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An Empirical Study on the Impact of Human Capital on the Quality of Urban Development in Shenzhen—Based on Shenzhen Urban Development Statistics from 2000-2021

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Abstract: *Based on the statistical data of Shenzhen from 2000-2021, the article empirically tests the impact of human capital on the quality of urban development in Shenzhen. It is found that :(1) the former is larger than the latter in the growth rate of human capital and urban development level, and the two have a long-term equilibrium cointegration relationship; (2) there is a significant correlation between the level of human capital and urban development level, and human capital can significantly improve the quality of urban development. Human capital can further promote high-quality urban development by promoting sustainable development of urban economy, urban society and urban ecology, which can provide useful reference for other cities to give full play to the benefits of human capital to promote high-quality urban development.*

Keywords: *human capital; urban quality development; inspiration*

1. Introduction

General Secretary Xi Jinping mentioned in the report of the 20th Party Congress that high-quality development is the key to building a comprehensive socialist modern country. China's economic development has realized the transformation from high speed growth to high quality development, and how to promote high quality development is a hot issue of current research. Shenzhen has developed from a frontier town to a high-quality development metropolis nowadays, which has an exemplary role in China's urban development. Over the past 40 years of reform and opening up, Shenzhen's population has continued to grow at a relatively fast pace, showing the main characteristics of continuous improvement in population quality. In 2021, Shenzhen overcame the severe epidemic situation, made every effort to prevent and resolve major risks, and focused on industrial structure optimization and energy efficiency improvement, with positive industrial output growth of 5% and positive regional GDP growth of 6.7%, 1.5 percentage points higher than the regional GDP growth rate in the same period, accomplishing the task of improving the quality of economic operation in a stable manner and increasing resilience, in which the advantages of human capital play an important role. The research in this paper focuses on the following three aspects: first, what is the impact of human capital, which is a carrier of human beings, on promoting the quality of urban development in Shenzhen? Second, what is the path of human capital's role in promoting quality urban development in Shenzhen? Third, what are the lessons learned from other cities in terms of the benefits of human capital in promoting high-quality urban development?

2. Literature Review

The research results on how human capital promotes high-quality urban development are abundant and focus on the following three aspects: (i) in terms of the sustainable development of human capital on urban economy, Wang Jingbin et al [1] (2022) used PVAR model, Hu Yan et al [2] (2022) based on shift-share analysis, proved that high human capital level can significantly enhance urban resilience of economic development; Xu Shidao et al [3] (2022) conducted an empirical test based on data from 114 resource-based cities in China and concluded that human capital is conducive to promoting the efficiency of urban economic development; (ii) in terms of the impact of human capital on sustainable urban social development, Li Xianbao [4] (2007) argued that high levels of human capital have stronger investment

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incentives and investment payment capacity, which which leads to higher income levels, which is one of the reasons for the gap between rich and poor in society; Zhang Chewei [5] (2006) found, based on a survey of sample data on returns to education, that increasing the level of human capital not only brings economic benefits, but also significantly reduces the gap between rich and poor in the long run, and Kong Lingfeng [6] (2000) argued that the increase and accumulation of human capital levels can effectively reduce urban population pressure and provide a good demographic environment for the high-quality development of society. (iii) In terms of the influence of human capital on the quality of urban ecological development, Huang and Ping [7] (2022) concluded based on the DEG theoretical framework and the construction of urban panel data models that human capital investment in the R&D sector and consumer time discount rate and risk preference have an inverse directional change relationship, and the higher the human capital investment, the better the greening development of the city; Chen, Shiyiyi [8] (2022) by constructing a spatial general equilibrium model with two variables of pollution and cleanliness concluded that the increase in the intensity of environmental regulations can attract the inflow of labor, which can change the structural ratio of high-skilled human capital to a certain extent and promote the improvement of the quality of urban ecological environment.

Reviewing the above research literature, there are both theoretical analyses and empirical analyses based on relevant data to construct models, but most of them analyze the importance of human capital to improve the quality of urban development from macro and meso levels such as national level, city clusters, etc. Different urban areas have different development differences, and the existing literature has less research on representative cities on micro level. Shenzhen is an important model of high-quality urban development. This paper intends to construct an evaluation index system of Shenzhen's urban development quality and human capital from a micro perspective, and construct a regression model based on data standardization to study the influence of human capital level on Shenzhen's urban development quality, and the research findings can provide inspiration and experience for other cities to promote high-quality urban development from the perspective of human capital.

3. Measurement methods of urban development quality level and human capital level

3.1. Construction of evaluation index system and explanation of data sources

3.1.1. Construction of urban development quality indicators

Table 1: Urban development quality (UDQ) evaluation index system.

Primary indicators	Secondary indicators	Tertiary indicators	Attributes
Urban Development Quality (UDQ)	Economic Quality	GDP per capita (Yuan) (Y1)	Positive
		Share of tertiary industry (%) (Y2)	Positive
		Disposable income of urban residents (yuan) (Y3)	Positive
		Total retail sales of social consumption (RMB) (Y4)	Positive
	Quality of social development	Urban Engel coefficient (%) (Y5)	Inverse
		Urban and rural registered unemployment rate (%) (Y6)	Inverse
		Financial education expenditure per capita (yuan) (Y7)	Positive
	Ecological quality	Road and traffic area per capita in municipal areas(square meters) (Y8)	Positive
		Greening coverage rate of built-up areas (%) (Y9)	Positive
		Household waste disposal rate (%) (Y10)	Positive

According to the comprehensive connotation of urban development quality, following the scientific and comprehensive nature of evaluation indexes and the availability and validity of data, this paper, based on the research of urban development quality level index system constructed with reference to (Ying

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Xiao et al., 2018 [9]; Peng Lv et al., 2022 [10]), combined with the actual situation of Shenzhen's geographical area, constructs the urban development quality as the primary index, economic quality, social quality, ecological quality as the secondary index, per capita GDP, the proportion of tertiary industry as the primary index, and the quality of human capital as the secondary index. development quality and ecological quality as secondary indicators, and 10 individual indicator layers such as GDP per capita, the proportion of tertiary industry and urban residents' disposable income as tertiary indicators, and the indicators are used to comprehensively characterize the urban development quality (UDQ) of Shenzhen. For details, see Table 1.

3.1.2. Human capital level index system construction

The article refers to the study of human capital level index system constructed by (Yan Chun et al., 2017 [11]; Su Yan, Lu Jin, 2019 [12]) based on the connotation of human capital, the comprehensiveness and scientificity of indicators, and the availability of data, and measures human capital from two aspects of brain quality and physical quality, and mainly constructs a rating index system with innovation ability, education scale, quality of life, and The rating index system with innovation ability, education scale, quality of life, health care as secondary indicators and seven indicators such as the number of patents granted, the number of general colleges and universities, and the natural population growth rate as tertiary indicators is constructed to comprehensively characterize the level of human capital (HR) in Shenzhen. For details, see Table 2 below.

Table 2: Human capital (HR) evaluation index system.

Primary indicators	Secondary indicators	Tertiary indicators	Attributes
Human Capital Level (HR)	Economic Quality	Number of patents granted (pieces)(X1)	Positive
	Innovation Capability	Research and experimental development (R&D) expenditure (million yuan)(X2)	Positive
			Positive
		Total retail sales of social consumption (RMB) (Y4)	Positive
	Quality of social development	Urban Engel coefficient (%) (Y5)	Inverse
		Urban and rural registered unemployment rate (%) (Y6)	Inverse
		Financial education expenditure per capita (yuan) (Y7)	Positive
	Ecological quality	Road and traffic area per capita in municipal areas(square meters) (Y8)	Positive
		Greening coverage rate of built-up areas (%) (Y9)	Positive
		Household waste disposal rate (%) (Y10)	Positive

3.1.3. Description of data sources

The data for the study of this paper are mainly from the China City Statistical Yearbook 2000-2021, Shenzhen Statistical Yearbook, Shenzhen Science and Technology Funding Input Bulletin, Guangdong Statistical Yearbook, etc. For the missing data, linear interpolation method and regression method are used for technical processing.

3.2. Standardization of indicators and determination of weights.

3.2.1. Polar difference standardization

In order to reduce the impact of errors generated by evaluation indicators with different attributes, units and magnitudes, this paper adopts the method of polarization standardization to carry out dimensionless processing of each evaluation indicator. It is divided into positive indicator processing and negative indicator processing, and the specific standardization formula is as follows.

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(1) Positive indicators:

$$X'_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)} \quad (1)$$

(2) Negative indicators:

$$X'_{ij} = \frac{\max(X_j) - X_{ij}}{\max(X_j) - \min(X_j)} \quad (2)$$

where: represents the dimensionless data of each indicator (i=1,2,3...n; j=1,2,3...m), Xij denotes the jth indicator value in year i, max(xij) and min(xij) are the maximum and minimum values of the corresponding indicator values, respectively.

3.2.2. Determination of index weights by the coefficient of variation method

Based on the dimensionless processing of the data using the polarization method, the coefficient of variation method is used to determine the weights of each index. The specific calculation formula is as follows.

Coefficient of variation:

$$V_i = \frac{\delta_i}{|\mu_i|} \quad (3)$$

Weights:

$$w_i = \frac{V_i}{\sum_{i=1}^{i} V_i} \quad (4)$$

Vi is the coefficient of variation, and $\delta_i = \left[\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2\right]^{\frac{1}{2}}$ is the standard deviation; $\mu_i = \frac{1}{N}\sum_{i=1}^{N} x_i$ is the mean value. The weights of each index can be derived by combining equations (3) and (4), as detailed in Table 3 below.

Table 3: Weights of each indicator of urban development quality (UDQ) and human capital (HR)

Urban Development Quality Indicators	Weights	Human Capital Metrics	Weights
Y1	0.097828	X1	0.170191
Y2	0.101747	X2	0.409631
Y3	0.130752	X3	0.055296
Y4	0.130828	X4	0.076181
Y5	0.13191	X5	0.089804
Y6	0.079473	X6	0.084855
Y7	0.164528	X7	0.114043
Y8	0.070743		
Y9	0.048901		
Y10	0.043289		

3.3. Urban development quality and human capital level measurement

Urban development quality level:

$$UDQ = \sum_{i=1}^{i} w_i y_{ij} \quad (5)$$

Level of human capital:

$$HR = \sum_{i=1}^{i} w_i x_{ij} \quad (6)$$

Using equations (5) and (6), the level of quality of urban development and the level of human capital are measured.

3.3.1. Model construction

Based on the above index construction and data collation, in order to reduce the impact of errors

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caused by the unstable and unbalanced time series, the urban development quality level (UDQ) and human capital level (HR) are treated by taking the logarithm of the natural logarithm respectively, and the following econometric model is constructed:

$$LNUDQ = \alpha_1 + \alpha_2 LNHR + \varepsilon \quad (7)$$

Where, ε is the random perturbation term.

4. Empirical tests and analysis of results

4.1. Analysis of urban development quality and changes in human capital level

The innovation diffusion effect and spillover effect generated by the absorption of technology and knowledge by human capital can significantly promote the improvement of urban development quality (Li Xianbao, 2007) [4]. Using the data of urban development quality level and human capital level to calculate the growth rate between them every two years, as shown in Figure 1 below, it can be seen that the growth rate of human capital level in Shenzhen is greater than the growth rate of urban development quality level in the period of 2000-2021. And the growth rates of the two have trend coincidence in the general trend, which indicates that there is a certain cointegration relationship between the two, and the Shenzhen government has promoted the improvement of the level of urban development quality while vigorously improving the level of human capital.

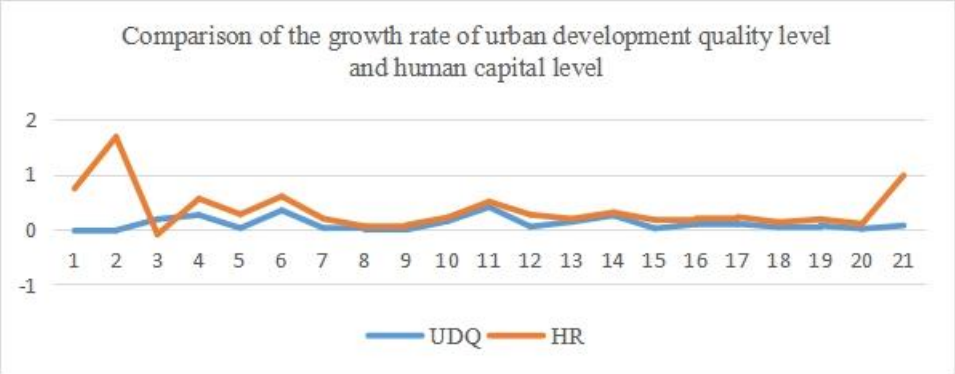

Figure 1: Comparison of growth rate of urban development quality level (NDQ) and human capital level (HR).

4.2. Urban development quality, human capital correlation analysis

Table 4: Urban development quality level (UDQ), human capital level (HR) overall Pearson correlation test.

		UDQ	HR
UDQ	Pearson Correlation	1	.883***
	Sig. (bobtail)		0.000
	Sum of squares and product of forks	1.770	1.126
	covariance	0.084	0.054

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

From Table 4 above, the overall Pearson correlation coefficient between the level of human capital and the level of urban development quality is 0.883 and significant at the 1% significance level, indicating that human capital and urban development quality of Shenzhen have a significant and extremely strong positive correlation.

In order to investigate the correlation between the level of human capital and the level of urban development quality, the Pearson correlation test was used to examine the correlation between human capital and urban development quality indicators Y_1-Y_{10}10, and the results are detailed in Table 5 above. The Pearson correlation coefficients of road and traffic area per capita, and greening coverage of built-up areas are 0.860, 0.853, 0.891, 0.861, 0.902, and 0.714, respectively, and they are all significant at the significance level of 1%, indicating that the six indicators of human capital and urban development quality are highly positively correlated at the 1% significance level, which is similar to the research

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results of (Ying Xiao et al., 2018) [9]'s research results are consistent. Human capital and the proportion of tertiary industry have a highly positive relationship, indicating that human capital can promote the optimization of industrial structure, which is consistent with the findings of (Kesha Guo, 1999) [13]. The Pearson correlation coefficient between human capital and the rate of harmless domestic waste disposal is 0.440, indicating a weak correlation at 5% significance level. The Pearson correlation coefficients of human capital and urban Engel coefficient and urban-rural registered unemployment rate are -0.652 and -0.727, respectively, indicating a significant negative correlation between human capital and these two indicators at the 1% significance level. It also proves that the increase of human capital level can suppress the increase of urban and rural unemployment rates to a certain extent.

Table 5: Pearson correlation test for each indicator of human capital and urban development quality.

Indicators	Indicator serial number	Pearson	Sig. (bobtail)
GDP per capita	Y1	0.860***	0.000
Share of tertiary industry	Y2	0.853***	0.000
Disposable income of urban residents	Y3	0.891***	0.000
Total retail sales of social consumption	Y4	0.861***	0.000
Urban Engel coefficient	Y5	-0.652***	0.001
Urban and rural registered unemployment rate	Y6	-0.727***	0.000
Financial education expenditure per capita	Y7	0.902***	0.000
Road and traffic area per capita in urban areas	Y8	0.714***	0.000
Greening coverage rate of built-up areas	Y9	0.312	0.158
Harmless treatment rate of domestic waste	Y10	0.440**	0.040

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

4.3. Regression analysis of human capital and urban development quality

4.3.1. Time series smoothness test

In order to test whether the series of Shenzhen urban development quality (LNUDQ) and human capital level (LNHR) from 2000 to 2021 are smooth, Eviews10 was used to test the unit root smoothness of both, and the results are shown in Table 6 below. The results show that the series LNUDQ and LNHR are smooth at 1% significance level, and the next OLS regression analysis can be conducted.

Table 6: LNUDQ LNHR -ADF test.

	Variables	Original level	First order differential
1% level	UDQ	-4.069	-3.809
	HR	-4.138	-3.809
5% level	UDQ	-3.127	-3.022
	HR	-3.155	-3.022
10% level	UDQ	-2.702	-2.651
	HR	-2.714	-2.651
t-Statistic	UDQ	-1.05	-4.629
	HR	8.266	-4.466
Prob.	UDQ	0.734	0.000***
	HR	1	0.000***
Conclusion	UDQ	Non-stationary series	Smoothing sequence
	HR	Non-stationary series	Smoothing sequence
Based on lags=9			

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

4.3.2. OLS regression analysis

According to the constructed model (7), OLS regression analysis was performed using Eviews10 on the LNUDQ and LNHR series that passed the unit root smoothness test, and the results are detailed in Table 7 below.

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Combining with equation (7), the regression equation can be obtained as follows:

$$LNUDQ = 0.238479 + 0.683365LNHR \quad (8)$$

From the calculated regression equation, we can get: the decidable coefficient R2=0.869059; the adjusted decidable coefficient is 0.862512, which indicates that the overall model fits well and the absolute change of human capital level can cause the relative change of Shenzhen urban development level. The p-value of LNHR is 0.0000 and the coefficient is 0.683, which indicates that at 1% significance level, the model as a whole significant, human capital has a significant positive impact on the quality of urban development in Shenzhen.

Table 7: OLS regression results of urban development quality (LNUDQ), human capital level (LNHR).

	Coef	Std.Err	t	p	95% CI
Constants	0.238	0.118	2.023	0.057	0.007 ~ 0.470
LNHR	0.683	0.059	11.521	0.000***	0.567 ~ 0.800
R2	0.869				
Adjusted-R2	0.863				
F	F (1,20)=132.740,p=0.000				
D-W	2.079				

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

4.3.3. E-G two-step cointegration test

To test whether the level of human capital (LNHR) and urban development quality (LNUDQ) have equilibrium cointegration relationship, E-G cointegration test is done for both using Eviews10.

In the first step, in the previous ADF smoothness test, the level of urban development quality (LNUDQ) and the level of human capital (LNHR) are single integer of the same order, i.e., LNUDQ~I(1) and LNHR~I(1), and dynamic regression is done on the series taking the natural logarithm to find the residual term e.

$$LNUDQ = \alpha_1 + \alpha_2 LNHR + \varepsilon \quad (9)$$

In the second step, the unit root test is done for the residual term, and the results are shown in Table 8 below. The residual series pass the unit root test, indicating that the level of human capital (LNHR) and urban development quality (LNUDQ) have a long-term stable cointegration relationship, excluding the pseudo-regression phenomenon.

Table 8: ADF test for residual series.

	level	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.250545		0.0025**
Test critical values:	1% level	-2.679735	
	5% level	-1.958088	
	10% level	-1.607830	

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

5. Research Conclusions and Countermeasure Suggestions

5.1. Research Conclusions

In order to further investigate the influence of human capital on urban development quality from the micro perspective of cities, this paper takes Shenzhen, which ranks among the top cities in China in terms of urban development quality, as an example, and constructs a regression model and analyzes the model empirically based on 21 years of relevant statistical data from 2000-2021 in Shenzhen, based on the analysis of the changes of urban development quality level and human capital level in Shenzhen, according to the empirical results , the following conclusions are drawn:

1) From the data and comparative graphs of the growth rate of urban development quality level and human capital level and the results of the E-G two-step cointegration test, it can be seen that the human capital level of urban development quality level in Shenzhen has gained a large increase during the 21-year period from 2000 to 2021, and the latter is larger than the former in terms of growth rate, and the two have a cointegration relationship in the long-term growth rate change trend, and the increase of

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human capital level The increase in the level of human capital has driven the improvement in the quality of urban development.

2) The results of Pearson correlation test between the level of urban development quality and the level of human capital show that they are significantly correlated on the whole, and human capital in Shenzhen has a significant positive correlation on several indicators of urban development quality, which indicates that human capital can make a positive positive contribution to the improvement of economic development quality, social development quality and ecological development quality subsystems in the urban development quality framework.

3) In the OLS regression results, the elasticity coefficient of human capital on the level of urban development quality is 0.683365, indicating that for every 1 percentage point increase in the level of human capital, the overall level of urban development quality in Shenzhen will increase by 0.683365 percentage points, and human capital has a significant positive contribution to the overall level of urban development quality in Shenzhen at the 1% significance level.

5.2. Insights

Combining the construction of secondary indicators of urban development quality and the results of empirical analysis, this paper intends to make a summary of the important role of human capital in improving the quality of economic development, social development and ecological development, which can provide experience for other cities to give full play to the benefits of human capital to promote high-quality urban development.

First, by increasing human capital investment, the optimization and upgrading of industrial structure is promoted to improve the quality of urban economic development. In the results of Pearson correlation test, the correlation coefficient between human capital and the proportion of tertiary industry is as high as 0.853, indicating that human capital has a significant positive contribution to the development of tertiary industry at 1% significance level. Improving the level of human capital can promote the dissemination of knowledge and technology, which in turn can improve the quality of labor force, promote the flourishing of service industry, increase the proportion of tertiary industry in the three industries, optimize the industrial structure, and realize the high-quality development of urban economy. Therefore, city managers should invest more in human capital to effectively improve the level of human capital and achieve sustainable development of the city economy.

Second, by increasing the investment in human capital, the registered unemployment rate of urban residents is reduced, the disposable income of urban residents is increased, and the quality of urban social development is improved. In the Pearson correlation test, the correlation coefficients between human capital and urban residents' Engel coefficient, urban residents' registered unemployment rate, and urban residents' disposable income are -0.652, -0.727, and 0.891, respectively, indicating that the improvement of human capital level can improve the employment level and income level of urban residents, and thus improve people's living standard. Thus, urban managers should increase the level of science and technology by increasing the expenditure on science and technology for economic and development research (R&D) costs, bringing into play the spillover effect of technological knowledge dissemination, and increasing the stock of human capital per capita in society, which is important for reducing the unemployment rate of urban residents, increasing disposable income, and improving living standards, which is also the right thing to do to achieve sustainable development of urban society.

Third, by increasing the level of human capital, improving the comprehensive quality of people, promoting the upgrade of green technology research and development, and improving the quality of urban ecological sustainable development. In the Pearson correlation test, the correlation coefficient between human capital and the rate of harmless disposal of domestic waste, a tertiary indicator of urban development quality, is 0.440, and it is significant at the significance level of 5%, human capital has a positive contribution to the rate of harmless disposal of urban domestic waste. The improvement of human capital level can improve the comprehensive quality of people on the one hand, which provides guarantee for the development of urban civilization; on the other hand, it promotes the research, development and upgrading of environmental protection technology, which provides a new path for the green transformation and upgrading development of enterprises and promotes the construction of an environment-friendly society. Therefore, city managers should enhance the level of human capital for all people as a grasp, strengthen the expenditure in the field of education and increase the investment in human capital, which not only has an important role in promoting the improvement of people's quality and the research and development of green development technology, but also promotes the sustainable

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development of urban ecological quality.

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