Green GDP and Openness:
Evidence from Chinese Provincial Comparable Green GDP

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Abstract:

The openness debate is one of the long recurrent topics in modern economics. Economists generally tend to be divided into two sides, one side argues openness to international trade has a positive effect on economic growth; and the other side disagrees with this. What adds fuel to the flames is, although strong supports can be found from modern economic growth models, results from profusion empirical work are ambiguous. The argument focus on rapid economic integration due to the greater globalisation has two different impacts: on one side, it increases productivity and contributes to economic growth; but on the other side, it worsens the environmental conditions and leads a serious environmental degradation problem. Economic prosperities are developing under the traditional GDP or GNP measurement; however, the real human welfare cannot be ascertained as really increasing, when taking the negative externalities into account. This paper tests the effect of openness to international trade at Chinese provincial level, by applying Comparable Green GDP data from 31 provinces and regions to a variant of Solow growth model. The main finding is: there seems exists a non-linear relationship between green GDP and openness, measured both by volume of trade and foreign directly investment (FDI), at provincial level. Intuitively, openness has an inverted U shape effect: it increases sustainable development at the beginning and decreases sustainable development after a threshold point. This result coincides with the finding by Talberth and Bohara (2006) at national level.

1. INTRODUCTION

According to the concept of sustainable development, Gross Domestic Product (GDP) appears to be a bad measurement. Economists attempt to build up alternatively better systems to measure true welfare and sustainable development. Green GDP often refers to some welfare and environmental indices, such as Comparable Green GDP (CGGDP), Index of Sustainable Economics Welfare (ISEW) and Genuine Progress Indicator (GPI); and has been used as a new indicator in research on economic openness.

Larger trade is often associated with greater economic growth and development, making it a regular theme on the agenda of governments. Although there appears some evidence to the contrary (see for example, Rodriguez and Rodrik, 2000), this chase for export-led development appears to be a general consensus that greater development leads to greater economic well being and improvement. However, a recent paper by Jones (2009) suggests instead, that higher growth is also associated with greater costs which are instead, detrimental to welfare. This is a rather contrasting finding to what is commonly believed, and also timely especially with the present focus on climate change and sustainable development.

1.1 Trade and the Environment

Chichilnisky (1998) discusses the products traded and resulting environmental problems associated with different regions. Countries which export natural resources, such as Latin America, may often experience severe environmental degradation as a result of deforestation, mining and other related activities, resulting in the loss of biodiversity. Yet, as it is difficult to measure such costs, suggesting that the prices at which such exports are traded is lower than the social costs they incur. Conversely however, knowledge-based production goods such as those by the Asian economies appear to alleviate this issue as they move firms towards lower resource usage, implying lower levels of environmental damage, or maybe even beneficial to the environment. This makes the environmental impact of trade somewhat ambiguous.

However, the enthusiasm for greater trade flows in pursuit of economic growth makes understanding the environmental impact of trade on especially relevant. From a theoretical view, Tsai (1999) used a partial equilibrium model to investigate the effect of trade liberalisation on the environment and finds that trade unambiguously improves environmental quality. Empirically, Frankel and Rose (2005) appear to lend support to this finding. They estimate the impact trade has on the level of emissions such as carbon dioxide, sulphur dioxide, and nitrogen oxides and conclude that countries need not necessarily give more emissions as a result. In turn, this implies that countries do not necessarily 'specialise in dirtier environments' as a result of opening to trade.

However, Talberth and Bohara (2006) use an alternative measure of GDP which is corrected for environmental costs and find that when countries have greater economic openness, i.e. more trade, welfare falls as a result of greater costs due to the reduction in environmental quality. This leaves the question to whether more trade actually improves or lowers welfare open for contention.

1.2 Aim and Layout

The main aim of this paper is to investigate empirically to see if trade has any impact when economic wellbeing is measured in alternative forms. It follows the methodology of Talberth and Bohara (2006) to test the effect of trade openness on the environmentally corrected GDP values at Chinese provincial level, or what is termed as 'Comparable Green GDP'.

The layout of the rest of the paper is as follows. The next section first looks at the original roots of Green GDP from the concept of sustainable development. Some of the shortcomings of GDP as a welfare measure are also covered here. Section 3 gives a brief overview of alternative forms of measurement and reviews one, Comparable Green GDP, in detail, from which Green GDP is calculated. We present our empirical results in Section 4. Section 5 concludes with some directions of future work.

2. SUSTAINABLE DEVELOPMENT AND MEASURING WELFARE

2.1 The Concept of Sustainable Development

> *"Development which meets the needs of the present without compromising the ability of future generations to meet their own needs"*
>
> *- Brundtland Commission (1987)*

This was the original definition released by the United Nations in 1987, from which the concept of `sustainable development' can be place in 3 constituent parts: Economic sustainability, Social sustainability and Environmental sustainability.

The requirement for sustainable development is for economic growth and development to be sustainable in all three aspects: economy, society and environment. Furthermore, their interactions have to be bearable, equitable and viable for all the players. This means that environmental development be viable for the economy, that environmental degradation be bearable by the society, and that, at the same time, economic development should be equitable to society. (Appendix Table 1)

Thus, a good measurement of sustainability should include all economic activities, social effects, environmental impacts and the interrelations between them.

2.2 Limitations of GDP as a Measure

Gross Domestic Product (GDP) by the expenditure approach for example, computes the sum total of income received by all producers in the country. This generally takes the form:

$$GDP = C + I + G + (X - M)$$

Where, C denotes personal consumption, I is gross investment, G represents government expenditure, X is export, M is import, and (X-M) is the net export.

What this calculation measures is the total value of goods and services that are circulated within the country. While GDP is commonly taken as a measure of a country's economic performance, it is also well known to suffer from some deficiencies. Both England (1998) and Lawn (2003) provide a review of the shortcomings, which in summary, can be described as follows. It does not take into account non-valued aspects such as income distribution, non-market activities such as housework and parenting, various social activities like crime, unemployment, and environmental issues of pollution, resource depletion and abatement expenditure.

Thus, what GDP does is tally the overall level of consumption (or income, or production depending on the method used to calculate), instead of actually accounting for national welfare.

3. ALTERNATIVE MEASURES

Inadequacies of GDP in measuring welfare and sustainable development stimulate economists seeking alternative indicators in recent few decades. Nordhaus and Tobin’s (1972) ‘Measure of Economics Welfare’ (MEW) is one of the earliest attempts to evaluate economic growth through incorporating leisure and housework into the national accounting system. Daly and Cobb (1989) also criticised GDP and GNP, and they proposed to substitute in the concept of Hicksian income as a measure of sustainability. To do so, a flow account: ‘the Index of Sustainable Economic Welfare’ (ISEW) was been introduced in the book: *For the common Good*, Daly and Cobb (1989), which further developed and revised in Greening the National Product, by Cobb and Cobb (1994).

The ISEW includes items on unaccounted economic activities, social cost and benefices, as well as environmental value. The Genuine Progress Indicator (GPI) is a more recent derivation of the ISEW mainly introduced and applied by Clive Hamilton (1997, 1999, and 2000) and John Talberth (2006) in Australia and US, this measurement takes more items into account than conventional ISEW. In 1993, the United Nations published a satellite system to the System of National Accounts (SNA): ‘Integrated Environmental and Economic Accounting’ (SEEA), further a latest version SEEA 2003. SEEA has the most of the concerns on resource depletion and environmental degradation related to sustainable development.

Following the methodology of welfare measurements and social indices above, Comparable Green GDP (Liu and Guo, 2005) corrects traditional System of National Accounts (SNA) by reflecting natural resources and the environmental losses to Gross Domestic Product (GDP) account. It highlights the contributions of environment to the economic growth, and indicating quality of growth under concept of sustainable development.

3.1 Comparable Green GDP (CGGDP)

Liu and Guo (2005) focus on the environmental aspect of sustainability development; and state those challenges impeding Green GDP computation are commonly: lack of wide acceptance in environmental accounting, unavailability of comprehensive survey in total natural resource stock, and difficulties in natural resource valuation. Because of those challenges, in stead of directly tackling those problems, Liu and Guo develop a method that approaching the real Green GDP, which they name it Comparable Green GDP. Comparable Green GDP, in essence, calculates an approximate green GDP figure from a uniform formulation by fixing accounting components and prices; the figures worked out reflect sustainability differences among regions over time and therefore allow for comparison.

Green GDP described in Liu and Guo (2005) as:

Green GDP = GDP – Depletion of Natural Resources – Costs of Pollution

For the calculation of Comparable Green GDP few hypotheses are made for the simplification, including (1) no production depreciation, (2) invariable monetary values and costs, which means the monetary value is relatively constant to price index, (3) natural resources only refer to coal gas, natural gas and petroleum gas, (4) environmental loss only includes pollutions of air, water and solid wastes, (5) pollutions are only from industries and residents in the city.

To simplify the calculation, some hypotheses are given as following:

(1) Production depreciation is not considered due to lack of relevant data;

(2) The money values and costs are supposed to be invariable from 1998 to 2003, for the price index during that period was relatively constant;

(3) Natural resources depletion simply includes the consumption of coal gas, natural gas and petroleum gas. Other resources are not included due to the lack of data;

(4) Environmental loss simply includes the loss of pollution accidents and the cost of waste treatment for water, air and solid wastes;

(5) The amounts of water, air and solid wastes only include the parts produced by industries and residents in the city.

Table 3.1.1: Monetary value of natural resources

Item	*Price per unit (RMB)*	*Unit*
Coal gas	*1.79*	m^3
Natural gas	*2.31*	m^3

Petroleum gas	*2.88*	*kg*
Waste water treatment	*0.63*	*Ton*
Atmosphere treatment	*0.000221*	m^3
Solid waste treatment	*76*	*ton*

Source from Liu and Guo(2005).

Advantages of Comparable Green GDP are: compare to other indexes, Comparable Green GDP is practically easier to calculate; because of that, it is also easy to apply to other countries or regions; practicality and applicability, discussed above, make Comparable Green GDP can be also used as a sustainable development indicator for government policies.

However, the fixed components and prices of natural resources and pollutions lead Comparable Green GDP, at most, an approximation of real Green GDP.

4. EMPIRICAL RESULTS

4.1 Previous Work

John Talberth and Alok K. Bohara (2006) analysed the relationship between economic openness and green GDP by developing a green GDP growth model. In their paper, Green GDP calculated by ISEW and GPI indices had been used to replace traditional GDP as the total real output in a variant Solow growth model. A panel pooled regression had been run for 8 countries data spanning 30-50 years, including: ISEW from Austria, Brazil, Italy, Netherland, Sweden, and the United Kingdom, and GPI from Australia and the United States. All green GDP figures were first converted to constant 2004 US dollars using exchange rates published by Penn World Tables 6.2 and consumer price indices from Federal Reserve Bank of Minneapolis. Gross fixed capital formation ratio to GDP (GFCF) and age dependency ratio (ADR) taken from World Development Indicators report (TWBG, 2004), had been used to representing capital and labour separately. The measure of openness (OPEN) is unlike the ratio of the value of trade (value of imports + value of exports) to GDP commonly used in literature, Talberth and Bohara chose Green GDP rather than GDP as the denominator; therefore their openness should be named ‘green openness’. The original openness data were from Penn World Table 6.2; and the ‘green openness’ data were computed from that. From the empirical study, Talberth and Bohara found strong and robust results suggesting a negative nonlinear correlation between openness and green GDP growth.

4.2 Theoretical Foundations

Talberth and Bohara (2006) hypothesise green GDP at any point in time can be explained by a variant Solow function with influencing from main factors: capital, labour and economic openness. In the general notation:

$$GDP_{grn_t} = f(K_t, L_t, O_t)$$

Where, GDPgrn is per capita green GDP at time t as measured by the ISEW, GPI or other alternative accounting systems; K is a measure of a nation's capital stock at time t; L is a measure of labour input at time t; and O is an index of economic openness at time t.

Following Mankiw et al (1992), they use a Cobb-Douglas type aggregate production function with constant returns to scale:

$$GDP_{grn_t} = \delta_0 K_t^{\alpha} O_t^{\beta} L_t^{1-\alpha-\beta} e^{ut}$$

In this function, δ_0 denotes the level of technology; e^{u_t} represents influences from all other factors apart from capital, labour and openness; and the constant return to scale are shown by that the sum of exponents of K, O, L is equal to 1.

This can also be present in log-linear form, in which all log notations are dropped for convenience as:

$$GDPgrn_t = \delta + \alpha K_t + \beta O_t + (1-\alpha-\beta)L_t + u_t$$

This linear form can be used a level model equation for regression.

In time series data, a presence of unit root may lead to spurious regressions, but converting the level model to a growth form model can restore the stationary. The growth rate form model is as following:

$$GGDPgrn_t = \delta + \alpha GK_t + \beta GO_t + (1-\alpha-\beta)GL_t + u_t$$

Where the prefix 'G' denotes the growth rate between years t-1 and t.

This growth rate model shows that the growth rate of green GDP is influenced the growth rate of technology, growth rate of capital, growth rate of labour, growth rate of openness and total effect of other factors.

In Talberth and Bohara (2006)'s empirical model, ISEW and GPI figures were used as green GDP, times series data of gross fixed capital formation ratio and age dependency ratio represented capital (K) and labour (L) respectively, 'green openness' used instead of traditional openness in the specific form. So the regression equation is as following:

$$GGDP_{grn_t} = \alpha_0 + \alpha_1 DGFCF_{pct_t} + \alpha_2 DOPEN_t + \alpha_3 DADR_t + u_t$$

Where, GGDPgrn is the growth rate of per capita green GDP calculated by taking first difference of logged green per capita GDP values from |ISEW and GPI in subsequent time periods; DGFCFpct is the first difference in the ratio of gross fixed capital formation to GDP; DOPEN is the first difference in the ratio of trade value to green GDP; DADR is the first difference in the age dependency ratio and u is the disturbance term.

After plotting 8 countries green GDP per capita against the openness index, Talberth and Bohara (2006) argued that there seems a non-linear relationship between green GDP and openness, so they modified the empirical model with a squared openness term as:

$$GGDP_{grn_t} = \alpha_0 + \alpha_1 DGFCF_{pct_t} + \alpha_2 DOPEN_t + \alpha_3 DOPEN_t^2 + \alpha_4 DADR_t + u_t$$

They also made the hypothesis of the directions of effects: positive for the capital (GFCGpct): an increase in capital growth rate raises green GDP growth rate; and negative for the age dependency ratio, since age dependency ratio is defined as the non-working age (<15 and >64) population divided by working age population: that is a rise in growth rate age dependency ratio leads labour forces fall short, and reduces the growth rate of green GDP.

4.3 Data

In the Chinese provincial level dataset, the Green GDP data are Comparable Green GDP (CGGDP) figures from 31 provinces and regions across China, including 4 directly governed cities: Beijing, Shanghai, Tianjin and Chongqing. The time spans year 1998 to 2003. The Environmental costs are the sum of nature resource depletions and pollution costs in the Comparable Green GDP (CGGDP). In China's provincial level case (see Appendix Table 2), geographic distribution of environmental costs to GDP ratio is denoted by different colours, the darker the colour is the larger the environmental costs to GDP ratio. The red colour represents the environmental costs to GDP ratio is between 3% and 4%; pink indicates 2% to 3% ratio; yellow means 2% to 1%; and the cyan colour means less than 1% environmental costs to GDP ratio. From this colour geographic distribution, generally speaking, the East China has comparatively lower rate of environmental costs to GDP; and as moving to the west, this ratio continues to increase. This is to say, the environmental costs ratio goes up along the way from the East to the West of China.

If divide the whole China into three planning regions: East, Mid and West as Chinese government announcing, the ratios of these three planning regions and an average ratio across the year 1998 to 2003 can be shown as line graph in Appendix Table 3. The dark blue line denotes the average environmental costs to GDP rates; the cyan line represents the Mid China; the yellow line indicates the East; and the pink line shows the situation of the West China in the 6 years. Generally, environmental costs to GDP ratios represented by four lines are all exhibiting a decreasing trend in the 6 years, with overall ratio reduces from about 2.70% in 1998 to 1.80% in 2003. Comparably, the ratios for the East China are about 1% lower than the

West China, on average, but the differences between regions are shrinking from the year 1998 to 2003.

Capital (K) is represented by Gross Capital Formation ratio; working age ratio (labour force divided by total population) is used as a proxy of labour (L). Openness levels are measured in two ways: the volume of trade (import + export) to GDP ratio and FDI to GDP ratio. All those data are sourced from China Year Book by National Bureau of Statistics of China (NBSC). CGGDP is firstly turned into per capita term in order to indicating personal wellbeing, and then also converted to constant price at base year 2000.

4.4 Methodology

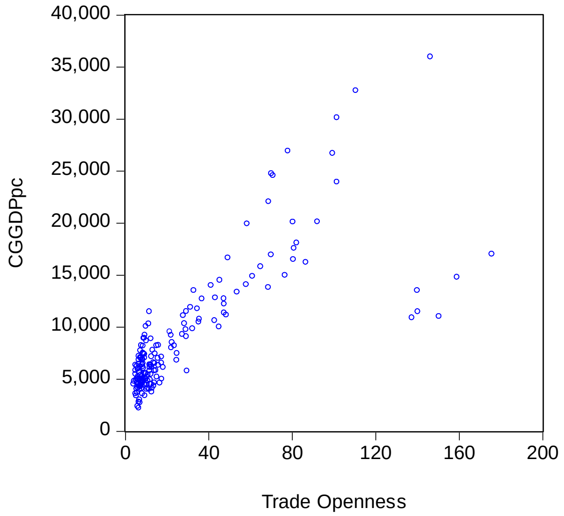
Talberth and Bohara (2006) first plot ISEW and GPI figures against Green Openness on a scatter gram then ran the regression for the level model, and then did the unit root test; after confirming the presence of unit roots, they transformed the level mode into a growth rate form. All their results were conducted using Stata Intercooled statistical software version 8.2.

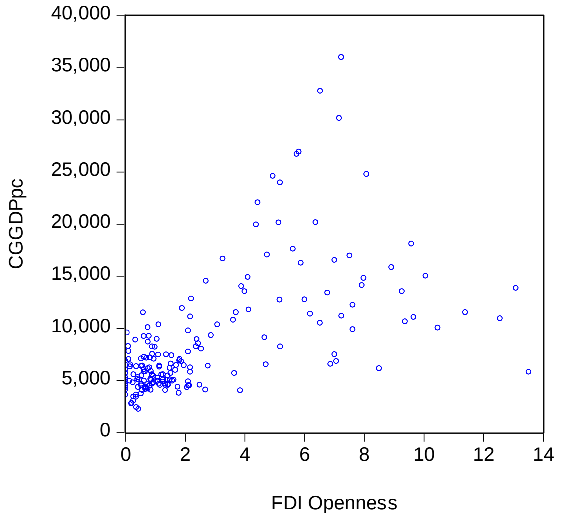
Following Talberth and Bohara (2006) research, scatter grams of CGGDP against trade openness and FDI openness are depicted then a pooled panel regression for the level model had been run for both trade openness and FDI openness. All the results were conducted using EViews 6.

4.5 Regression results

4.5.1 Scatter grams for 31 regions

From scatter grams of CGGDP per capita and Openness for the 31 regions, there seems to be a non-linear relationship between green GDP and Openness; it appears that openness is positively correlated with green GDP up to a point, often called threshold point and then effect reverses afterwards.





4.5.2 Level model results for 31 regions

Empirical level model forms as:

$$CGGDP_{it} = \alpha_0 + \alpha_1 K_{it} + \alpha_2 L_{it} + \alpha_3 O_{it} + \alpha_4 O_{it}^2 + u_{it}$$

Table 4.5.2.1: Level model of CGGDP pooled panel regression for 31 regions

Panel Pool	Trade openness		FDI openness	
Regressor	Coefficients	t−stat	Coefficients	t−stat
Constant	4.7283***	13.8948	3.1174***	7.3500
Capital	0.0214	0.1269	0.6833***	3.1493
Labour	0.0532***	11.1045	0.0730***	11.9139
Openness	0.0238***	14.9206	0.2004***	8.9728
Openness Square	−9.83E−05***	−8.7006	−0.0095***	−4.4800

*, **, and *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively.

In the 31 regions level model regression result, under the trade volume measure of regional openness, constant denoting technology level turns up to be positive and significant (4.728394***), if this is the case, an increase in technology level will raise the total green GDP level. Capital represented by the ratio of gross formation ratio, has a positive and insignificant coefficient (0.021484), suggesting a rise in capital leads an increase in green GDP but not econometrically significant. Influence of working age ratio appears to be positive as expectation, and significant (0.053228***).In the case of openness effect, a positive sign for trade openness (0.023895***), but a negative sign for squared green openness (-9.83E-05***), these two opposite direction effects exhibit non-linear correlation between green openness and green GDP, green GDP first goes up with an increase in trade openness up to a turning point, then reduces with green openness increasing further.

Similarly, in the FDI openness case, the constant term is also positive stating positive effect of technology (3.117421***); coefficient for capital formation is positive (0.683390***) same with trade openness case suggesting positive effect of capital to green GDP as anticipated; positive (0.073049***) expected coefficient for working age ratio; and same as trade openness, positive coefficient for openness (0.200423***) and negative openness squared coefficient (-0.009513***) under the FDI openness measurement and both coefficients are significant.

These results suggest an inverted U shape curve between openness and green GDP. This is same to the finding of Talberth and Bohara (2006). It shows that true human welfare is non-linearly correlated with openness, that is, it goes up with openness up to a peak and then drops afterwards.

4.5.3 Results for West 12 regions

West China includes provinces and regions of Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

Table 4.5.3.1: Level model of CGGDP pooled panel regression for West 12 regions

Panel Pool	Trade openness		FDI openness	
Regressor	Coefficients	t−stat	Coefficients	t−stat
Constant	4.1369***	6.4810	3.6326***	4.9865
Capital	0.3495	1.5098	0.6678***	2.6638
Labour	0.0568***	6.2506	0.0678***	6.2445
Openness	0.0348	0.9734	−0.1878**	−2.0049
Openness Square	−5.87E−05	−0.0375	0.0599*	1.9173

*, **, and *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively.

The pooled regression results from West 12 regions of China, show different openness effects from the country regression pooling 31 regions. Trade openness has the same coefficient sign: positive for the openness and negative for the squared term, but both coefficients are insignificant. Whereas, in the case of FDI openness, the relationship reversed to be a U shape curve, green GDP reduces as FDI rises to a bottom point and grows afterwards. This tells a negative effect of FDI on green GDP in the short run, but a positive compensation in the long run. Therefore, proposition for the West China is attracting FDI and bearing the negative impact on the green GDP at lower level of openness, but expecting compensation after threshold point at higher openness level..

4.5.4 Results for East 11 regions

East China includes Beijing, Tianjing, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan.

Table 4.5.4.1: Level model of CGGDP pooled panel regression for East 11 regions

Panel Pool	Trade openness		FDI openness	
Regressor	Coefficients	t−stat	Coefficients	t−stat
Constant	5.4985***	10.0483	5.1746***	6.1366
Capital	0.3365	0.9820	0.4371	0.8925
Labour	0.0446***	5.5417	0.0483***	3.7589
Openness	0.0163***	6.4371	0.2072***	4.2829
Openness Square	−6.08E−05***	−3.9443	−0.0119***	−3.0894

*, **, and *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively.

In the East 11 regions, both trade openness and FDI openness have the similar effects as in the whole country results. The results tell that, although openness can increase green GDP in those regions, but only up to a certain level, after the peak point, further openness will reduce green GDP in this part of China. Therefore a proposition for East China is control optimal openness level to ensure a positive effect of openness on green GDP or sustainable development.

4.5.5 Results for Mid 8 regions

Shanxi, Jinlin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan form the mid China.

The openness effects from this area of China is ambiguous, the regressions results show econometrically insignificant coefficients for both openness and its square in both trade volume and FDI cases. This finding suggests a further research on this area is needed.

Table 4.5.5.1: Level model of CGGDP pooled panel regression for Mid 8 regions

Panel Pool	Trade openness		FDI openness	
Regressor	Coefficients	t−stat	Coefficients	t−stat
Constant	4.0498***	5.5579	4.9042***	8.4445
Capital	0.7217	1.2407	0.1502	0.2918
Labour	0.0641***	7.5087	0.0544***	8.1819
Openness	−0.0083	−0.3185	−0.0688	−0.7838
Openness Square	−0.0001	−0.1666	0.0181	0.9364

*, **, and *** denote significance at the 0.10, 0.05, and 0.01 levels, respectively.

5. CONCLUSION

Sustainable development requires better indicator that measures change of economic welfare, GDP fails to measure ‘true’ welfare thus behaves an improper measurement for sustainability. ‘Green GDP’ as a recently prevalent term has started to apply in economic research. Talberth and Bohara (2006) developed an empirical model from a variant Solow model, using 8 countries green GDP referring to ISEW and GPI, and found that there was a non-linear relationship between economic openness and green GDP, an evidence for the ‘threshold effect’ in recent openness debate.

Although, results from 31 regions of China are very similar to Talberth and Bohara (2006), showing that under two openness measurements, there is obvious correlation between openness and green GDP, and an inverted U shape relationship can also be found. However, this inverted U shape curve cannot be supported once divided the dataset into 3 groups. This may due to different levels of development between regions, or different patterns of trade.

For the future work, it is interesting to investigate what possibilities there are causing the differences in results. One avenue which can be pursued is to use different estimation techniques to see if the results hold. Another area for investigate could be to examine if environmental degradation results from different types of trading regimes, such as custom unions.

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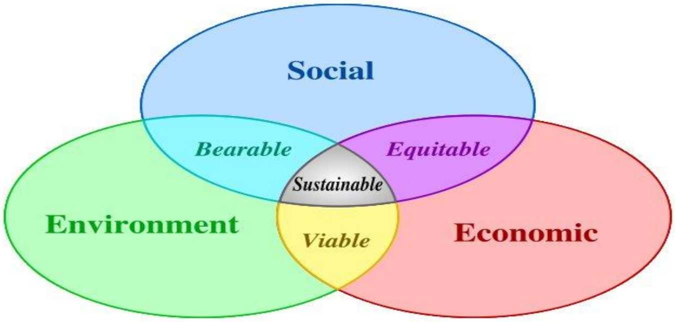
Appendix

Table 1: Sustainable Development



Source : Wikipedia

Table 2: Geographic distribution of Environmental Loss/GDP (Liu and Guo, 2005)

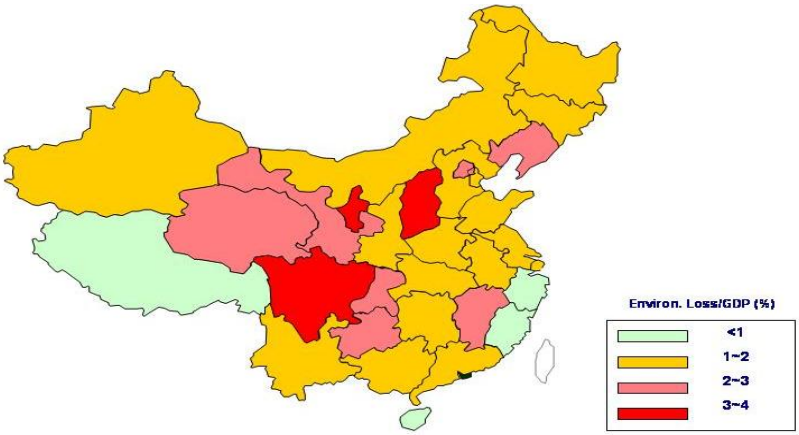


Table 3: Environmental Loss/GDP in the West, East and Mid China (Liu and Guo, 2005)