Green City and Green Growth: Environment Governance as a Moderating Variable

Ya-Ting Chang

Abstract—**The issues surrounding energy governance, climate change and global sustainable development have become more and more important since the twentieth century. Over the decade, the concept of "green growth" has been applied to international environment policy, and "green economy" has also occupied a dominating position. This study used the data of major Asian cities investigated by the Economist Intelligence Unit (EIU) to empirically analyze the connection between Green City Indices and City Gross Domestic Product (City GDP). The first objective of this study is to investigate the correlation between individual Green City Indices and green growth in terms of City GDP. The second objective was to evaluate the moderating role of public governance in the relationship between Green City Indices and green GDP. The results show the significant association between seven of the Green City Indices and City GDP. Most of these indices are associated with local infrastructure construction. The findings also indicate that environment governance has a moderating effect on the relationship between Green City indices and City GDP. Public managers are encouraged to use the research results to foster economic growth and improve environment sustainability.**

Index Terms—**Green growth, green economy, environment governance.**

I. Introduction

Climate change and global sustainability have become common challenges to all countries. In the past, industrialization increased productivity and stimulated economic development. However, it also resulted in rapid urbanization and accompanied environmental damage. Traditionally, most environment policies implied to pay more for ecological protection and developing low-carbon economy. For realistic considerations, policy-makers, especially those of local governments who strive for the short-term economic goal, resisted to face the environmental issue. In recent years, the concept of green growth overcomes the dilemma between environment protection and economy development. The essential meaning of green growth is that environmental sustainability does not conflict with economic prosperity. While economic growth occurs, environmental impacts can be reduced through various innovative methods including recycling wastes and water, using renewable energy, and changing the structure of the economy. Hence, the economic growth could meet environmental objectives [1], [2]. Green growth is not a substitute for sustainable development but a way of achieving it [2]. It could not be a zero-sum game. Environmental protection would not restrict economy. It even stimulates economic growth. The benefits of green growth could be an incentive for political concern and make the environment policy more attractive for the governments.

Green growth is an important issue. However, most previous studies related to this topic focused on national governments. Very few studies addressed the issues of the empirical effect of green practices on economic growth at the level of local governments. Due to the deficiency, this research focuses on local governments and attempts to evaluate the impact of Green City Indices on City Gross Domestic Product (City GDP). Our study seeks to answer the following research questions about the role of the green practices (i.e., develop renewable energy and build waste water recycling system) and their association with economic growth. First, are the Green City Indices associated with City GDP? Second, why should the city government pay more attention to environment governance? The outline of the paper is as follows. The next section introduces literature of green growth and green cities. Section III introduces the data and the methodology of this article. Section IV shows the results and analysis. Finally, Section V, the core of the article, presents the research findings, implications and brief conclusion.

II. Literature Review and Research Hypotheses

The Organization for Economic Cooperation and Development (OECD) defined "Green growth means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" [2]. The World Bank stated that green growth is growth that is efficient in use of natural resources and minimizes pollution and environmental impacts [3]. The conception of green growth proposes a pragmatic approach to the contradiction between "green" (environment) and "brown" (industrialization) [4], [5]. These descriptions had common definition of green growth which is economic growth also achieving environmental protection.

When the global population grows, consumption increases, which in turn impacts the environment. This consequence can be avoided through technological improvements [6]. The United Nations Environment Program (UNEP) has gathered considerable evidence on the positive impact of the conservation and sustainable management of natural resources on green growth [7]. Based on Keynesianism, when economies experienced a huge recessionary shock, governments could sustain aggregate demand by replacing lost private-sector demand with public expenditure. Such

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spending can be also used in green investments. Thus, Keynesianism could be applied to improving the environment [8]. Green Keynesianism indicated that environmental policies can stimulate economic growth and employment during a recession [9]. Government promotes green industry and green technology in order to improve energy efficiency which can provide more job opportunities and increase the demand of economy. Without any additional budget, government can still achieve environmental improvements by applying policy instruments and creating green incentive such as tax reduction [10].The World Bank reported that most cities have been slow to join the "green cities" club and finance green investments in cities were new options, such as private sector partnerships and involving citizens within a participatory strategy [11]. Thus, based on the above discussion, the following hypothesis is proposed:

H1: Some of the Green City Indices in terms of energy and CO_2, land use and buildings, transport, waste, water, sanitation, and air quality are correlated with City GDP.

As serious global warming and climate change occurred, environmental protection has become international policy. The governments were forced to put more effort on green policy. The UNEP stated that global governments should use 2% of GDP for green investment to lead the world towards a green economy [6]. Reilly [12] believed that green GDP is the indicator to measure green growth. However, the value of depletion and environmental degradation of natural resources is not easy to measure and limits its application. Schmalensee [13] argued that adopting appropriate policies can lead to achieving the goals of green growth. Thus, government plays a key role and may modify the form of the relationship between Green City Index and GDP. In other words, Green City Index may have a positive effect on GDP, particularly when the government puts more effort into environment policies. This leads to the following hypothesis:

H2: Environment governance moderates the relationship between Green City Index and City GDP.

III. Methodology

The study analyzes the relationship between Green City Indices and City GDP in Asia. The theoretical model is shown in Fig. 1. The data was based on the research project conducted by the Economist Intelligence Unit (EIU) and sponsored by Siemens [14], [15], which investigated Green City Indices and City GDP of 22 Asian cities. These cities are capital cities or leading business centers selected based on their size and importance. The Green City Indices used in this study include seven categories: 1) Energy and CO_2, 2) Land use and buildings, 3) Transport, 4) Waste, 5) Water, 6) Sanitation, and 7) Air quality [14], [15]. The Green City Indices are presented in Table I.

Energy and carbon dioxide (CO_2) was considered along the two dimensions: CO_2 emissions per person and energy consumption per US$ GDP. Land use and buildings was measured by population density and green spaces per person. Transport was assessed by superior public transport network, covering trams, light rail, subway, and bus rapid transit (BRT). Additionally, waste was estimated by share of waste collected and adequately disposed and waste generated per person. Water contained the two aspects: water consumption per person and water system leakages. Sanitation was composed of population with access to sanitation and share of wastewater treated. Finally, air quality was evaluated by daily nitrogen dioxide levels, daily sulphur dioxide levels, and daily suspended particulate matter levels.

Additionally, environmental governance is classified into five levels: well below average, below average, average, above average, and well above average. For the purpose of this study, levels 1 to 3 are associated with low level of environmental governance. On the other hand, Levels 4 and 5 pertain to high level of environmental governance.

This study conducted correlation analysis to determine the relationships between Green City Indices and City GDP. Additionally, to test for the moderating influence of environmental governance on the association between Green City Indices and City GDP, two steps analysis were used. In the first step mean was used on the basis of the individual City Indices. The first group is composed of cities with index values higher than mean and the second group consists of cities with index values lower than mean. In the second step 2 (Green City Index) x 2 (environmental governance) analysis of variance (ANOVA) was performed. The two-way ANOVA was utilized to determine the joint effect of Green City Index and environmental governance on City GDP.

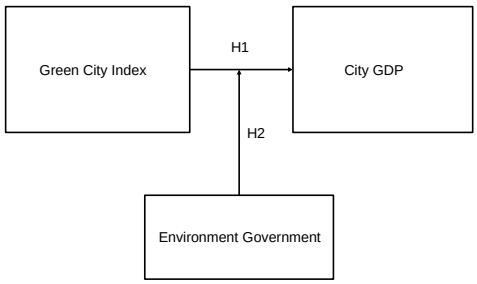

Fig. 1. Theoretical model.

TABLE I: The Green City Indices

Category	Index
Energy and CO_2	CO_2 emissions per person
Energy and CO_2	Energy consumption per US$ GDP
Land use and buildings	Population density
Land use and buildings	Green spaces per person
Transport	Superior public transport network , covering trams, light rail, subway and BRT
Waste	Share of waste collected and adequately disposed
Waste	Waste generated per person
Water	Water consumption per person
Water	Water system leakages
Sanitation	Population with access to sanitation
Sanitation	Share of wastewater treated
Air quality	Daily nitrogen dioxide levels
Air quality	Daily sulphur dioxide levels
Air quality	Daily suspended particulate matter levels

IV. Results and Analysis

A. Relationships between Green City Indices and City GDP

The significant results of the correlation analysis are

presented in Table II. The analysis showed that seven of the Green City Indices have significant correlation with City GDP. Most of these indices are associated with local infrastructure construction. In addition, three of the indices are negatively correlated with City GDP. One the other hand, four of them are positively correlated with City GDP. The Green City Indices negatively correlated with City GDP include: 1) energy consumption per US$ GDP, 2) water system leakages, and 3) daily suspended particulate matter levels. The four indices positively correlated with City GDP are as follows: 1) superior public transport network, 2) share of waste collected and adequately disposed, 3) population with access to sanitation, and 4) share of wastewater treated. Among these indices, "population with access to sanitation" has the highest correlation with City GDP. Seven scatter plots were used to identify the relationship between individual Green City Indices and City GDP among the investigated cities. Six of the scatter plots have clearly shown the positive or negative correlation between Green City Index and City GDP. However, scatter plot for "Energy consumption per US$ GDP" and City GDP showed an interesting result (see Fig. 2). Below a certain level of City GDP (i.e., GDP=US$12300), energy consumption is positively associated with City GDP. On the other hand, above that level, energy consumption is negatively associated with City GDP.

TABLE II: CORRELATION ANALYSES

Variable	A	B	C	D	E	F	G	H
A.GDP	1							
B. Energy consumption per US$ GDP	-.55*	1						
C. Superior public transport network	.53*	-.51*	1					
D. Share of waste collected and disposed	.50*	-.08	.32					
E. Water system leakages	-.57*	-.04	-.29	-.50*	1			
F. Population with access to sanitation	.76*	-.36	.62*	.52*	-.66*	1		
G. Share of wastewater treated	.60*	-.04	.28	.57**	-.89*	.70*	1	
H. Daily suspended particulate matter levels	-.50*	.24	-.37	-.10	.37	-.44*	-.20	1

*significant at the 0.05 level

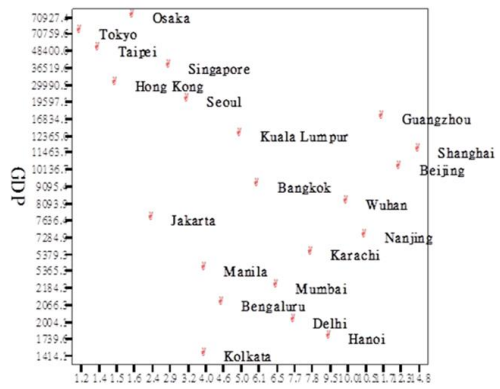

Fig. 2. Scatter plot.

B. Testing the Moderating Effect of Environmental Governance

Hypothesis 2 was concerned with the moderating effects of environmental governance on the relationship between Induvial Green City Indices and City GDP. Mean was used in an exploratory mode to develop an objective classification of cities. In order to identify city groups with the same levels of induvial City Index, mean was used on the basis of the individual City Indices. The analysis has identified two groups for "Share of waste collected and disposed" and "Share of wastewater treated" respectively, with the group mean values of discriminating variables given in Table III. For "Share of waste collected and disposed", the first group is composed of cities with index values higher than mean (i.e., mean = 82.80). The second group consists of cities with index values lower than mean. Similarly, for "Share of wastewater treated", the first group is composed of cities with index values higher than mean (i.e., mean = 59.90). The second group consists of cities with index values lower than mean. In addition, the independent-samples t tests shown in Table III confirm that the variables of "Share of waste collected and disposed" and "Share of wastewater treated" do significantly differentiate across the two groups. For "Share of waste collected and disposed", the first group was labeled cities with high level of share of waste collected and disposed. The second group consists of cities with low level of share of waste collected and disposed. For "Share of wastewater treated", the first group was labeled cities with high level of share of wastewater treated. The second group consists of cities with low level of share of wastewater treated.

TABLE III: GROUP MEANS OF DISCRIMINATING VARIABLES

Variable	Cities with high index		Cities with low index		t-statistic
	Mean	Standard deviation	Mean	Standard deviation	
Share of waste collected and disposed	94.50	6.89	62.34	19.42	4.525**
Share of wastewater treated	87.25	11.50	20.40	18.21	10.588***

**significant at the 0.01 level; ***significant at the 0.001 level

The study revealed two segments for "Share of waste collected and adequately disposed" and environmental governance respectively. Thus, to test for the moderating influence of environmental governance on the association between "Share of waste collected and adequately disposed" and City GDP, 2 (Share of waste collected and adequately disposed) x 2 (environmental governance) analysis of variance (ANOVA) was performed. The two-way ANOVA was utilized to determine the joint effect of "Share of waste collected and adequately disposed" and environmental governance on City GDP. Table IV summarizes the results of ANOVA. The results suggest a significant interaction of "Share of waste collected and adequately disposed" (SWC) and environmental governance (EG) for City GDP ($F = 4.780$, $p < 0.05$). The findings indicate that environmental governance has a moderating effect on the relationship between "Share of waste collected and adequately disposed" and City GDP.

Since the interaction term was significant, the form of

interaction was graphically represented to evaluate the direction of the differences within each of the conditions. Fig. 3 shows the relationship between "Share of waste collected and adequately disposed" and environmental governance. In addition, the results in Fig. 3 demonstrate that cities with high environmental governance may achieve higher level of City GDP when they experience high level of share of waste collected and adequately disposed than low environmental governance.

TABLE IV: RESULTS OF TWO-WAY ANOVAS FOR SWC AND EG

Variable	Degrees of freedom	Mean square	F
Share of waste collected and disposed (SWC)	1	954272720.1	6.195*
Environmental governance (EG)	1	1089064618	7.070*
SWC x EG	1	736264777.7	4.780*

*significant at the 0.05 level

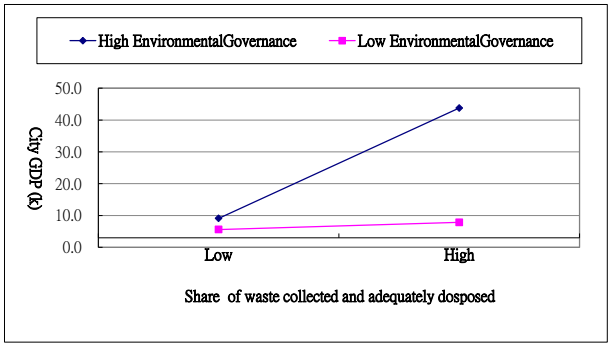

Fig. 3. Moderating effect for SWC.

Similarly, the study revealed two segments for "Share of wastewater treated" and environmental governance respectively. Thus, to test for the moderating influence of environmental governance on the association between "Share of wastewater treated" and City GDP, 2 (Share of wastewater treated) x 2 (environmental governance) analysis of variance was performed. The two-way ANOVA was utilized to determine the joint effect of "Share of wastewater treated "and environmental governance on City GDP. Table V summarizes the results of the ANOVA. The results suggest a significant interaction of "Share of wastewater treated" (SWT) and environmental governance (EG) for City GDP ($F = 4.179$, $p < 0.10$). The findings indicate that environmental governance has a moderating effect on the relationship between "Share of wastewater treated" and City GDP.

Fig. 4 shows the relationship between "Share of wastewater treated" and environmental governance. The results show that cities with high environmental governance may achieve higher level of City GDP when they experience high level of share of wastewater treated than low environmental governance.

TABLE V: RESULTS OF TWO-WAY ANOVAS FOR SWT AND EG

Variable	Degrees of freedom	Mean square	F
Share of wastewater treated (SWT)	1	1074660275	7.116*
Environmental governance(EG)	1	1048812037	6.945*
SWT x EG	1	631164269.2	4.179*

*significant at the 0.10 level

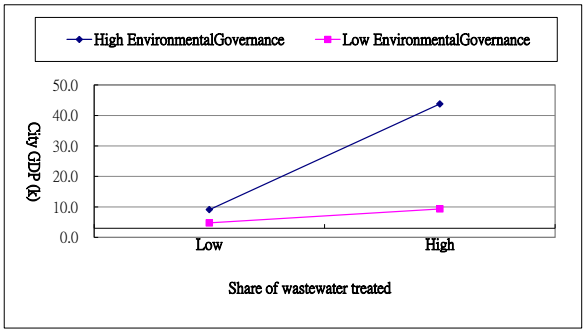

Fig. 4. Moderating effect for SWT.

V. CONCLUSION AND IMPLICATIONS

While environmental sustainability issues have received substantial attention, the number of studies dealing with the influence of adopting green practices on "city" GDP is rather scarce. Thus, developing such support will illustrate how adopting green practices can contribute to GDP in cities. This study attempts to fill the gap in the literature by identifying the relationship between Green City Indices and City GDP. Therefore, the first objective of this study was to determine the relationship between individual Green City Indices and City GDP. The second objective was to evaluate the moderating role of environment governance in the relationship between Green City Indices and City GDP.

The results show that seven of the Green City Indices have significant correlation with City GDP. Most of these indices are associated with local infrastructure construction. In addition, three of the green city indices (i.e., energy consumption per US$ GDP, water system leakages, and daily suspended particulate matter levels) are negatively correlated with City GDP. The findings show that high income does not mean that the consumption of energy is also high and the public infrastructure of the cities well-built or not is related with the economic development. One the other hand, four of them (i.e., share of waste collected and adequately disposed, water consumption per person, population with access to sanitation and share of wastewater treated) are positively correlated with City GDP. The empirical results show that in affluent cities, residents have high awareness of environmental protection and local governments have a high degree of willingness to invest in enterprise technologies to promote alternative energy policies and pay more attention on urban construction and public facilities. Most interestingly, according the scatter plot of "Energy consumption per US$ GDP", below a certain level of City GDP, energy consumption is positively correlated with City GDP. However, above that level, energy consumption is negatively correlated with City GDP. It might indicate that the cities with high level of GDP such as Hong Kong, Osaka, Seoul, Singapore, Taipei, and Tokyo actively reduced the consumption of natural resources. This phenomenon empirically proved the Environmental Kuznets Curve (EKC). In the early stages of economic growth degradation and pollution increase, but beyond some level of income per capita the trend reverses, so that at high-income levels economic growth leads to environmental improvement [16]. In addition, environmental governance has a moderating effect on the relationship between Green City Indices on City

GDP. Specifically, cities with high environmental governance (i.e., Bangkok, Hong Kong, Osaka, Seoul, Singapore, Taipei, Tokyo, and Yokohama) may achieve higher level of City GDP when they experience high level of share of waste collected and adequately disposed than low environmental governance. In addition, cities with high environmental governance may achieve higher level of City GDP when they experience high level of share of wastewater treated than low environmental governance.

The research results offer guides to adopt green practices to develop and build cities. Local government can use the research results to modify their current green policy. This study has several implications for local government. For developing cities, the local government should pay more attention to infrastructure development (e.g., water system, waste collection and disposal system, urban sanitation development, and wastewater treatment plant). More importantly, environmental governance plays an important role in facilitating city development. Local government should develop green action plan and increase public participation in green policies. Government decision makers need to enhance city's environmental oversight, closely monitor its environmental performance, and involve the public in environmental decision-making.

While this study offers important insights into the adoption of green practices, there are some limitations. First, results are obtained from 22 cities in Asian. Although these cities are either capital cities or leading business centers selected based on their size and importance, generalizations should be drawn with care. Furthermore, consideration can be given to use DEA (data envelopment analysis) to measure the performance of green cities in the future. Additionally, because of regional differences in the culture, history and economic structure, it would be worthwhile to conduct similar studies in other continents. Finally, it would be interesting to compare the difference in the effect of green practices on City GDP among these geographic regions.

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