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ESG and Urban Sustainable Development

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Abstract. The social advocacy of sustainable development and expanding super-cities such as Beijing seemed to be in a conflict, and so did the balance between economic growth and environmental protection. Environmental, social, and governance (ESG), a financial evaluation criterion encouraging sustainable development of firms, is frequently discussed in this context, especially in the fields of finance and microeconomics. Our research examined how ESG performances at the urban level have influenced urban sustainable expansion through innovatively created measurements of the overall conditions of ESG performances and sustainable progress in cities. Based on the newly created indexes, we found the positive effect of urban ESG development on urban sustainable development. Four mediating pathways, including financial sector, pollution treatment, social insurance, and efficiency of capital use, were found and tested. Further investigation shows that the effect of urban ESG development on urban sustainable development varies significantly. The effect is considerably positive in high-GDP cities but even reverse in low-GDP cities. Also, the effect performs better in the recent compared with the past.

Keywords: ESG; Urban Sustainable Development; Principal Component Analysis.

1. Introduction

The grand society is severely suffering from poly-crisis, such as climate change, global warming, extreme weather, wars and conflicts, pandemics, and poverty. At this moment, an established collective consensus for the international society on the concept of sustainable development became especially important. In assessing the "total development of society" from the last century, economics tends to focus primarily on economic changes, thus isolating economic development from "total" development. In the 1970s, the emergence of a significant revision in development thinking presented a fundamental challenge to the conventional consensus on economic development, including increasing awareness of environmental pollution, poor accessibility, etc. (Pezzey et al., 2002)[6]; In 2015, the endorsement of Sustainable Development Goals (SDGs) from "The 2030 Agenda for Sustainable Development" of the UN officially provided a prosperous blueprint for future development among all nations, calling on the society to be equally responsible for progressing a more sustainable path forward (Scheyvens et al, 2016)[9]. Based on this global trend, Environmental, Social, and Governance (ESG) criteria have been developed in 2004, aiming to advocate more socially responsible investments and regulate firm performances.

Environmental, social, and governance (ESG) criteria is an investment concept that advocates a holistic evaluation of firms from environmental (E), social (S), and governance (G) factors in the investment decision-making process, including information disclosure, evaluation and rating, and investment guidelines. It is currently the basis of socially responsible investment and an essential part of the green financial system (Zhang, 2017)[15].

A corporate ESG performance score is usually obtained from an overall 36 criteria in 3 categories (E, S, G). For the "Environmental" pillar, carbon and greenhouse gases emissions, waste pollution and management, energy use, and employee awareness of environmental protection are usually in consideration. For the "Social" pillar, rating standards include but are not limited to gender composition, human rights policies and violations, employee health and safety, public welfare and charity, etc. For the "Governance" pillar, management of corruption and bribery, anti-unfair competition, board independence and diversity, and investor relations are usually listed in ESG rating. ESG has been a top-heat research field in the past decades, emphasizing its correlation with firm performance (Pu, 2023), measuring from the scale of firms[7]. Using empirical evidence from China and eliminating endogeneity issues, Pu (2023) conducts empirical research and finds that ESG activities positively correlate with firm performance, and it is a non-linear but inverted U-shaped relationship. It provides a general finding between the relationship of ESG activities and firm performance in China and sequential policy instruction to firms for seeking more cost-effective ESG activity levels to avoid adverse shocks to their profitability. The mechanism was explained by Chen (2022): the concept of ESG sustainable development helps to enhance the attractiveness of equity investment and reduce investment risks, thus lowering the cost of equity financing for enterprises[2]; the effectiveness was specifically demonstrated in the Environmental (E) factor (Chen, 2022)[1].

Under the context of sustainable development, the case of ESG development in China provides an excellent example as the Chinese have made significant progress over the past few years regarding policy initiatives and effective industry regulations (Jin, 2018)[3]. At the same time, Chinese cities are still confronting development obstacles, such as shifting from end-of-pipe treatment to source control, moving from point source treatment to regional environmental governance, and turning away from administrative management-based approaches and towards a legal means and economic instruments-based approach (Zhang, 2007)[4].

There is also a vast amount of research on urban sustainable development, mainly centralizing on economic aspects or self-developed holistic evaluation indexes. Jin (2018) provided a general guideline by concluding that the direction of the sustainable development stage is mainly structural upgrading and system optimization; it emphasizes the value of authenticity and encourages the concept of seeking progress while maintaining stability, sharing by the people, and green environmental protection[3]. His research elaborated the high-quality development under the “new development concept”, a policy advocacy the Chinese government proposed in 2015 that encourages the pursuit of a society that is “innovative, coordinated, green, open development, and has its fruits shared by everyone.” Therefore, urban sustainable development (USD) concept was mostly interpreted as urban high-quality development in China. Contemporary understanding of high-quality development not only focuses on short-term economic performance, such as GDP, tertiary industry expenditure, and unemployment, but also requires a people-oriented and sustainable performance. Based on this general framework, Yang (2023) examined the sustainable urban development index systems applied internationally and domestically, providing this research with corporeal system references from ISO, OECD, the EU, the US, Japan, Shanghai, Ningbo, etc[14]. Zhang (2023) provides an essential innovation to the high-quality city development index by measuring 328 cities in China from 21 indicators in five categories[17]. She combined three criteria—high-quality economic development, people-oriented high-quality development, and the other five requirements from the “new development concept”: high-quality economic development has an abundance of empirical evidence, and it is conventionally the central part to evaluate cities’ sustainable development; people-oriented development is the crucial focus after entering 21 century Jin (2018)[3]; also for the “new development concept”, which opened the new possibility to incorporate innovation, coordination, green, openness, and shared-development into the index.

Overall, former ESG scores were only obtained as an addition to single firm performances, and the main focus of ESG research before was also limited to microeconomics evaluation such as finance market and firm performance. Similarly, the focal point of urban sustainable development has just stepped to a broader understanding of not only incorporating economic factors but also evaluating living standards, green development, shared levels, etc., in recent years. There has rarely been research investigating the relationship between ESG performance and sustainable urban development, especially from a macroeconomics perspective, and the mechanism needed to be clarified.

Therefore, under a global context of sustainable development, our research discussed the mediating mechanism of urban ESG development on urban sustainable development through four pathways, considering the ESG performance of 50 top GDP cities in China as the explanatory variable, the newly fitted urban sustainable development index as the explained variable.

There are mainly three contributions in our study. Firstly, our research filled the gap for the previous research. We connected ESG concept with the notion in macroeconomics and discovered the broader effect of ESG other than in finance and corporates. Secondly, the measurements of urban ESG development and urban sustainable development were new; innovative ways and methods were used, providing guides for future research. The descriptive analysis for those measurements also reveals the development trend of cities in China, which provides evidence for enhancing situations in China. Lastly, the effect and mediating pathways of urban ESG development on urban sustainable development were tested; the differences in the effect in different cities and periods were found.

2. Research Design

2.1. Methods

2.1.1. Introduction of Principal Component Analysis (PCA)

Principal component analysis (PCA) is an important statistical process method to transform a complex problem with multiple indexes into a small number of representative indexes with minimum information loss----a dimensionality reduction processing method used to simplify data and interpret information (Tian, 2022)[11].

2.1.2. Calculation of Explained Variable by PCA

Through PCA, our research's component score of the coefficient matrix can be obtained as:

$$\mathbf{X} = \begin{bmatrix} \alpha_{1,1} & \alpha_{1,2} & \cdots & \alpha_{1,n} \\ \alpha_{2,1} & \alpha_{2,2} & \cdots & \alpha_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_{m,1} & \alpha_{m,2} & \cdots & \alpha_{m,n} \end{bmatrix} \quad (1)$$

where m is the number of unfitted variables picked for the measurement, and n is the number of major components.

The complete dataset can then be introduced through matrix M, where i and t are the categorizations of samples.

$$\mathbf{M} = \begin{bmatrix} x_{1,1,1} & x_{1,1,2} & \cdots & x_{1,1,m} \\ x_{1,2,1} & x_{1,2,2} & \cdots & x_{1,2,m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{i,t,1} & x_{i,t,2} & \cdots & x_{i,t,m} \end{bmatrix} \quad (2)$$

To obtain the score of each major component, the component score coefficient matrix is multiplied by the dataset:

$$\mathbf{MX} = \begin{bmatrix} \sum_{k=1}^{m} \alpha_{k,1}x_{1,1,k} & \sum_{k=1}^{m} \alpha_{k,2}x_{1,1,k} & \cdots & \sum_{k=1}^{m} \alpha_{k,n}x_{1,1,k} \\ \sum_{k=1}^{m} \alpha_{k,1}x_{1,2,k} & \sum_{k=1}^{m} \alpha_{k,2}x_{1,2,k} & \cdots & \sum_{k=1}^{m} \alpha_{k,n}x_{1,2,k} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_{k=1}^{m} \alpha_{k,1}x_{i,t,k} & \sum_{k=1}^{m} \alpha_{k,2}x_{i,t,k} & \cdots & \sum_{k=1}^{m} \alpha_{k,n}x_{i,t,k} \end{bmatrix} \quad (3)$$

Eventually, the synthesis score of those major components can be calculated through:

$$SS_{it} = \frac{C_1 \sum_{k=1}^{m}(\alpha_{k,1}x_{i,t,k}) + C_2 \sum_{k=1}^{m}(\alpha_{k,2}x_{i,t,k}) + \cdots + C_n \sum_{k=1}^{m}(\alpha_{k,n}x_{i,t,k})}{\sum_{j=1}^{n} C_j} \quad (4)$$

where C is the variance contribution rate of a component.

2.1.3. Testing Procedures for Mediating Variables

There are four steps to test the existence of a mediating effect for a variable.

Step 1: The relationship between the explanatory and explained variable is tested by the model:

$$y = \beta_0 + \beta_1 x + \beta_2 \boldsymbol{controls} + \varepsilon$$

Step 2: The relationship between the explanatory and mediating variable is tested by the model:

$$Med = \beta_3 + \beta_4 x + \beta_5 \boldsymbol{controls} + \varepsilon$$

Step 3: The relationship between the mediating variable and the explained variable is tested by the model:

$$y = \beta_6 + \beta_7 Med + \beta_8 \boldsymbol{controls} + \varepsilon$$

Step 4: The nature of the mediating variable (whether it has partial or complete mediating effect) is tested by the model:

$$y = \beta_9 + \beta_{10} x + \beta_{11} Med + \beta_{12} \boldsymbol{controls} + \varepsilon$$

If the effects of the explanatory variable on the explained variable in the models of Step 1-3 are significant, then the mediating effect of the tested variable exists. If x in the model of Step 4 is significant, then the tested variable conducts partial mediating effect; otherwise, it conducts complete mediating effect.

To investigate the effect of urban ESG development on urban sustainable development, we picked the top 50 cities of China in terms of GDP in a range of 10 years from 2011 to 2020.

2.2. Explained Variable

Table 1. Evaluation Indicators System

Primary Indicator	Secondary Indicator	Tertiary Indicator
Economic Quality	Economic Development	Value Added of Tertiary Industry/GDP, ***TAG***
		Annual Actual Use of Foreign Capital/GDP, ***FIG***
Living Quality	Living Standard	GDP per capita, ***GPC***
		Total Retail Sales of Consumer Goods/GDP, ***CRG***
	Social Insurance	Unemployment/Total Population, *UPP*
		Health and Welfare Workers/Total Population, ***HWP***
Innovation Level	Innovation Input	Internal R&D Expenditure/GDP, ***RFG***
		R&D Employees/Total Population, ***RWP***
	Innovation Output	Number of Patents Granted/Total Population, ***PAP***
	Innovation Environment	Number of Colleges and Universities, ***UN***
Coordination Level	Regional Coordination	Average Wage of Urban Workers/Average Wage of National Workers, ***CWN***
Green Development	Environmental Governance	Comprehensive Utilization Rate of Industrial Solid Waste, ***SCU***
		Harmless Treatment Rate of Household Garbage, ***HTG***
	Afforestation	Green Space Coverage Rate of Built-up Area, ***GCB***
Sharing Level	Public Infrastructure	Number of Doctors/Total Population, ***DNP***
		Number of Students in General Secondary Schools/Total Population, ***MSP***
		Public Library Collections per Hundred People, ***PLB***

The measurement of the degree of urban sustainable development is multi-dimensional, difficult to be absolutely exact and conclusive. Many researchers used total factor productivity or green total factor productivity, which may be not suitable for urban but economic high-quality development. Since we investigated about the development condition of cities, several aspects of cities, including environment, society, economy, etc., should be considered. Following the studies of Li&Wei (2018)[12], Zhang (2023)[17], and Zhu (2020)[19], and the “New Development Concept” raised by Chinese Government, which are “Innovative, Coordinated, Green, Open Development, Sharing”, we chose indicators from 6 dimensions: Economic Quality, Living Quality, Innovation Level, Coordination Level, Green Development, and Sharing Level. Most indicators were divided by GDP or the total population of the city because high-quality development does not equal to the accumulation of products; small cities with relatively low GDP and population could also reach a high degree of sustainable development, so average share and proportion are important for the measurement. Dividing GDP or total population can eliminate the effect of the difference between the sizes of cities.

This study adopts Principal Component Analysis (PCA) as the method for the dimension reduction of data and index synthesis. 17 indicators over 10 years from 2011 to 2020, which are deemed as appropriate measurements for urban sustainable development, were picked and dimensionally reduced into the synthesis indicator, named Urban Sustainable Development Index (SDI). For the generalizability and vitality of the index, the data of 178 cities that have relatively complete information in the dataset were used for index fitting, but only the index of 50 cities that were picked as samples for the investigation of the relationship between urban ESG and sustainable development were collected. The source of data is Chinese City Statistical Yearbook and Chinese City Database from EPS Data. Indicators were transformed into different components that are the linear combination of the original variables and that are independent from other components. Following the procedures described in the study of Li&Wu[13], PCA was conducted in our study.

2.2.1. Feasibility Check

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.869
Bartlett's Test of Sphericity	Approx. Chi-Square	13635.044
	df	136
	Sig.	0.000

Through the analysis on the raw data by SPSS26.0, KMO and Bartlett's test was conducted after the effect of different unit between variables on the result was eliminated by standardization. KMO test measures the strength of correlation between variables, checking the feasibility of using PCA for the dimension reduction of the original data. The value of KMO is between 0 and 1; the higher the KMO value is, the stronger the generalizability of the variables is and the more suitable the PCA is for the dimension reduction. Generally, it is suitable to use PCA method when KMO value is greater than 0.8. As shown in table 2, the KMO value in the test for this study is 0.869, and the value of Bartlett's Test of Sphericity is 13635.044, with the significance of 0.0000, which means that it is reasonable and acceptable to conduct PCA in this study.

2.2.2. The Selection of Major Components

Table 3. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.711	33.594	33.594	5.711	33.594	33.594	5.088	29.931	29.931
2	1.783	10.486	44.081	1.783	10.486	44.081	1.874	11.024	40.955
3	1.323	7.785	51.865	1.323	7.785	51.865	1.565	9.204	50.160
4	1.117	6.572	58.437	1.117	6.572	58.437	1.362	8.013	58.173
5	1.019	5.994	64.431	1.019	5.994	64.431	1.051	6.180	64.353
6	1.003	5.897	70.328	1.003	5.897	70.328	1.016	5.975	70.328
7	0.976	5.742	76.070						
8	0.876	5.151	81.221						
9	0.650	3.822	85.043						
10	0.529	3.109	88.152						
11	0.449	2.642	90.794						
12	0.357	2.102	92.896						
13	0.341	2.008	94.904						
14	0.288	1.696	96.600						
15	0.232	1.362	97.962						
16	0.222	1.306	99.267						
17	0.125	0.733	100.000						

Extraction Method: Principal Component Analysis.

Based on the general standard that the cumulative rate of variance contribution is greater than 70%, and that the characteristic values of the picked components are greater than 1, 6 components were extracted from the 17 indicators. This shows that little amount of information was excluded from the 6 components, and the result of factor analysis is reliable.

2.2.3. The Explanation of Major Components

By analyzing the main factors that affect each component, we categorized and named the six components. The first major component, with a variance contribution rate of 33.594%, mainly consist of RWP, DNP, PAP, HWP, PLB, GPC, MSP, RFG, CWN. These indicators mainly reflect the capacity of innovation and coordination of a city, so the component can be named as Factor of Innovation and Coordination (F1). In the same way, we name the second major component with a variance contribution rate of 10.486% as Factor of Economic and Innovation Environment (F2), the third component with a variance contribution rate of 7.785% as Factor of Opening and Foreign Cooperation (F3), the fourth component with a variance contribution rate of 6.572% as Factor of Environmental Governance from Life Aspect (F4), the fifth component with a variance contribution rate of 5.994% as Factor of Environmental Governance from Industrial Aspect (F5), and the sixth component with a variance contribution rate of 5.897% as Factor of City Environment and Social Insurance (F6).

Summarizing the nature of the six components, we found that our synthetic index is highly related to the innovation ability, the economic foundation, and the environment regulation of a city.

2.2.4. Synthesis Index Calculation

Following the steps introduced in **Section 2.1.2**, each of components score and the synthesis index for sustainable development are calculated.

Table 4. Component Score Coefficient Matrix

	Component					
	1	2	3	4	5	6
TAG	0.018	0.408	-0.059	0.080	0.003	-0.013
FIG	-0.056	-0.132	0.634	-0.211	0.073	0.002
GPC	0.092	-0.141	0.083	0.306	-0.001	0.013
CRG	-0.063	0.538	-0.137	-0.153	0.081	0.019
UPP	0.006	0.048	0.133	-0.185	-0.060	-0.672
HWP	0.139	0.110	-0.047	0.063	-0.134	-0.021
RFG	0.137	0.005	0.109	-0.365	-0.043	0.019
RWP	0.183	-0.071	0.013	-0.056	0.112	0.014
PAP	0.210	-0.042	-0.117	-0.105	0.151	0.023
UN	-0.042	0.222	0.336	0.003	-0.075	-0.020
CWN	0.040	-0.031	0.238	0.180	0.001	-0.016
SCU	0.000	0.020	0.024	0.063	0.926	0.000
HTG	-0.027	-0.027	-0.133	0.556	0.059	0.007
GCB	-0.012	0.042	0.121	-0.189	-0.048	0.729
DNP	0.159	0.099	-0.093	0.058	-0.121	-0.032
MSP	0.234	-0.087	-0.285	-0.286	0.041	-0.021
PLB	0.158	-0.067	-0.014	0.053	-0.017	-0.004

Extraction Method: Principal Component Analysis

Rotation Method: Varimax with Kaiser Normalization

Based on the component score efficient matrix, we can calculate the six components score by summing up each variable multiplied with the coefficients given. After the score of each component is gotten, we calculate the synthesis index SDI through weighted average based on the variance contribution rate of each component:

$$SDI = \frac{(33.594F_1 + 10.486F_2 + 7.785F_3 + 6.572F_4 + 5.994F_5 + 5.897F_6)}{70.328}$$

2.3. Explanatory Variable

We used the Bloomberg ESG Rating as the source of data for the explanatory variable, since it elaborates on cities where firms are located.

The data of ESG was categorized according to the cities and years that firms are in. 8071 pieces of data of A-share listed companies in 50 cities over 10 years were collected. To measure the overall ESG development condition of a city in a specific year, data of firms located in the city in that year were combined through weighted average. The weighted average was calculated based on the proportion that the registered capital of a firm take compared with the total registered capital in the city the firm locates at. The mathematical equation for this is:

$$UES_{it} = \sum_{k=1}^{n} (FES_{itk} \times \frac{RC_{itk}}{\sum_{k=1}^{n} RC_{itk}})$$

where UES is Urban ESG Score; FES is Firm ESG Score; RC is the Registered Capital of the firm; i is the city the firm locate at (Top 50 cities in China in terms of GDP); t is the specific year measured (2011-2020); n is the total number of firms in the city.

The reason for why the proportion of registered capital was used as weight is that firms with different scales will affect the development of cities to different extent. The greater the scale of the firm is, the stronger their effect on city development is. Registered Capital indicates the foundation of the firm, so it basically represents firms' relative scale and power of influence on urban development.

2.4. Mediating Variables

There are four aspects that are deemed as the mediating pathways for the effect of urban ESG development on urban sustainable development: The Development of Financial Sector (DFS), Pollution Treatment Condition (PTC), Social Insurance and Welfare (SIW), and Efficiency of Capital Uses (ECU).

According to the past research of Zhao et al. (2020)[18], Shangguan & Ge (2020)[10], and Zhang (2022)[16], Deposits of Financial Institutions at Year-end/GDP (FSG) is used for the measurement of DFS; Centralized Sewage Treatment Rate (WTR) is used for the measurement of PTC; Sum Insured for Insurance/Total Population (IOP) is used for the measurement of SIW; Capital Productivity (CR) is used for the measurement of ECU. These data are all from Chinese City Statistical Yearbook.

2.5. Control Variables

This study set Labor Productivity, Fiscal Revenue over Fiscal Expenditure, Number of Industrial Enterprises above Designated Size, Year (nominal variable) and City Code (nominal variable) as control variables to control the effect of the improvement of people' education level and working productivity, government intervention, progress of industrial sector and other endogenous factors on the sustainable development. The Year (10 years from 2011-2020) and the City Code (50 cities numbered in the order of GDP rank) can control the effect of different years and different incomes on urban sustainable development. The source of data is Chinese City Statistical Yearbook.

Table 5. Variables Summary

Variable Type	Variables Name	Unit	Abbreviation	Definition/Treatment
Explained Variable	Urban Sustainable Development Index		***SDI***	The fitted variable of 17 indicators related to sustainable development through PCA
Explanatory Variable	Urban ESG Score		***UES***	The weight average of firms ESG score based on their registered capital
Mediating Variables	Deposits of Financial Institutions at Year-end/GDP	Yuan/Yuan	***FSG***	Amount of deposits of financial institutions divided by gross domestic product
	Centralized Sewage Treatment Rate	%	***WTR***	Rate of Industrial wastewater that is centralized and treated
	Sum Insured for Insurance/Total Population	Billion Yuan/Ten thousand persons	***IOP***	Amount of money insured by social insurance divided by total population
	Capital Productivity	Yuan/Yuan	***CR***	Gross domestic product divided by investment of fixed capital
Control Variables	Labor Productivity	Billion Yuan/Ten thousand persons	***LR***	Gross domestic product divided by total employees
	Fiscal Revenue/Fiscal Expenditure	Yuan/Yuan	***GRS***	Government revenue divided by government spending
	Number of Industrial Enterprises above Designated Size	Enterprises	***SIN***	Number of industrial corporates on scales
	Year		***Y***	Nominal variable, the specific year measured
	City Code		***CC***	Nominal variable, the specific city measured

3. Empirical Analysis

3.1. Descriptive Analysis

Table 6. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistics	Statistics	Statistics	Statistics	Statistics	Statistics	Statistics	Std.Error	Statistics	Std.Error
UES	500	0.00	43.38	21.20	5.38	28.96	0.71	0.11	2.95	0.22
SDI	500	-0.37	2.93	0.43	0.53	0.28	1.73	0.11	3.89	0.22
FSG	500	0.66	5.31	1.85	0.74	0.55	1.43	0.11	3.61	0.22
WTR	500	59.30	100.00	91.27	7.11	50.54	-1.67	0.11	3.38	0.22
IOP	500	0.06	212.37	6.79	21.14	446.86	6.37	0.11	46.58	0.22
CR	500	0.50	61.47	2.06	3.61	13.05	12.06	0.11	173.98	0.22
SIN	500	401.00	11900.00	3605.03	2243.15	5031732.63	1.20	0.11	1.40	0.22
GRS	500	0.24	1.54	0.75	0.16	0.03	0.11	0.11	0.56	0.22
LR	500	0.77	5.58	2.29	0.74	0.54	0.86	0.11	1.54	0.22

To get an overview about the conditions and trends of data, descriptive analysis was conducted for the major variables over 10 years. The result is shown in table 6.

As presented in the table, the greatest urban ESG score is 43.48 (Yang Zhou in 2020); the average level national wide is 21.2004 over 10 years. The standard deviation of UES is 5.38, which indicates that the volatility of the data is relatively high. The highest sustainable development index is 2.93 (Shen Zhen in 2013), while the lowest SDI is -0.37 (Xiang Yang in 2012); the average level national wide is 0.4274 over 10 years.

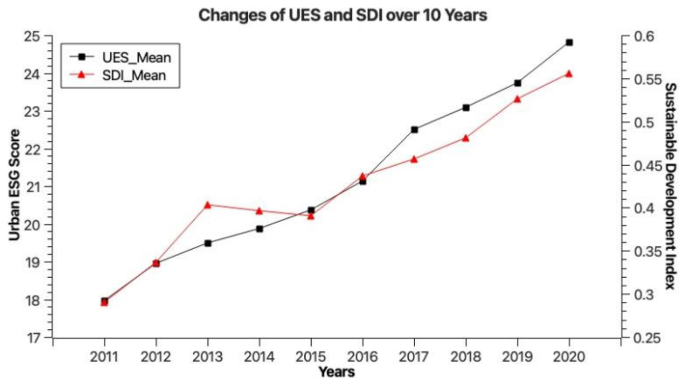

Figure 1. Line Chart of the Trend of UES and SDI over Time

Figure 1 shows the change of national-wide average urban ESG score and urban sustainable development index from 2011 to 2020. It can be seen that both UES and SDI grew significantly in these 10 years. This indicates that the promotion of Chinese government on ESG and urban sustainable development through the proposal of "New Development Concept", the release of "Environmental, Social, and Governance Reporting Guide", and etc. did work well over 10 years. Compared with the trend of SDI, average UES rose gradually and steadily, whereas SDI fluctuated more and changed in a greater range between years. Two obvious increases of SDI can be seen in 2012-2013 and 2015-2016. Being coincident or not, the first and second editions of "Environmental, Social, and Governance Reporting Guide", as promoting policies for ESG, were released in 2012 and 2015.

3.2. Empirical Findings

Table 7. Results of Baseline Model – The Effect of UES on SDI

Variables		Explained Variable: SDI	
		Model 1	Model 2
Explanatory Variable	UES		0.015***
Control Variable	Constant	-80.927***	-57.981***
	SIN	0.000***	0.000***
	GRS	0.733***	0.711***
	LR	-0.073***	-0.080***
	Y	0.040***	0.029***
	CC	-0.016***	-0.014***
Empirical Result	F	86.617	77.842
	R^2	0.467	0.486

*p<0.1. ** p < 0.05. ***p < 0.01

As shown in table 7, Urban ESG Score does affect Urban Sustainable Development Index under a significance level of 0.01. After adding UES into the model, R-squared increases by 0.019, which means the model has a stronger explanatory power compared with the former one. The coefficient of UES for its effect on SDI is 0.015, which means the urban ESG development can effectively improve the high-quality development of cities. This indicates that UES has a significant positive effect of SDI. The mean of UES is 21.20, and the mean of SDI is 0.43. The coefficient means that every unit increase of UES will cause the increase of SDI by 0.015.

Table 8. Model with FSG– Check of the Mediating Effect of FSG

Variable		Explained Variable: FSG		Explained Variable: SDI			
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Explanatory Variable	UES		0.032***		0.015***		0.006*
	FSG					0.294***	.282***
Control Variable	Constant	-137.409***	-89.781***	-80.927***	-57.981***	-40.466***	-32.685***
	Y	0.070***	0.046***	0.040***	0.029***	0.020***	.016***
	CC	-0.025***	-0.022***	-0.016***	-0.014***	-0.008***	-.008***
	SIN	0.000***	0.000***	0.000***	0.000***	0.000***	.000***
	GRS	0.413*	0.366*	0.733***	0.711***	0.612***	.608***
	LR	-0.392***	-0.406***	-0.073***	-0.080***	0.043*	.035
Empirical Results	F	51.157	51.002	86.617	77.842	113.883	-32.685
	R^2	0.341	0.383	0.467	0.486	0.581	0.584

*p<0.1. ** p < 0.05. ***p < 0.01

Table 9. Model with WTR– Check of the Mediating Effect of WTR

Variable		Explained Variable: WTR		Explained Variable: SDI			
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Explanatory Variable	UES		0.159***		0.015***		0.014***
	WTR					0.011***	0.009***
Control Variable	Constant	-2084.258***	-1846.382***	-80.927***	-57.981***	-58.675***	-40.685***
	Y	1.078***	0.959***	0.040***	0.029***	0.029***	0.020***
	CC	-0.014	0.001	-0.016***	-0.014***	-0.016***	-0.014***
	SIN	0.000*	0.000	0.000***	0.000***	0.000***	0.000***
	GRS	0.092	-0.139	0.733***	0.711***	0.732***	0.712***
	LR	1.461	1.386***	-0.073***	-0.080***	-0.088***	-0.093***
Empirical Results	F	31.400	27.766	86.617	77.842	76.736	69.848
	R^2	0.241	0.253	0.467	0.486	0.483	0.498

*p<0.1. ** p < 0.05. ***p < 0.01

Table 8, Table 9, Table 10, and Table 11. shows the combination of regressions results for the testing of mediating effects for FSG, WTR, IOP, and CR. The Model 1 and Model 3 are control groups with only control variables in the model. Model 4 is the Step 1 in the testing procedure, which check the relationship between UES and SDI; Model 2 is the Step 2 that checks the relationship between UES and the tested mediating variables; Model 5 corresponds with Step 3 that tests the relationship between the mediating variables and SDI; Model 6 is Step 4 that examine the nature of the mediating effects.

Table 10. Model with IOP– Check of the Mediating Effect of IOP

Variable		Explained Variable: IOP			Explained Variable: SDI			
		Model 1	Model 2		Model 3	Model 4	Model 5	Model 6
Explanatory Variable	UES		0.579***			0.015***		0.009***
	IOP						0.012***	0.011***
Control Variable	Constant	-1580.156**	-711.230		-80.927***	-57.981***	-62.620***	-49.970***
	Y	0.788**	0.350		0.040***	0.029***	0.031***	0.025***
	CC	-0.097	-0.044		-0.016***	-0.014***	-0.015***	-0.014***
	SIN	0.004***	0.004***		0.000***	0.000***	0.000*	0.000
	GRS	-6.710	-7.554		0.733***	0.711***	0.811***	0.796***
	LR	-2.842**	-3.113***		-0.073***	-0.080***	-0.040**	-0.045**
Empirical Results	F	23.599	21.844		86.617	77.842	147.175	129.363
	R^2	0.193	0.210		0.467	0.486	0.642	0.648

*p<0.1. ** p < 0.05. ***p < 0.01

Table 11. Model with CR– Check of the Mediating Effect of CR

Variable		Explained Variable: CR			Explained Variable: SDI			
		Model 1	Model 2		Model 3	Model 4	Model 5	Model 6
Explanatory Variable	UES		0.106***			0.015***		0.014***
	CR						0.015***	0.013***
Control Variable	Constant	-252.140**	-92.783		-80.927***	-57.981***	-77.097***	-56.818***
	Y	0.125**	0.045		0.040***	0.029***	0.038***	0.028***
	CC	-0.012	-0.002		-0.016***	-0.014***	-0.016***	-0.014***
	SIN	0.000	0.000		0.000***	0.000***	0.000***	0.000***
	GRS	2.162*	2.007		0.733***	0.711***	0.701***	0.686***
	LR	0.170	0.121		-0.073***	-0.080***	-0.075***	-0.081***
Empirical Results	F	2.211	3.576		86.617	77.842	75.171	68.499
	R^2	0.022	0.042		0.467	0.486	0.478	0.494

*p<0.1. ** p < 0.05. ***p < 0.01

The results of Model with FSG indicate that FSG does have mediating effect between UES and SDI. Looking at Model 2, the coefficient of UES on FSG is 0.032 under a significance level of 0.01, which means that urban ESG improvement can promote the growth of financial sector in cities. The result of Model 5 shows that the development of financial sector in a city can significantly contribute to urban sustainable development, with a coefficient of 0.294. In Model 6, UES keeps significant to SDI when adding FSG into the model, so FSG partially mediates the effect of UES on SDI. It should be noticed that even though the effect of UES is still significantly, the significance level drops to weak correlation (p<0.1) from strong correlation (p<0.01). This signifies that FSG dominates the mediating pathways to some extent albeit being a mediating variable with partial effect.

Similar to the Models with FSG, the results of Models with WTR, IOP, and CR respectively demonstrate that urban ESG development is beneficial for the enhancement of pollution treatment (with the coefficient of 0.159, p<0.01), social insurance and welfare (with the coefficient of 0.579, p<0.01), and efficiency of capital uses (with the coefficient of 0.106, p<0.01), and that the three mediating variables are positively related to SDI under the significance level of 0.01. Lastly, through the test of Model 6, it is found that WTR, IOP, and CR are all mediating variables with partial mediation.

3.3. Heterogeneity Tests

Table 12. Results of Grouping Regressions Based on the Rank of Cities GDP

GDP Rank	Variable		Explained Variable: SDI	
			Model 1	Model 2
Rank 1-25	Explanatory Variable	UES		0.051***
	Control Variable	Constant	-69.772***	11.907
		Y	0.035***	-0.006
		CC	-0.024***	-0.007
		SIN	0.000**	0.000***
		GRS	0.741***	0.842***
		LR	-0.049	-0.073
	Empirical Result	F	15.378	21.282
		R^2	0.240	0.334
Rank 26-50	Explanatory Variable	UES		-0.004*
	Control Variable	Constant	-105.037***	-110.694***
		Y	0.052***	0.055***
		CC	-0.004**	-0.003*
		SIN	0.000***	0.000***
		GRS	1.094***	1.129***
		LR	-0.066***	-0.061***
	Empirical Result	F	51.997	44.190
		R^2	0.516	0.522

*p<0.1. ** p < 0.05. ***p < 0.01

Cities' demands of and citizen's awareness of sustainable development affect how factors will contribute to the economic growth. For well-developed cities like Beijing or Shanghai, they are the most representative and concerned cities since the foundation of China; their development represents the overall rising conditions of China, so the high-speed economic growth is not the only important aim, but the improvement of residents' happiness and convenience levels which requires high-quality development. In comparison, less-known and less-developed cities normally focus on economic growth and only pay attention to sustainable development when they fulfill their goals of developing economy. Given the varied intensity of demand on sustainable development from cities, the effect of ESG development on sustainable development may perform differently.

In this study, the heterogeneity between cities with different conditions of economy was tested. Based on the rank of GDP of cities in 2020, the 50 cities used as samples in this study are divided into two groups: Cities ranked 1-25, cities ranked 26-50. Cities in the rank 1-25 are deemed as cities that are economically developed and large, while cities ranked 26-50 are considered as relatively medium or small scaled cities. The effect of urban ESG on urban sustainable development in cities with different size and economic development is checked through grouping regression.

Table 12 shows the regression results of the heterogeneity check between cities with different economic conditions (GDP). The coefficient of UES in group of Rank 1-25 is 0.051 under a significance level of 0.01, and that in group of Rank 26-50 is -0.004 under a significance level of 0.1. This clearly indicates the heterogeneity of the effect of UES on SDI between cities with different economic conditions. For larger cities with relatively developed economy, the effect of UES on SDI is significantly positive, which means UES has a great promoting effect of the high-quality development of big cities. However, in small cities with relatively worse economic conditions, the development of urban ESG is only weakly related to urban sustainable development. More importantly, there is even negative effect for UES on SDI. This means that when the economic development (GDP) of a city does not reach a certain level, developing ESG is meaningless and even reverse for the improvement of high-quality city construction.

Table 13. Results of Grouping Regression Based on Time Periods

Year	Variables		Explained Variable: SDI	
			Model 1	Model 2
	Explanatory Variable	UES		0.021**
2011-2012	Control Variable	Constant	-67.221	-22.660
		Y	0.033	0.011
		CC	-0.017***	-0.015***
		SIN	0.000	0.000
		GRS	1.026***	0.946***
		LR	0.071	0.091
	Empirical Result	F	14.148	12.902
		R^2	0.429	0.454
	Explanatory Variable	UES		0.027**
2013-2015	Control Variable	Constant	-35.137	-11.356
		Y	0.018	0.006
		CC	-0.016***	-0.015***
		SIN	0.000	0.000
		GRS	0.744***	0.738***
		LR	-0.115**	-0.115**
	Empirical Result	F	22.468	20.434
		R^2	0.438	0.462
	Explanatory Variable	UES		0.014***
2016-2020	Control Variable	Constant	-99.894***	-76.067**
		Y	0.050***	0.038**
		CC	-0.016***	-0.014***
		SIN	0.000**	0.000***
		GRS	0.616***	0.585***
		LR	-0.114***	-0.132***
	Empirical Result	F	51.381	47.331
		R^2	0.513	0.539

*p<0.1. ** p < 0.05. ***p < 0.01

In addition, it is believed that cities in different time periods would demand differently for sustainable development. When most cities were in the stage of high-speed growth, the effect of ESG on sustainable development may be weak and non-significant; when most cities have realized the goal of economic growth, their developing goals may turn to high-quality development, and ESG may affect more to it.

Based on that, another heterogeneity test was for the effect of UES on SDI in different periods of time. Three periods were divided based on the release of promoting policies for ESG. In late 2012, The Stock Exchange of Hong Kong Ltd published the first edition of "Environmental, Social, and Governance Reporting Guide". In late 2015, the second edition of "Environmental, Social, and Governance Reporting Guide" was released. These two policies are all promoting for the development of ESG. Since policies always have hysteresis nature, we included the release year of the policy in its former period. Based on that, data were categorized into Period 2011-2012, Period 2013-2015, and Period 2016-2020.

As presented in table 13, the effect of UES on SDI in the three groups are all significantly positive. Looking at the coefficient of UES in models, it is found that it is the largest in the group of 2013-2015, which is inconsistent with our speculation that the effect of UES on SDI is greater in the later periods. The change of the coefficients of UES present an inverted-U relationship, meaning that the marginal benefit of promoting urban ESG development for urban sustainable development decreases after reaching the peak point, as shown in figure 2.

From another perspective, however, the significance of the effect of UES on SDI constantly increases over the three periods. This actually proves that the relationship between UES and SDI becomes stronger over time. The t-value for UES increases from 2011-2012 (t=2.059) to 2013-2015 (t=2.491), and to 2016-2020 (t=3.702). UES is more determinative for urban sustainable development in the period of 2016-2020, but it has lower effect on SDI in that period because SDI has already developed to a certain level, and its growing speed decelerated, causing the diminishing marginal benefit of developing UES on enhancing SDI. In this sense, our speculation is partially demonstrated, with the fact that developing ESG has diminishing marginal return for urban sustainable development.

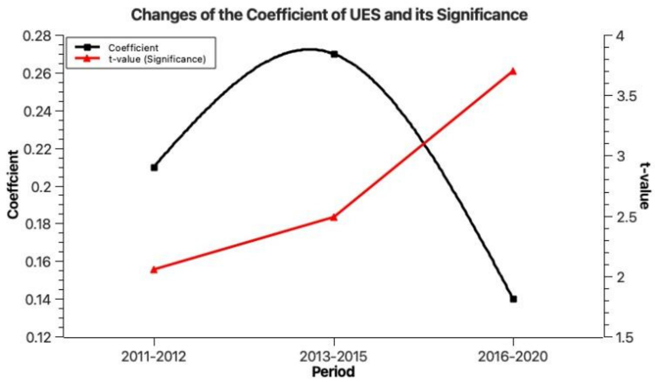

Figure 2. Line Chart of the Coefficient of UES and its significance for its Effect on SDI

4. Conclusion

Our research investigated the relationship between Urban ESG Development and urban sustainable development and the mechanism within the effect and has reached three major findings.

Firstly, through scoping the change of the mean of urban ESG score and urban sustainable development index, we observed a significant steady increase of both UES and SDI over these 10 years (2011-2020). Specifically, average UES rose gradually and steadily while SDI fluctuated more in the year between 2013-2016 and had a steeper changing rate. This finding shows a bloom of ESG and urban sustainable development in Chinese cities and their diverse focus on total development instead of only economic growth. Therefore, our innovative measurement provides evidence to describe the current state of Chinese cities.

Secondly, applying linear regression, our research proved that ESG has a positive correlation with urban sustainable development. Moreover, this effect is partially mediated by four pathways: The Development of the Financial Sector, Pollution Treatment Condition, Social Insurance and Welfare, and Efficiency of Capital Uses. All the mediating variables have demonstrated partial mediating effects between UES and SDI; it should be noted that The Development of the Financial Sector was particularly significant as it accounts for a higher effect ratio than UES, so the mediating effect of FSG is particularly significant. Our findings proved that developing urban ESG is beneficial to the development of financial sector, pollution treatment condition, social insurance and welfare, and the efficiency of capital uses in a city, which would further improve its sustainable development.

Thirdly, heterogeneity test results confirmed that the effect of urban ESG development on urban sustainable development exists in different periods, but further shows two findings: (1) In comparison between regions, ESG, as a contributor to urban high-quality development, is more effective in larger cities with relatively developed economy (top 1-25 GDP cities), but developing ESG may even harm smaller cities with relatively less-developed economy (top 26-50 GDP cities). The reason behind is that, on the one hand, ESG evaluation system is mostly applied to A-share listed companies, which makes it more effective for city with higher GDP (more A-share listed companies); on the other hand, relatively developed economies (top 1-25 GDP cities) have a higher ability to respond the “high-quality development” advocacy that does not only focused on economic development. Their changes would account for a higher weight in national GDP and other variables. (2) In comparison through a time length of 10 years (2011-2020), the changes of the coefficients of UES on SDI have demonstrated an inverted-U track, signifying a diminishing marginal benefit of developing ESG in urban areas. However, we found that the t-value increased throughout time, which means that because of the development of SDI itself, the extent to which all factors promote SDI are decreasing due to the diminishing marginal return, and the significance of the effect of UES on SDI is actually increasing. In this scenario, therefore, promoting the development of UES is still, and even more necessary for urban sustainable development.

Lastly, our research provided a few suggestions for future policies: (1) to prompt the development of local financial sectors, pollution treatment condition, social insurance and welfare, efficiency of capital use in firms, and, most importantly, urban sustainable development, ESG-promoting policies are generally helpful. (2) ESG-promoting policies should be formulated after a comprehensive investigation of the condition of local financial sectors and numbers of A-share listed companies since it is highly correlated with the effectiveness of UES on SDI; otherwise, the policy may hardly reach the expected performance and even have a negative influence. (3) As both ESG development and urban sustainable development have demonstrated a significant increase, policymakers should pay more attention to ESG promoting or even enforcing policies; however, displaying a diminishing marginal benefit entering the late period, policy instructors need cautious cost-benefit analysis, monitoring investment at once with gaining.

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