1.611
ECARBON		50.08	16.15			
ECROP		50.28	16.33	0.185		
EFISH		51.28	15.93	-0.217		
EFOREST		49.67	16.09	-0.055		
EGRAZING		50.17	16.35	0.204	0.231	0.212
HEALTH	0.036		0.039	0.039	0.011	
PERGDP	1.37		1.5	1.49	1.60	1.56
STABILITY	-0.003		-0.002	-0.002	0.002	-0.002
UNEMPLOY	-0.043		-0.04	-0.04	-0.041	-0.037
VOICE	0.006		0.005	0.005	-0.001	0.004
UBR	0.016		0.014	0.014	-0.01	0.014
EDUCATION	0.007		0.007	0.007	0.009	0.006
C	1.221	3.91	0.943	0.942	4.144	0.852
R2	0.759	0.575	0.771	0.77	0.922	0.77
N	965	965	965		965	965
F	430.9	161.779	213.04		91.22	154.47
Prob	0	0	0		0	0

2. Stepwise Regression

In order to eliminate impacts of multicollinearity, one of available ways is stepwise regressions we performed. Stepwise regression is a modified approach of the automatic selection, which leads to the situation that after a variable was added in each step, all candidate variables will be checked to see if their significance has been reduced under the specified tolerance level. If a nonsignificant variable is found, it is removed from the model.

The finding of Model 4 (Table 17) shows that the p value of variable BC, EBUILD and EGRAZING less than 0.05, which means they are significant to explain SWB and have positive effects on SWB; conversely, EFOREST, EFISH, and TEF coefficients are shown that they are not significant to explain SWB and have negative impacts on SWB; Only ECROP coefficient is 0.185, means not significant to explain SWB, but have positive impacts on SWB.

Two of main problems in stepwise regression which makes it unreliable specifically the problems with forward selection, backward elimination and bidirectional elimination are that either R-squared values were badly biased high, or the remaining coefficients were biased and need shrinkage. In our stepwise model, R-squared value was biased high (0.77), which should be shrink. Thus, stepwise regression is not what we want most.

3. Fixed Effects Panel Regression

In order to capture spatial-temporal heterogeneity of linkages between SWB and

EF, we analyzed fixed effects panel regression models in terms of longitude and cross-section respectively. After that, based on the model's analysis, we could figure out which one was more remarkable in association between SWB and EF.

By 965 observation records over a decade, we built the cross-section fixed effects panel regression of model 5 (Table 17), the result shows that the reliability of the model is increased due to R-squared value increased from 0.77 to 0.92. Simultaneously, it illustrates that stepwise regression model we did is meaningful.

In the same vein, Table 18 shows that impacts of cross-section differences in SWB are more remarkable than time series of Table 19. Reasons are the following:

(1) The effect degree of longitudinal fixed effects panel regression is in small range from -0.12 to 0.14, while the effect degree of cross-sectional fixed effects is in large range from -2.09 to 1.75.

(2) R-square values in the longitudinal model is less likely than that in the cross-sectional model (0.77versus 0.92).

(3) Spatial distribution impacts map of cross-section fixed effects model 5 is exhibited reasonably in different rich levels.

(4) Time-series fixed effects panel regression model 6 has low volatility value with different period of the same countries.

(5) Model 6 wasn't considered Health factor, compared to Model 5.

According to Spatial distribution impacts map of cross-section fixed effects Model (Fig8.), We can see on the map that impacts are divided into five categories with different color. Green color represents negatively high effects, the values range from -2.09 to -0.98, those countries are distributed in second-most populous continent. In these areas, most countries are mainly poor countries with poor health care such as Congo, Niger and Afghanistan. Tender green colors represent negatively low effects, the values are the range from -0.98 to -0.03, those countries are distributed in the most populous continent such as Asia. In these areas, most countries are mainly developing countries with fair health care such as China, India and Mali. Yellow color represents mediate effects. The values are the range from -0.03 to 0.73, those countries are distributed in Europe. In these areas, most countries belong to developed countries with good health care such as France, Germany and Italy. Red color represents highest positive effects. The values are the range from 0.73 to 1.75, those countries are in North America, Europe and South America. In these areas, most countries belong to the most developed countries with very good health care such as U.S, Denmark, and Sweden. Blue color represents no data.

Table 18 The effect value of divergent countries in the same period

COUNTRY	Effect	COUNTRY	Effect	COUNTRY	Effect
Afghanistan	-1.51088	Lebanon	-0.180311	Estonia	-0.090499
Albania	0.045380	Lithuania	0.277951	Ethiopia	-1.07871
Angola	-0.619248	Luxembourg	-0.271843	France	0.582562
Argentina	0.923528	Macedonia	0.584715	Germany	0.586486
Armenia	-0.436922	Madagascar	-1.670047	Ghana	-0.537327
Australia	0.910666	Malawi	-1.132996	Greece	0.429039
Austria	0.728967	Malaysia	0.355872	Haiti	-0.665673
Azerbaijan	-0.466232	Mali	-1.145177	India	-0.711663
Bahrain	0.101220	Mexico	1.530931	Indonesia	-0.036024
Bangladesh	-0.689438	Montenegro	0.389134	Israel	1.725349
Belarus	0.304442	Myanmar	-1.222246	Italy	0.403465
Belgium	0.894801	Nepal	-1.098227	Japan	-0.033037
Benin	-1.783677	Netherlands	1.272200	Jordan	0.616101
Bhutan	-0.976775	Nicaragua	0.173986	Kazakhstan	0.313510
Bolivia	-0.13884	Niger	-1.55483	Kenya	-0.823037
Bosnia and Herzegovina	0.545076	Norway	0.579930	Kuwait	0.156473
Botswana	-0.672194	Pakistan	-0.125697	Latvia	-0.059265
Brazil	1.248360	Panama	1.219165	Sri Lanka	-1.253539
Burkina Faso	-1.374199	Paraguay	-0.284495	Sweden	1.014358
Burundi	-1.96029	Peru	0.103869	Switzerland	0.853278
Cameroon	-0.74744	Philippines	-0.295956	Tanzania	-1.802745
Canada	1.242624	Poland	0.393796	Thailand	0.532577
Chad	-1.650706	Portugal	-0.187612	Togo	-2.091407
Chile	0.925958	Romania	-0.198973	Tunisia	0.163915
China	-0.600853	Russia	0.320365	Turkey	0.259620
Colombia	1.101339	Rwanda	-1.840178	Uganda	-1.173354
Congo	-1.143827	S Korea	0.210454	United Arab Emirates	0.931038
Costa Rica	1.749141	Saudi Arabia	1.125122	United Kingdom	0.786135
Croatia	0.286016	Serbia	0.236301	United States	1.037721
Czech Republic	0.602562	Sierra Leone	-1.002086	Uzbekistan	0.314745
Denmark	1.048223	Singapore	0.544174	Venezuela	1.414359
Dominican Republic	-0.100939	Slovenia	0.218718	Vietnam	-0.472808
El Salvador	0.613418	Spain	1.408133	Yemen	-0.835204
		Zimbabwe	-1.095074	Zambia	-0.341393

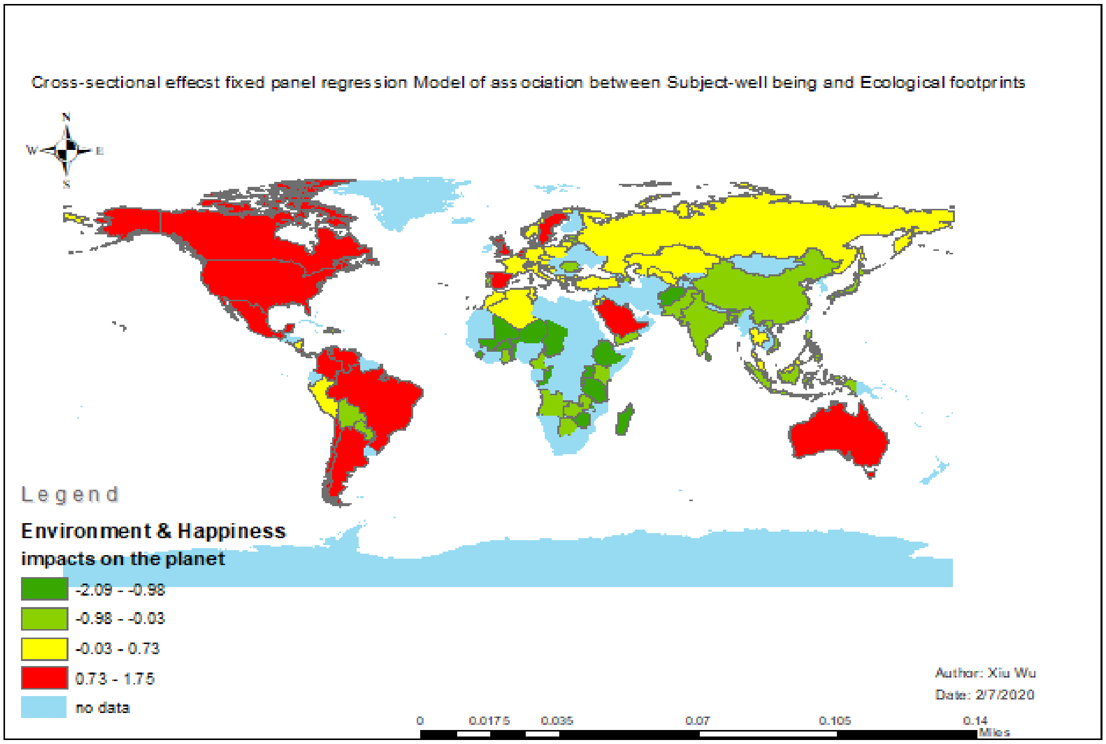

Fig.8 Cross-sectional Fixed Effects Panel Regression Model Map

Table 19 Time series fixed effects value of with the same countries

Time	Effect
2006-01-01	-0.074002
2007-01-01	0.137514
2008-01-01	0.003006
2009-01-01	0.079477
2010-01-01	0.085703
2011-01-01	0.099512
2012-01-01	0.013835
2013-01-01	-0.009075
2014-01-01	-0.080115
2015-01-01	-0.099625
2016-01-01	-0.122509

Table 20 Cross-section fixed effects panel regression model

Dependent Variable: SWB
Method: Panel EGLS (Cross-section weights)
Date: 09/10/19 Time: 21:33
Sample: 2006 2016 IF FLAG1=1
Periods included: 11
Cross-sections included: 101
Total panel (unbalanced) observations: 965
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TBC	-0.032131	0.033433	-0.961042	0.3368
TEF	0.059125	0.021677	2.727521	0.0065
EBUILT	1.072607	0.826403	1.297923	0.1947
EGRAZING	0.083497	0.121051	0.689768	0.4905
VOICE	-0.001739	0.001819	-0.955970	0.3394
UPR	-0.004341	0.008171	-0.531263	0.5954
UNEMPLOY	-0.044785	0.005499	-8.144363	0.0000
STABILITY	0.001496	0.001118	1.338161	0.1812
PERGDP	6.31E-06	7.39E-06	0.854006	0.3933
EDUNEW	0.003451	0.009830	0.351046	0.7256
HEALTH	0.022598	0.010068	2.244603	0.0250
C	3.867909	0.859549	4.499930	0.0000

Effects Specification

Cross-section fixed (dummy variables)

Weighted Statistics

R-squared	0.964015	Mean dependent var	7.787289
Adjusted R-squared	0.959332	S.D. dependent var	4.854981
S.E. of regression	0.337928	Sum squared resid	97.40874
F-statistic	205.8665	Durbin-Watson stat	1.621291
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.921740	Mean dependent var	5.498159
Sum squared resid	99.34218	Durbin-Watson stat	1.431227

Table 21 The result of time series fixed effects panel regression model

Dependent Variable: SWB
Method: Panel Least Squares
Date: 09/19/19 Time: 03:08
Sample: 2006 2016 IF FLAG1=1
Periods included: 11
Cross-sections included: 101
Total panel (unbalanced) observations: 965

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TBC	0.022203	0.007150	3.105222	0.0020
TEF	-0.022559	0.015398	-1.465064	0.1432
EBUILT	1.610775	0.501275	3.213356	0.0014
EGRAZING	0.212209	0.086861	2.443085	0.0147
VOICE	0.003888	0.001092	3.559349	0.0004
UPR	0.014282	0.001387	10.29617	0.0000
UNEMPLOY	-0.037247	0.003764	-9.896914	0.0000
STABILITY	-0.002375	0.001067	-2.225021	0.0263
PERGDP	1.56E-05	1.98E-06	7.882508	0.0000
EDUNEW	0.006114	0.001621	3.771844	0.0002
HEALTH	0.042731	0.004508	9.479099	0.0000
C	0.851933	0.223650	3.809222	0.0001

Effects Specification

Period fixed (dummy variables)

R-squared	0.774774	Mean dependent var	5.498159
Adjusted R-squared	0.769758	S.D. dependent var	1.147516
S.E. of regression	0.550619	Akaike info criterion	1.666985
Sum squared resid	285.8994	Schwarz criterion	1.778059
Log likelihood	-782.3202	Hannan-Quinn criter.	1.709274
F-statistic	154.4714	Durbin-Watson stat	0.487185
Prob(F-statistic)	0.000000		

Fig.9 shows the time trends of SWB for four models between two countries such as U.S and China. U.S represented developed countries; China represented developing countries. Four predictors from Model 3 to Model 6 show difference of SWB between U.S and China. SWB of U.S for four models is almost flat, keeping stable, whereas SWB of China for four models are upward trends from 2006 to 2016. Model 3 (OLS) and Model 4 (SR) are predicted linear increased trends. Model 5 (CSFR) and Model 6 (TSFR) are predicted exponential increased trends.

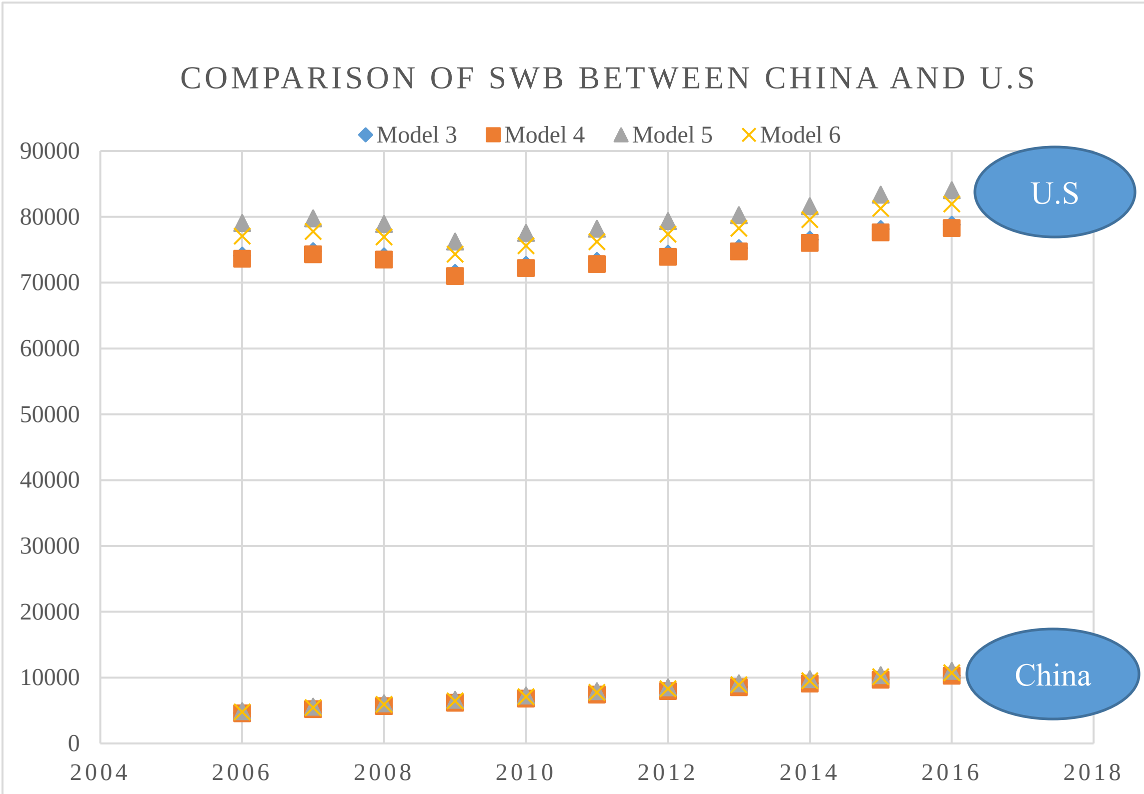

Fig.9 Comparison SWB Disparities Between U.S and China

Discussion

1 which model is more available in fixed effects panel regression Models?

According to fixed effects panel regression analysis, the results seem to show that the cross-sectional model is more remarkable than the time-series model. However, in fact, the time-series model is more available than the cross-sectional model in association between SWB and EF related factors. We can the following analysis to support this opinion.

First, R-squared values couldn't determine whether the model is good or not. R-squared (R^2) is a statistical measure of model-fit that indicates how much variation of a dependent variable is explained by the independent variable(s) in a regression model.

Indeed, high R-squared not means good models. In other words, R-square could neither convey the reliability of the model, nor whether we have chosen the right regression. R-square is not a unique standard to examine the reliability of the model. A good model might have a low R-squared, a poorly fitted model might have a high R-square, and vice versa.

Second, effects values' range couldn't determine whether the model is good or not. In the context of the fixed effect models, effects values are constants, which are less important than variables, just like residuals. They just influence on model's movements but could not change tendency or directions of models. Hence, effects value is not a key point when we estimate good models or bad models.

Third, correlation coefficients are not reliable in cross-sectional fixed effects panel regression model. Gehlke and Biehl (1934) argued that correlation coefficients go up with the level of geographic aggregation by census data. In 1950, Robinson found out that the correlation between race and illiteracy increased with the level of geographic aggregation. In other words, what is significant at one spatial scale may cause not significant at another. The reason is heteroscedasticity, which is common in spatial regression analysis. Accordingly, correlation coefficients in cross-sectional fixed effects panel regression model are not available in our research.

Last but most importantly, time-series fixed effects panel regression model supported PC analysis, i.e. SWB is significantly positive related to TBC. In cross-sectional fixed effects panel regression model (Table 20), SWB has not significant impacts on TBC due to p-value (0.337) beyond 0.05, but SWB has significantly positive impacts on TEF in that coefficient is 0.059 and p-value (0.006) is less than 0.05. On contrary, in time-series fixed effects panel regression model, SWB is significantly positive related to TBC for the reason that coefficient is 0.022 and p-value is 0.002, but not significant related to TEF, since coefficient is -0.023 and p-value is 0.143. Hence, it is evident that time-series fixed effects panel regression model reveals as the same result as previous PC analysis.

To sum up, time-series fixed effects panel regression model is more available than cross-sectional fixed effects panel regression model to explore association between SWB and EF related factors.

2 Is it possible that fixed effects panel regression models are alternatives of SWB survey method?

Fixed effects panel regression models we built have some strengths in SWB assessment: (1) considered contribution of control variables, which highly related to SWB; (2) blended EF related Factors; (3) compared SWB in global area; (4) provide a reference in the same economic development level of countries; (5) saved investigation time, labors and budgets; (6) offered dynamic monitoring process. Their weaknesses focus on ignoring micro-compatibility and taking no political intervention, emergencies (wars) and unpredicted natural disasters seriously. We found out that either EBUILD or EGRAZING are significantly positive contribute to SWB, regardless of the cross-sectional model and time-series model. Cross-sectional fixed effects panel regression models were built on diversity between countries, including 101 equations. Time-series fixed effects panel regression models were built on diversity of time, including 10 equations. Due to time span not enough long, the models might be limited in application.

All in all, it is possible that fixed effects panel regression models are alternatives of SWB survey method.

3. Does environmental improvement help to shrink SWB gap between developing countries and developed countries?

Fig.8 shows the big disparity of SWB between developed countries and developing countries. EF has statistically insignificant impact on the SWB gap, but economic and demographic structure, and GDP per capita growth contribute to the underlying SWB growth. Therefore, environmental improvement is not a determinant of SWB development. However, they have correlations for two reasons.

On one hand, EF per capital is related to individual SWB improvement. For example, we chose 12 countries to represent debtor countries and creditor countries, respectively. In the ranking table of between total EF and EF per capital (Table 22), EF per capital in developed countries is more than that of developing countries. Resources consumption per person is highly related to the degree of own property. It seems that the more EF, the more consumed resources, the more enjoyable feeling. The increasing of population is the main reason of environmental degradation in developing countries, which leads to the low EF per capital produced low feeling of happiness. In other words, EF per capital might indirectly generate causality with SWB. The consequence might possible that individual about environmental improvement benefits individual happiness, instead, SWB of each country is restricted by multiple factors such as economic and demographic structure, and GDP per capita growth.

On the other hand, even though TEF having not causality with SWB in terms of statistics, in correlation analysis, EF is invert u-shaped link to SWB using Weka correlation analysis (Fig.10). That is accord with a Kuznets curve, which means environmental improvement has increased from the beginning of SWB growth to a turning point. After that, the SWB development benefits environmental degradation with excessive carbon emission, taking up over 60% of TEF. As far as environmental quality increasing, the low-carbon circular economy model might be underlying, sustainable development trend in future.

As a result, environmental improvement is not able to help shrink SWB gap between developing countries and developed countries.

Table 22 The Ranking table of Between TEF and EF per capital

Country	debtor countries hierarchy			Creditor countries hierarchy		
	total EF	EF per capital	SWB (2017)	total EF	EF per capital	SWB (2017)
China	1	65	90			
USA	2	6	19			
India	3	162	133			
Japan	4	43	56			
Germany	5	38	15			
U.K.	7	42	14			
Afghanistan	71	Opposite	Opposite			
Brazil		5th	1	1	86	33
Canada				2	7	7
Russia				3	32	73
Australia				4	11	12
Congo Demo				5	183	97

Fig.10 Correlation Between EF and SWB

Conclusions

Fixed effects panel regression models are alternatives of SWB survey method. Time-series fixed effects panel regression model is the most available among three types regression models to explore association between SWB and EF related factors. EF does not have causality with SWB, instead, have a correlation of invert u-shape of SWB, which is relatively correspond to environmental Kuznets curve (EKC).

VII. CONCLUSIONS

Summary

The harmonious development between SWB and the environment system is dynamic, instead of a static process. International disparity in SWB are an important issue of high interest. The existing literature has discussed this intensively from psychology perspectives. As economic and demographic factors, including incomes, health and so on, have been found to be of limited explanatory power for international disparity in SWB, environment is regarded as a possible factor that accounts for the disparity in the mean level of SWB. This paper takes advantages to EF indices and SWB of the Gallup World Poll to investigate the association between SWB and EF. Our main purpose is to compare the explanatory power of EF variables relative to traditional factors, and the relative importance of EF related factors in explaining the divergence in SWB between countries.

Our empirical results show that increase of SWB is associated with change of rich level, not with time increase. In PC, the conclusion of TBC having significantly positive influences on SWB leads to pursuing happiness is not conflict with environmental protection. ECROP, EGRAZING, and EBUILT has significantly positive influences on SWB, EFISH has significantly negative influences on SWB. The number of EF factors being significant to SWB are increased with rich levels of countries, generating higher possibility of impacts on SWB. In upper-level countries and top-level countries, carbon emission is negatively significant related to SWB, so low-carbon daily life is the good way to increase SWB. In three regression comparison, fixed effects panel regression models are alternatives of SWB survey method. Time-series fixed effects panel regression model is the most available among three types regression models. EF is invert u-shaped link to SWB, which is satisfied EKC hypothesis.

We argue that within the continuous improvement of the human development index and the popularity of the concept of ecological protection, the low-carbon circular economy model will be underlying, sustainable development trend to mitigate environment pressure and improve happiness satisfaction from being enforced by the government to people's subjective consciousness. Panel data analysis provides an effective way to study this problem.

Limitation and Recommendation

Despite all our efforts to establish a quantified model to measure SWB on environmental influence, we have to say this work still has some problems to be developed. The model presents different ways without flexible equations and coefficients lead to the model has more potential requirements to be improved in future. EF concept himself should offer detailed components in terms of structures. For example, carbon footprint takes up beyond 70% of total footprints, which disguise influence of other footprints, especially built-up land sprawls due to global urbanization overwhelming. EF on global network does not include water footprints. With scarcity of fresh water, water requirement and consumption are a part of EF. We are supposed to pay attention to add it on global footprints network. What’s more, identification of both equivalence factors and yield factors need more consideration of geographic disparity. This is not only because different geologic structure has impacts on EF change, but it also because aggregation of population and industrialization caused environmental change. In addition, government policies contribute to SWB on environmental influence. When a new leader of a country comes out, there are so many policies would be changed, intangibly lead to SWB decline. All these we did not notice in this work should be taken more seriously later on.

APPENDIX SECTION

Individuals rich level depends on GDP per capital standard from World Bank GNI per capita Operational Guidelines & Analytical Classifications. The first period of 2006-2010, 2009 GDP per capital was viewed as classified standard, accounting for $995 as low level, $3945 as middle level, and $12195 as upper level. The second period of 2011-2016, 2014 GDP per capital was considered as classified standard, accounting for $1045 as low level, $4125 as middle level, and $12735 as upper level. The following code that we used to identify rich level of individuals is edited by Foxpro.

```
DO WHILE !EOF()

if   period="2006-2010"
     IF PERGDP<= 995
        repl   isrich with 1
        repl   richlevel with "1 Lower"
     ELSE
         IF PERGDP<= 3945

             repl   isrich with 2
               repl   richlevel with "2 L Middle"
         ELSE
             if   PERGDP<= 12195
                  repl   isrich with 3
                    repl   richlevel with "3 U Middle"
             else
                repl   isrich with 4
                  repl   richlevel with "4 High"
             endif

         endif

     ENDIF
```

```
endif

if period ="2011-2016"
       IF PERGDP<= 1045
           repl    isrich with 1
               repl    richlevel with "1 Lower"
       ELSE
             IF PERGDP<= 4125

                   repl    isrich with 2
                         repl    richlevel with "2 L Middle"
             ELSE
                   if    PERGDP<= 12735
                         repl    isrich with 3
                           repl    richlevel with "3 U Middle"
                   else
                       repl    isrich with 4
                       repl    richlevel with "4 High"
                   endif

             endif

       ENDIF
endif

skip
enddo
```

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