

Sustainable Development of Human Capital Structure and Firm Performance

—Based on Chinese A-Share Listed Companies

Yan Zhang^{1,2}, Rujian Lian¹

¹School of Political Science and Public Management, Shanxi University, Taiyuan, China

²Faculty of International Trade, Shanxi University of Finance and Economics, Taiyuan, China

Email: 422913397@qq.com

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Abstract

Human capital is identified as one of the main determinants of firm performance. Nevertheless, existing studies have to some extent ignored the effect of human capital structure on enterprise performance. This paper is based on Chinese A-Share Listed Companies from 2010 to 2022, not only the impact of sustainable development of human capital structure on firm performance are discussed, but also the different intermediate paths of the change of human capital structure on enterprise performance are explored. By constructing a sustainable index of human capital structure and a relative peer human capital structure index, we found that sustainable development of human capital structure is an important driving factor in improving firm performance. We also found that there is no positive interaction mechanism between human capital and innovation, and the interaction mechanism is affected by the level of human capital structure and innovation; the internal pay gap has a negative regulatory effect on the sustainable development of human capital structure on enterprise performance; labor productivity plays a part of intermediary effect in the impact of sustainable development of human capital structure on enterprise performance. Furthermore, we proved the importance of sustainable development of a human capital structure for enterprise performance based on the regional market. This paper has important reference value for human resource management. Specifically, managers should not only pay attention to improving the level of human capital structure, but also explore and establish interaction mechanisms between human capital and innovation, and pay attention to the moderating role of the internal pay gap.

Keywords

Sustainable Index of Human Capital Structure, Relative Peer Human Capital

1. Introduction

Human resources management refers to a series of management activities of enterprises, for example, staff recruitment and selection, training and development, etc., the human capital structure of enterprises has changed in this process. However, existing studies have to some extent neglected the importance of human capital structure for firm performance.

Modern firm development relies on human capital. Since [Schultz \(1960\)](#) first proposed the concept of human capital, a lot of research has proved that human capital is the most important resource for firm development ([Scherer, 1965](#); [Hurwitz et al., 2002](#)). The measurement of human capital includes two aspects: human capital stock and human capital structure ([Schultz, 1960, 1961](#)). Compared with human capital stock, human capital structure is more important for the development of enterprises. There are two reasons why human capital structure is important in this context. First, over the last few decades, several studies have shown that the higher education level of staff, the stronger ability to information collection and the recognition of employees, the better absorption of new ideas, and the faster adoption of new production technologies ([Doms & Lewis, 2006](#)). Second, high-quality human capital can engage in low-level human capital work, and the converse is not true.

Nevertheless, a lot of research is almost based on human capital stock, and mainly explores the impact of human capital stock on firm development ([Youndt, 1996, 2004](#); [Weisberg, 1996](#); [Bontis & Fitz-enz, 2002](#); [Giannetti et al., 2015](#)). Especially in China, numerous scholars have focused on the management of human capital in enterprises. [Alchian and Deynsetz \(1972\)](#) pointed out that the enterprise is essentially a human capital team, therefore, the objective of this paper is to study the direct effects of sustainable development of human capital structure on enterprise performance, as well as indirect effects embodied in the interaction between human capital structure and innovation, while controlling for other determinants reported in the literature.

The evolution of human capital from primary to advanced level is one of the typical characteristics of a strategy of “reinvigorating China through human resource development”. This change in human capital structure has been proven to be an important source of economic growth from the macro level ([Liu et al., 2018](#)). To examine the effect of human capital structure on firm performance, we define sustainable development of human capital structure as the process of a company or region improving its human capital structure and moving from human capital with low-level education to higher-level education. We construct a measure of a sustainable index of human capital structure and a relative peer

human capital structure index. We find that sustainable development of human capital structure is conducive to improving enterprise performance, however, there are no mutually reinforcing mechanisms between the process of sustainable development of human capital structure and innovation for firm development. Labor productivity plays a part of intermediary effect in the impact of sustainable development of human capital structure on enterprise performance, while the internal pay gap plays a negative moderating role in the impact of the sustainable development of human capital structure on corporate performance.

Our paper makes two primary contributions to the literature. First, instead of simply measuring human capital structure by employee proportion at different educational levels, we construct a sustainable index of human capital structure and a relative peer human capital structure index, explore the overall impact of the sustainable development of human capital structure on enterprise performance, which is influenced by the nature of enterprise property rights. Second, we first explore the interaction between human capital structure and innovation, the intermediary effect of labor productivity and the moderating effect of the internal pay gap, which helps to uncover the black box between human capital and enterprise performance.

The remainder of the paper is organized as follows. Section 2 develops hypotheses for the impact of sustainable development of human capital structure on firm performance. Section 3 describes the data and discusses the construction of our key variables. Section 4 presents empirical tests of the impact of sustainable development of human capital structure on firm performance, at the same time, presents the tests of influence mechanism. Section 5 presents our additional analysis based on regional human capital structure. Section 6 conducts robustness tests. Section 7 concludes.

2. Hypotheses

Over the last few decades, studies found that human capital has a direct effect on firm performance, because people with more education are more productive and innovative, which leads to the creation of new products and improving the productivity of factors (Romer, 1990; Benhabib & Spiegel, 1994; Teixeira & Fortuna, 2011; Bodman & Le, 2013). The accumulation of human capital is mainly formed through education, so it is reasonable to believe that the higher education level of staff, the greater contribution to enterprises. The sustainable development of human capital structure is the process of increasing the proportion of high-quality human capital, thus forming a human capital structure dominated by high-quality talents, which is conducive to the digestion, absorption and application of various new technologies, as well as the promotion of enterprise innovation, and thus is conducive to improving enterprise performance. We propose that the higher level of human capital structure, the greater contribution to enterprises. Most studies show a positive and significant relationship between human capital and economic development (Bodman & Le, 2013; Hall & Jones, 1999). At the

same time, we further consider the nature of property rights of enterprises, based on which we put forward Hypothesis 1a.

Hypothesis 1a (H1a). *The higher level of human capital structure, the better performance of enterprises, which is influenced by the nature of property rights of enterprises.*

At the same time, because of the differences in the distribution of human capital among industries, human capital is different in different industries. Usually, there is a similar demand for talent in the same industry. Therefore, in order to further demonstrate the impact of sustainable development in human capital structure on enterprise performance, this paper proposes and constructs relative peer human capital structure index, and puts forward Hypothesis 1b on the basis of Hypothesis 1a.

Hypothesis 1b (H1b). *Compared with other enterprises in the same industry, the higher level of human capital structure, the smaller adverse impact on enterprises.*

Over the last few decades, a large body of literature has been produced examining the role of human capital and innovation in determining the enterprises growth. However, existing studies have to some extent neglected the influence of interaction between human capital structure and innovation. Human capital and innovation essentially belong to resources and capabilities, there is interaction between them in the process of influencing the development of enterprises. For example, Chesbrough (2004) has proved that human capital and innovation have complementary effects. In the process of promoting enterprise innovation, the breakthrough of enterprise innovation will lead to the further accumulation of human capital. In other words, human capital is the source of enterprise innovation, innovation can further encourage workers and enterprises to invest in human capital.

However, the interaction effect between human capital structure and innovation is influenced by factors such as the level of human capital structure and innovation. For example, enterprises whose human capital structure level and innovation level are relatively low, there may be mutual restriction between them, that is, the low level of human capital structure will inhibit the innovation level of enterprises, and the enterprises with low innovation ability may think little of improvement their human capital. As a result, this negative chain reaction leads to the decline of enterprise performance. Specifically in China, there is a mismatch between innovation investment and human capital (China Entrepreneur Survey System, 2015). For example, R&D investment in real estate industry is in the lower levels in all industries, but their proportion of university students is in the third place in all industries. From the above, we assume that:

Hypothesis 2a (H2a). *The interaction between sustainable development of human capital structure and innovation helps to improve enterprise performance.*

Hypothesis 2b (H2b). *The interaction between sustainable development of*

human capital structure and innovation is not conducive to the development of enterprises.

The concept of human capital can be interpreted as the set of intangible resources embedded in the labor factor, which have improved its productivity. Black and Lynch (1996) and Ichniowski and Shaw (2003) have proved that human capital affects labor productivity, the higher level of human capital, the higher labor productivity and the greater contribution to enterprises. Then, the sustainable development of human capital structure can theoretically improve the labor productivity, which helps to improve the performance of enterprises. From the above it is conjectured that:

Hypothesis 3 (H3). *Labor productivity plays an intermediary role in the impact of sustainable development of human capital structure on enterprise performance.*

It has been proved that material incentive to talents is the fundamental way to stimulate their innovation ability. Compensation incentive is the most effective and widely accepted currently. At present, there are two opinions in compensation incentive. One is the championship theory, which advocates that a larger pay gap is conducive to improving corporate performance, and the other is the behavioral theory, which believes that a smaller pay gap is conducive to the whole team cooperation, that is conducive to improving corporate performance. So, what role does the pay gap play in the process that sustainable development of human capital structure is conducive to the development of enterprises? It has been found that Chinese pay more attention to fair distribution than other countries (Kim & Leung 2007), Chinese have higher job satisfaction under fair distribution (Pillai et al., 2001). Based on this, we formalize this discussion with the following testable hypotheses.

Hypothesis 4 (H4). *The internal pay gap plays a negative moderating role in the impact of sustainable development of human capital structure on enterprise performance.*

3. Data and Variables

3.1. Sample Construction

We construct our sample from A-share Listed Companies in China during the period from 2000 to 2022. Employee education background comes from Wind database, Choice database and manual collection of annual reports, due to the incomplete collection of this indicator in each database, the data is checked one by one through these three channels to ensure its integrity. The number of patent applications comes from the National Patent Application Network and CSMAR database. Tobin Q, total debt, total asset and net asset return rate come from Wind Database. The educational background of employee in various provinces comes from China Labor Statistics Yearbook.

We further process the initial sample data in the following procedures. First,

enterprises with five consecutive years' absence of employee education background should be deleted, and enterprises with three consecutive years' absence of patent applications should be deleted. Second, if the number of patent applications is still missing, the number is replaced by zero. Third, all variables are winsorized at the 1st and 99th percentiles of their distributions except sustainable index of human capital structure and relative peer human capital structure index. These requirements result in an initial sample of 2367 companies with a total of 17,566 data, when Tobin Q was used to measure corporate performance. When the number of patents is used to measure the innovation level, there are 1886 enterprises with a total of 13902 data.

3.2. Sustainable Index of Human Capital Structure

Sustainable development of human capital structure refers to the process in which a company or region adjusts and optimizes the structure of human capital, promotes the coordinated development of various types of human capital, gradually reduces the proportion of primary human capital and gradually increases the proportion of advanced human capital, in order to continuously meet the needs of high-quality human capital in economic and social development (Liu et al., 2018). Schultz (1960, 1961) has proved that human capital mainly accumulates through education. We construct a measure of sustainable index of human capital structure based on employee education background. The specific construction process is as follows:

First, rank workers according to their education level. Employees in enterprises are divided into four categories according to their educational background: senior high school, junior college, undergraduate and master. Take the proportion of each type of employees as a component of the space vector in proper order, a set of four-dimensional human capital space vectors is formed as

$$X_0 = (x_{0,1}, x_{0,2}, x_{0,3}, x_{0,4}).$$

Second, Choose the basic unit vector group ($X_1 = (1,0,0,0)$, $X_2 = (0,1,0,0)$, $X_3 = (0,0,1,0)$, $X_4 = (0,0,0,1)$) as the reference vector, Calculate human capital space vector X_0 and the angle of θ_j ($j=1,2,3,4$) in proper order according to Formula (1):

$$\theta_j = \arccos \left(\frac{\sum_{i=1}^4 (x_{j,i} * x_{0,i})}{\left(\sum_{i=1}^4 x_{j,i}^2 \right)^{1/2} * \left(\sum_{i=1}^4 x_{0,i}^2 \right)^{1/2}} \right) \quad (1)$$

where $x_{j,i}$ represents the i -th component of the basic unit vector group X_j ($j=1,2,3,4$); $x_{0,i}$ represents the i -th component of vector X_0 .

Third, define the weight of angle θ_j , calculate sustainable index of human capital structure according to Formula (2):

$$HS = \sum_{j=1}^4 (W_j * \theta_j), \quad W_j \text{ is the weight of } \theta_j \quad (2)$$

W_j is calculated from the coefficient of variation V_j of θ_j , where $TV = V_1 + V_2 + V_3 + V_4$, $W_j = V_j / TV$. We have found that human capital with relatively low education level has relatively high weight. In order to facilitate the comparison between companies, set the weight of human capital about master's degree to 1. According to the level of employees' education from high to low, set the weights of human capital are 1, 2, 3 and 4 in order. According to the monotonous decreasing nature of anti-cosine function, if the proportion of human capital with lower education drops faster and the proportion of human capital with higher education rises more, θ_j will be larger. Therefore, the bigger of HS , the higher human capital structure level.

3.3. Relative Peer Human Capital Structure (RPS) Index

According to the industry classification, peer firms are from the same industry. This paper further constructs relative peer human capital structure index on sustainable index of human capital structure, which can analyze the impact of different companies in the same industry on corporate performance due to their differences in human capital structure. The reason for this approach is motivated by recent research (Francis et al., 2016). The concrete steps are as follows: according to China Securities Regulatory Commission's Guidelines for Classification of Listed Companies (Chinese Securitise Regulatory Commission, 2012), the enterprises in the sample are divided into 19 industries.

We rank both firm i and its peer companies by their HS of the previous year and assign a value of zero to the firm that has the lowest human capital structure score and the value $N - 1$ to the firm that has the highest human capital structure score, assuming a firm i has N peers. The relative peer structure index (RPS) of firm i at the beginning of fiscal year t can be formally defined as Formula (3):

$$RPS_{i,t} = 1 - \frac{rank_{i,t}}{N_{i,t}} \quad (3)$$

where $rank_{i,t}$ represents the rank value of firm i among its peers in ascending order, $N_{i,t}$ represents the total number of companies in the same industry in year t for firm i . The higher of RPS , the lower level of human capital structure. For example, firm i have 10 peers in the same industry. If firm i ranks second in that year according to HS_{t-1} in ascending order, the RPS score of firm i should be 0.9, if firm i ranks eighth in that year based on HS_{t-1} in ascending order, its RPS score should be 0.3. RPS reports the fraction of peers that have higher human capital structure scores than firm i . By construction, it is always between zero and one. The higher of RPS , the higher level of human capital structure peer firm i faces.

3.4. Control Variables

Griliches et al. (1991) pointed out that the number of patent applications of enterprises can more truly reflect the level of innovation of enterprises. Compared

with R&D investment, this index can reflect the contribution of all human capital better. So in this paper, the number of patents applied by enterprises is used to measure the innovation ability of enterprises. We use Tobin Q to measure corporate performance, because existing research has found that Tobin Q can combine corporate market data with corporate financial data, and it is not easy to operated by people, and can reflect the long-term performance of the company. The control variables include company size, debt asset ratio, asset growth rate and net asset return rate. The control variables at the regional level involve the average wage and GDP per worker. All variables are detailed in **Table 1**.

3.5. Model Setting

Based on the existing literature, Model (4) and Model (5) are established to test the impact of sustainable development of human capital structure on corporate performance, Model (6) is established to test the interaction between human capital structure and innovation, Model (7) and Model (8) are established in order to test the intermediary effect of labor productivity, Model (9) is established to test the moderating effect of internal pay gap.

$$Q_{it} = \alpha_0 + \alpha_1 HS_{it-1} + \alpha control_{it-1} + \mu_i + v_i + \varepsilon_{it} \quad (4)$$

Table 1. Variable definitions.

Variable	Description
<i>Q</i>	Tobin Q
<i>HS</i>	Sustainable index of human capital structure, calculated by Formula (2)
<i>RPS</i>	Relative peer human capital structure index, calculated by Formula (3)
Leverage	Debt asset ratio
Size	Company size, is computed as the log of market value
Growth	Asset growth rate, $(asset_t - asset_{t-1})/asset_{t-1}$
Equity	Return on net assets, net profit divided by the average value of shareholder's equity at the beginning of year plus equity at the end of year
Wage	Average wage increase rate of employees in the province where the enterprise are headquartered
Per GDP	Growth rate of per capita gross domestic product in the province where the enterprise are headquartered
Apply	Measuring innovation level by the number of patent applications annually in company
Lz	Labor productivity growth rate, labor productivity in t -year minus labor productivity in $t - 1$ year, divided by labor productivity in $t - 1$ year, labor productivity is the main business income divided by the number of employees
Gap	Internal pay gap, per capita compensation of management divided by per capita compensation of ordinary employees. Management includes board of directors, board of supervisors and executives

$$Q_{it} = \alpha_0 + \alpha_1 RPS_{it-1} + \alpha control_{it-1} + \mu_i + \nu_i + \varepsilon_{it} \quad (5)$$

$$Q_{it} = \alpha_0 + \alpha_1 HS_{it-1} + \alpha_2 HS_{it-1} * apply_{it-1} + \alpha_3 apply_{i,t-1} + \alpha control_{it-1} + \mu_i + \nu_i + \varepsilon_{it} \quad (6)$$

$$lz_{it} = \alpha_0 + \alpha_1 HS_{it-1} + \alpha control_{it-1} + \mu_i + \nu_i + \varepsilon_{it} \quad (7)$$

$$Q_{it} = \alpha_0 + \alpha_1 HS_{it-1} + \alpha_2 lz_{it-1} + \alpha control_{it-1} + \mu_i + \nu_i + \varepsilon_{it} \quad (8)$$

$$Q_{it} = \alpha_0 + \alpha_1 HS_{it-1} + \alpha_2 HS_{it-1} * gap_{it-1} + \alpha_3 gap_{it-1} + \alpha control_{it-1} + \mu_i + \nu_i + \varepsilon_{it} \quad (9)$$

From Model (4) to Model (9), i represents the firm, t represents the year, u_i represents the firm fixed effect, ν_i represents year fixed effect, $control$ represents control variables.

4. Empirical Results

4.1. Descriptive Statistics

Table 2 provides descriptive statistics for all variables. The mean of sustainable index of human capital structure is 10.1642, the maximum is 12.8142, the minimum is 9.4579, and the standard deviation is 0.7159. The mean of relative peer human capital structure index is 0.4044, the maximum is 0.9935, the minimum is 0.0013, and the standard deviation is 0.2837. We can find that there are great differences in human capital structure among enterprises. At the same time, at the regional level, the mean of sustainable index of human capital structure is 26.0806, the maximum is 28.1787, the minimum is 23.3849, and the standard deviation is 0.9765, the mean of relative peer human capital structure index is 0.3601, the maximum is 1.0000, the minimum is 0.0323, and the standard deviation is 0.2745. We can find that there are great differences in human capital structure

Table 2. Descriptive statistics.

Variable	Number	Mean	Max	Min	Std. dev.	Median	Skewness	Kurtosis
HS_1	17566	10.1642	12.8142	9.4579	0.7159	9.8732	1.3793	1.2271
RPS_1	17566	0.4044	0.9935	0.0013	0.2837	0.3651	0.3753	-1.0228
HS_2	17566	26.0806	28.1787	23.3849	0.9765	25.7866	1.0342	-0.1334
RPS_2	17566	0.3601	1.0000	0.0323	0.2745	0.2903	0.3894	-1.1864
Leverage	17566	0.4447	0.9787	0.0334	0.2098	0.4316	0.2816	-0.7205
Size	17566	0.1633	9.1706	-0.5606	0.5301	0.0875	161.7979	161.7979
Growth	17566	0.2252	15.6193	-0.3803	0.7537	0.1166	16.8157	335.2482
Equity	17566	0.0616	0.4017	-1.8215	0.1561	0.0709	-5.8226	57.1527
Wage	17566	0.1087	0.1983	0.0258	0.0285	0.1115	-0.1125	0.6137
Per gap	17566	0.0947	0.2730	-0.0369	0.0434	0.0863	1.4601	3.2393

Note: HS_1 represents sustainable index of human capital structure for enterprises; RPS_1 represents relative peer human capital structure index based on HS_1 ; HS_2 represents sustainable index of human capital structure based on provinces; RPS_2 represents relative peer human capital structure index based on HS_2 . From: Calculated by the author.

among provinces. The remainder of **Table 2** reports descriptive statistics of all other variables.

4.2. The Effect of Sustainable Development of Human Capital Structure on Enterprise Performance

The model specified previously (see Model (4)) serves to test whether the sustainable development of human capital structure is increasing firm performance (Hypothesis 1) with our sample. The estimation also involves a set of control variables, which the empirical literature identifies as relevant factors (see **Table 1**). All regressions reported in **Table 3**, coefficients, z-statistics (in parenthesis), and significance level are reported for each variable. The coefficient on HS_1 is significantly positive. However, notice that the estimates vary from a low of 0.0927 in Column (2) to a high of 0.2911 in Column (3). The cause of this instability is that the sample is state-owned enterprises in Column (2) and the sample is non-state-owned enterprises in Column (3).

We continue to report regressions with RPS_1 in Column (4) in **Table 3**, the coefficient on RPS_1 is significantly negative confirm that the higher sustainable level of human capital structure, the lower adverse impact on enterprises, the better for enterprises. Overall, consistent with Hypothesis 1, the higher sustainable level of the overall human capital structure, the better performance of enterprises, and this relationship is more significant in non-state-owned enterprises.

Table 3. The effect of sustainable change of human capital structure on enterprise performance.

Variable	(1)	(2)	(3)	Variable	(4)
HS_1	0.2905*** (5.76)	0.0927* (1.75)	0.2911** (2.88)	RPS_1	-0.4122*** (-3.65)
Leverage	1.3201*** (12.11)	-1.6037*** (-10.93)	3.1206*** (17.72)	leverage	1.4485*** (12.31)
Size	-0.0002*** (-22.27)	-0.0002 (-0.65)	-0.0002*** (-15.28)	size	-0.0002*** (-21.06)
Growth	-0.0028 (-1.31)	-0.0079*** (-3.00)	0.0034 (1.03)	growth	-0.0025 (-1.12)
Equity	0.0022*** (3.41)	0.0105*** (10.79)	0.0021** (2.12)	equity	0.0024*** (3.34)
Adjusted R ²	0.5099	0.5996	0.4328	Adjusted R ²	0.5065
Year FE	Y	Y	Y	Year FE	Y
Firm FE	Y	Y	Y	Firm FE	Y

Note: The table reports the results of OLS regressions. All variables are defined in **Table 1**. We use ***, **, and * to denote significance at the 1%, 5% and 10% levels, respectively. We report t-statistics in parentheses below parameter estimates that are computed using robust standard errors clustered at the year level. From: Calculated by the author.

4.3. Interaction between Sustainable Change of Human Capital Structure and Innovation

We argue in Section 2 that human capital and innovation are two different strategic resources for company, so we test whether the interaction between sustainable changes in human capital structure and innovation promotes enterprise development. The regressions in **Table 4** in Column (1) show that $HS_1 * apply$ has a significance negative effect on firm performance. Furthermore, we analyze why interactions do not have a positive effect. We classify the samples according to the nature of enterprise property rights, sustainable level of human capital structure and innovation level.

At the beginning of each year, companies are sorted to three groups according to sustainability index of human capital structure in the previous year, the groups last for one year, and it is adjusted in next year. The sample in Column (2) is the highest group according to HS_1 , the sample in Column (3) is the lowest group according to HS_1 . The coefficient on $HS_1 * apply$ is positive in Column (2), although not significant, the coefficient on $HS_1 * apply$ is negative but not significant in Column (3). We sort companies according to the number of patent

Table 4. Interaction between sustainable development of human capital structure and innovation.

Variable	(1)	Sort by HS_1		Sort by apply		Double sort by HS_1 and apply		Sort by the nature of enterprise property rights	
		High (2)	Low (3)	High (4)	Low (5)	High (6)	Low (7)	State-owned enterprises (8)	Non-state-owned enterprises (9)
HS_1	0.4916*** (5.23)	-1.0778 (-1.04)	0.1550 (0.92)	-0.1618 (-1.29)	0.5495** (2.41)	-0.0262 (-0.09)	-2.7502 (0.93)	0.0680 (1.15)	0.6194*** (5.94)
$HS_1 * gap$	-0.00003*** (-5.54)	0.0048 (0.58)	-0.00000 (-0.02)	3.46e-06 (0.04)	0.0042 (0.19)	0.00004 (0.27)	-0.1263 (-1.27)	-0.0003** (-2.56)	-0.0006** (-2.46)
Apply	0.0012 (0.96)	-0.0475 (-0.59)	-0.0002 (-0.13)	-0.0001 (-0.22)	-0.0445 (-0.20)	-0.0005 (-0.36)	1.2003 (0.27)	0.0024** (2.35)	0.0058** (2.10)
Leverage	-1.2831*** (-9.23)	-2.6845*** (-9.95)	-0.0498 (-0.10)	-1.8533 (-5.96)	-1.3343*** (-3.19)	-0.5258 (-0.70)	-3.6274*** (-6.53)	-1.2613*** (-8.98)	-1.2927*** (-5.79)
Size	1.2984*** (44.74)	1.0306*** (19.35)	1.8242*** (18.56)	0.8096*** (15.36)	1.8292*** (16.37)	0.9899*** (8.03)	1.3657*** (10.89)	0.9583** (-2.56)	1.5149*** (26.50)
Growth	0.0035 (1.51)	-0.0514** (-2.85)	0.0036 (0.09)	-0.0029 (-0.88)	-0.1863** (-2.85)	0.0868 (0.72)	-0.6111*** (-3.91)	-0.0467*** (-4.41)	0.0051 (1.53)
Equity	0.0007 (1.29)	0.0215*** (3.10)	0.0004 (0.26)	0.1474*** (3.55)	0.0088 (2.96)	0.2908 (1.48)	0.1254 (0.70)	0.0024*** (4.49)	0.0020 (1.06)
Adjusted R ²	0.4612	0.4978	0.4666	0.5180	0.4254	0.5086	0.4957	0.5316	0.4670
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. From: Calculated by the author.

applications in the same way. The sample in Column (4) is the highest group according to *apply*, the sample in Column (5) is the lowest group according to *apply*. The coefficient on $HS_1 * apply$ is positive in Column (4) and Column (5), although not significant. Furthermore, we sort companies into three groups according to HS_1 from low to high, within each group, we sort companies into three groups according to *apply* from low to high, the groups last for one year, and it is adjusted in next year. The sample in Column (6) is the highest group when HS_1 and *apply* are highest simultaneously, the sample in Column (7) is the lowest group when HS_1 and *apply* are lowest simultaneously. Similarly, we found that the coefficient on $HS_1 * apply$ is positive in Column (6), although not significant, the coefficient on $HS_1 * apply$ is negative but not significance in Column (7).

Overall, the results from Columns (2) to (7) proved that whether the interaction between human capital and innovation can play the role of improving enterprise performance is greatly influenced by the sustainable level of human capital structure.

In China, there are state-owned enterprises and non-state-owned enterprises, there are differences between the two types in innovation input and talent input. We further test whether the interaction between the sustainability of human capital structure and innovation is affected by the nature of enterprise property rights. Companies are allocated to two groups according to the nature of enterprise property rights. The sample in Column (8) is state-owned enterprises, the sample in Column (9) is non-state-owned enterprises, the coefficients on $HS_1 * apply$ are significance negative in Column (8) and Column (9). This suggests that there is no mutual aid mechanism to promote the development of enterprises in human capital and innovation in China.

Overall consistence with Hypothesis 2b, the interaction between sustainability development of human capital structure and innovation has not played a role in improving enterprise performance.

4.4. Test of Mediation Effect and Regulation Effect

Our discussion in Section 2 suggests that with the improvement of human capital structure level, the labor productivity will also increase in the company, which is conducive to promoting the performance of enterprises. This idea is proved in this section. First, in OLS regression, the growth rate of labor productivity is dependent variable, the sustainable index of human capital structure is the main independent variables. Using the regression reported in Column (1) in **Table 5**, as expected, the coefficients on HS_1 are positive significant. Second, in OLS regression, using Tobin Q as dependent variable, HS_1 and Iz as the main independent variables. The coefficients on HS_1 are positive significant in Column (2) in **Table 5**, the coefficients on Iz are positive but not significant in Column (2) in **Table 5**, the Z value of Sobel test is $1.529 > 0.97$, our results show that labor productivity plays a part of intermediary effect in the impact of human capital structure on enterprise performance.

Table 5. Test the influence factors.

Variable	The mediating effect of the growth rate of labor productivity		Variable	Moderating effect of internal pay gap
	(1)	(2)		(3)
HS_1	2.4178*** (6.50)	0.4951*** (12.68)	$HS_1 * gap$	-0.0781** (-2.69)
Lz		0.0117 (1.57)	HS_1	-0.0554 (-0.38)
Leverage	34.3082*** (41.57)	-2.0733*** (-17.17)	Leverage	-0.7290** (-2.92)
Size	-0.6010** (-2.85)	-0.3849*** (-13.17)	Size	0.1878** (2.90)
Growth	0.0103 (0.57)	-0.0027 (-0.62)	Growth	0.0009 (0.21)
Equity	-0.0021*** (-33.37)	-0.0001 (-1.44)	Equity	-0.0001 (-0.93)
			Gap	0.7448** (2.59)
Adjusted R ²	0.5112	0.3087	Adjusted R ²	0.5462
Year FE	Y	Y	Year FE	Y
Firm FE	Y	Y	Firm FE	Y

Note: ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. From: Calculated by the author.

With the improvement of the sustainable level of human capital structure, the pursuit of fairness and justice is more urgent for people. What role does internal pay gap play in the impact of human capital structure on enterprise performance? Column (3) in **Table 5** report OLS regressions, the coefficient on $HS_1 * gap$ is negative significant, which is consistent with the analysis in the Section 2. This suggests that with the improvement of employee' education level, people will pay more attention to the issue of equity. Therefore, managers should pay attention to the negative impact of pay gap with the sustainable development of human capital structure.

So far, we have proved the Hypothesis 3 and Hypothesis 4, labor productivity plays a part of intermediary effect in the effect of human capital on enterprise performance, internal pay gap plays a negative regulatory role in the effect of human capital on enterprise performance.

5. Further Analysis Based on Regional Level

The distribution of human capital differs across cities (Berry & Glaeser, 2005). China has a vast area, there are difference in human capital structure level in different provinces, for example, the eastern coastal areas, relying on geographical advantages, economic strength and resource endowment, are more likely to

absorb high-quality talents, and their overall level of human capital structure is relatively high. Therefore, we further examine the impact of human capital structure on corporate performance from the regional level. China has 31 provincial regions, excluding Hong Kong, Macao and Taiwan. Every year, we classify employees in each province into six categories according to their educational level: illiteracy, primary, junior, senior, tertiary and undergraduate, set the corresponding weights to 6, 5, 4, 3, 2, and 1 respectively. Then, we construct the sustainable index of human capital structure at the regional level according to Formulas (1) and (2). Every year, all companies in the same industry are ranked in ascending order according to HS_2 . According to Formula (3), we calculate relative peer human capital structure index based on regional, in there, $rank_{i,t}$ indicates the ranking of company i in the same industry in the year t , $N_{i,t}$ indicates the total number of company headquarters in the same industry in the year t .

Specifically, if headquarters of company A and B are located in the same province, then they have the same HS_2 . If headquarters of company A and B are located in different provinces, they have different HS_2 . If company A and B are headquartered in the same province and belong to the same industry, they have the same RPS_2 . If company A and B are headquartered in the same province but not belong to the same industry, they have different RPS_2 . If company A and B are headquartered in different provinces and belong to the same industry, they have different RPS_2 . If company A and B are headquartered in different provinces and not belong to the same industry, they have different RPS_2 .

The model specified previously (see Models (4) and (5)) serves to test the effect of sustainable development of human capital structure on firm performance based on regional. **Table 6** presents the results, as postulated in the literature, the coefficient on HS_2 is positive significant, the coefficient on RPS_2 is negative significant. This result meets the expectation that with the sustainable improvement of human capital structure presents a significant positive impact on firm performance.

6. Robustness Test

In this paper, the robustness test is carried out from three aspects. First, the sample is divided into two sub-samples according to time, one sample period is 2010-2016, and the other sample period is 2017-2022. The regression results are shown in Columns (1) and (2) in **Table 7**, both coefficients on HS_1 are significantly positive, which shows that the process of the sustainable level of human capital structure is conducive to improving enterprise performance. Second, we sort employees into three groups based on their educational background, junior college and below, bachelor's degree and master's degree and above, we recalculate sustainable index of human capital structure at enterprise level. The regression results are listed in Columns (3) in **Table 7**, as expected, the sustainable development of human capital structure helps to improve enterprise performance.

Table 6. The sustainable of human capital structure and enterprise performance based on regional.

Variable	(1)	Variable	(2)
HS_2	0.1978* (1.70)	RPS_2	-2.0092*** (-5.63)
Leverage	-1.5924*** (-7.32)	Leverage	0.2949*** (6.86)
Size	0.0609 (5.32)	Size	0.0073*** (6.20)
Growth	-0.0510*** (-3.74)	Growth	-0.0821*** (-17.92)
Equity	0.0091*** (10.66)	Equity	0.0073*** (6.20)
Wage	0.4123 (0.69)	Wage	-5.7955*** (-7.33)
Per GDP	3.9275** (5.45)	Per GDP	-5.5304*** (-10.91)
Adjusted R ²	0.5497	Adjusted R ²	0.4484
Year FE	Y	Year FE	Y
Firm FE	Y	Firm FE	Y

Note: ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. From: Calculated by the author.

Table 7. Robust test results.

Variable	(1) 2010-2016	(2) 2017-2022	(3)	(4)
HS_1	0.5535*** (8.26)	0.1567* (1.94)	0.5932* (1.64)	11.3861*** (7.02)
Leverage	7.6845*** (6.25)	2.6154* (1.96)	-4.2848*** (-6.16)	23.7121*** (39.20)
Size	-0.1842 (-1.27)	-0.2085 (-1.47)	-0.3155* (-1.71)	-33.4165** (-2.56)
Growth	-0.0468*** (31.16)	-0.0093*** (-3.37)	-1.932 (-1.00)	0.5053 (0.45)
Equity	-11.0172* (-1.76)	-0.1031* (-1.65)	1.7216*** (6.14)	-0.1208*** (-31.41)
Adjusted R ²	0.5710	0.4393	0.1569	0.4797
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y

Note: ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. From: Calculated by the author.

Last, we use ROA (return on asset) to measure enterprise performance, coefficient on HS_1 is significantly positive in Column (4) in **Table 7**. Overall, we fur-

ther confirm that sustainable development of human capital structure is conducive to improving enterprise performance.

7. Conclusion

7.1. Main Points

Our paper differs from existing literature in that our focus is on the sustainable development of the human capital structure. Developing a measure of sustainable index of human capital structure and relative peer human capital structure index, we test whether the development of company benefits from the sustainable development of human capital structure. Consistent with our hypotheses, we find strong evidence that the sustainable improvement of human capital structure is beneficial to enterprise performance. We also reveal that these effects are affected by innovation, labor productivity and internal pay gap.

More concretely, we find that human capital and innovation are two important strategic resources for enterprise development, but there is no positive interaction mechanism between them, which is related to the level of human capital structure, but has nothing to do with the nature of enterprise property rights. With the improvement of the level of human capital structure, the labor productivity of the company will be further improved. Labor productivity plays a part in the intermediary effect in the impact of human capital structure on enterprise performance. However, the internal pay gap is not conducive to the positive effect of human capital on promoting enterprise performance, which means that with the improvement of human capital structure, managers should pay attention to employees' sensitivity to the pay gap. Further, we prove that sustainable development of human capital structure is conducive to improving enterprise performance based on the region.

7.2. Policy Implications

This research has certain practical significance and application value. Suggestions for the enterprise: First, in human resources management, compared with the stock of the human capital, managers should pay more attention to the sustainable development of human capital structure. Second, managers should establish a multi-channel mechanism of good coordination and mutual promotion between human capital and innovation, so that the two resources can promote enterprise development and improve enterprise performance. For example, implementing of an innovation strategy should take full account of the company's existing human capital level. If the innovation strategy does not match the existing level of human capital structure, it will affect the realization of the innovation strategy. Third, managers should pay attention to the negative impact of the internal pay gap, that is, with the improvement of the human capital structure level, the pursuit of fairness and justice will become more urgent for people, and therefore, managers should implement a differentiated salary strategy.

Suggestions for the Chinese Government: China should further implement the strategy of promoting economic development through talent, and at the same time, we should adjust the imbalance of talent in different regions. For example, for different provinces, differentiated talent strategy is promulgated from the national level.

7.3. Limitations and Paths for Future Research

This paper attempts to explore the impact of sustainable development in human capital structure on corporate performance, but there are still some shortcomings due to data and methods. Firstly, there are many intermediate paths and influencing factors for the change of human capital structure to affect enterprise performance. This study can not fully cover other influencing factors or influencing channels. Secondly, this paper finds that there is no interactive mechanism between the change of human capital structure and innovation to promote the development of enterprises, but we still don't know how to establish an interactive mechanism between them to promote the development of enterprises. Finally, the sample used in this study is listed companies, these enterprises are relatively successful enterprises in China, and there are many non-listed companies in reality, so what is the impact of the human capital structure of these non-listed companies on corporate performance? These nevertheless remain to be proved and demand further research.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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