

Social Security Fund (SSF) holding and ESG performance

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ABSTRACT Compared with other institutional investors, social security funds pursue stable returns, maintain relatively high independence, and exert a certification effect on firms in their portfolios. Using Chinese Shanghai-Shenzhen A-share listed companies from 2011 to 2021 as samples, this paper empirically examines the impact of social security fund holdings on enterprise ESG performance. The results show that social security funds improve ESG performance through corporate governance, incremental financing flexibility, and external pressure. Heterogeneity analysis indicates that the impact is stronger when market competition, government environmental regulation, and regional digital-economy development are high. The findings provide evidence that long-term public capital supports the stable development of the capital market and green investment, including advanced communication infrastructure and energy-saving technology sectors.

INDEX TERMS social security fund, ESG, corporate financing, green investment, communication infrastructure

I. INTRODUCTION

ESG stands for Environmental, Social, and Governance, and focuses on a company's performance in environmental protection, social responsibility, and corporate governance. ESG is an extension of Corporate Social Responsibility (CSR) and represents the integration of sustainable development principles with modern corporate governance. Its core philosophy holds that companies should not only pursue economic objectives but also consider factors such as environmental protection, social responsibility, and governance effectiveness, thereby achieving sustainable development for the enterprise. This embodies a company's investment philosophy, action guidelines, and values. Strong ESG performance helps companies maintain positive relationships with stakeholders and also serves as a risk management tool. China's ESG framework shares commonalities with the global ESG system while also exhibiting distinct Chinese characteristics; for instance, the ESG philosophy aligns with the new development philosophy. As micro-level entities, companies play a crucial role in the implementation of national strategies through their ESG performance. However, compared to developed countries, China's corporate ESG development began later. Currently, efforts are primarily focused on institutional development; therefore, exploring the factors and mechanisms influencing corporate

ESG performance holds significant practical importance for enhancing such performance. The National Social Security Fund was established in August 2000 as the national social security reserve fund. It is composed of funds raised through allocations from the central government budget, transfers of state-owned capital, investment returns, and other methods approved by the State Council. The fund is specifically designated to supplement and adjust social security expenditures—such as pension insurance—during the peak period of population aging, and is managed and operated by the National Social Security Fund Council. China's social security fund entered the capital market in June 2003 [1-2] to preserve and increase its value through equity investments in listed companies. Unlike typical institutional investors, the social security fund possesses certain unique characteristics: First, the fund pursues stable returns. As a vital source for addressing pension issues, its investment efficiency and the preservation and appreciation of its value are significant for people's livelihoods and social stability. Consequently, it faces relatively less short-term performance pressure and places greater emphasis on capital safety and value preservation; Second, as an investor with a unique political background, the Social Security Fund maintains no commercial relationship with the companies in which it invests. It enjoys relative independence and demon-

strates a stronger commitment to corporate governance [3-6]; Third, the Social Security Fund possesses a certain “certification effect.” Backed by government credit, the companies it invests in, to some extent, reflect the direction of national macroeconomic policies and serve as a signal. Since entering the market, the Fund has generated substantial investment returns, which can, to a certain degree, encourage other investors in the capital market to follow suit [7]. This study uses a sample of companies listed on the Shanghai and Shenzhen A-share markets in China from 2011 to 2021 to empirically examine the impact of Social Security Fund holdings on corporate ESG performance. The reliability of the findings is ensured through a series of robustness tests and endogeneity treatments. Furthermore, this paper empirically examines the transmission channels and mechanisms through which Social Security Fund holdings influence corporate ESG performance, focusing on corporate governance, financing constraints, and external pressures. Building on this foundation, the study explores the heterogeneity of the impact of Social Security Fund holdings on corporate ESG performance when there are differences in market competition, the extent of government environmental regulations, and the level of regional digital economic development. Finally, through an analysis of economic consequences, the paper examines how the Social Security Fund can enhance corporate competitive advantages by improving ESG performance.

II. THEORETICAL ANALYSIS

As a form of value investment for companies, ESG does not yield significant returns in the short term and may even increase financial burdens; however, in the long run, strong ESG performance contributes to improved corporate performance. According to stakeholder theory, strong ESG performance serves as a form of reputational guarantee, helping companies maintain positive relationships with stakeholders—such as fostering more loyal customers, more dedicated employees, and stable supply chain partnerships—while also earning the trust of creditors and reducing debt financing costs. Furthermore, it aids companies in establishing political ties with local governments, securing scarce government resources, and enhancing competitiveness [8], thereby supporting steady corporate development [9]. According to legitimacy theory, practicing ESG is a requirement imposed on companies by laws, regulations, and social norms. When companies actively engage in ESG initiatives, they signal to society that their business philosophy and conduct align with social norms, which helps enhance their image and reputation [10], increases their risk-bearing capacity, and enables them to survive in uncertain environments. The social security fund is willing to improve the ESG performance of its invested enterprises. On the one hand, enterprises’ commitment to improving ESG performance is a long-term behavior, which is in line with the goal of social security fund to pursue low risk, stability and long-term returns. Social security funds pursue long-term stable re-

turns. Social security funds are long-term investors, pressure resistant investors, and stable investors [11]. Compared with the short-term arbitrage goal orientation of other types of institutional investors and frequent trading behavior, social security funds have lower risks and are more inclined to hold long-term shares, obtain high and stable investment returns from the excellent performance of enterprises, achieve their value preservation and appreciation goals, and are more willing to guide enterprises to invest in value [12,13]. On the other hand, the Social Security Fund’s political attributes do not contradict its market independence; rather, they function as a dual-governance mechanism. While the fund operates independently to ensure pension stability, its long-term investment horizon naturally aligns with national sustainable development goals. Therefore, its ‘signaling’ effect is not a direct administrative intervention, but a market-based validation that the enterprise’s ESG strategy is consistent with long-term macroeconomic stability and national policy directions [14]. Currently, China has issued a series of policies, laws and regulations to improve the ESG performance of enterprises. The social security fund may be more willing to promote the investment enterprises to improve the ESG performance and support the national strategy, policies and systems.

III. RESEARCH DESIGN

A. SAMPLE SELECTION AND DATA SOURCES

This study uses Chinese A-share listed companies from 2011 to 2021 as the research sample and applies the following criteria: (1) Exclude companies in the finance and insurance sectors; (2) Exclude companies classified as ST, ST*, and PT; (3) Exclude samples with missing data; (4) Trim all continuous variables at the 1% level. After the above screening, a total of 13,648 observations were obtained. Details of the data sources are as follows: Social Security Fund holdings data were obtained from the WIND database; corporate ESG data were obtained from the Huazheng ESG Rating Database; macro-level data were obtained from the <China Urban Statistical Yearbook>; and other firm-level control variables were obtained from the CSMAR database.

B. MODEL SPECIFICATION AND INDICATOR CONSTRUCTION

To test the hypotheses H1 (H1a and H1b) presented earlier, this study specifies the baseline regression model as follows:

$$ESG_{it} = \alpha_1 + \alpha_2 S\_fund_{it} + \sum_j \alpha_j Controls_{jit} + v_k + \mu_t + \varepsilon_{it} \quad (1)$$

Among them, ESG_{it} refers to the ESG performance of enterprise i in year t , S_fund_{it} represents the proportion of social security fund investment in enterprise i in year t . Controls are control variables, see Table 1 for details; v_k , μ_t and ε_{it} represent industry fixed effect, year fixed effect and

random error term respectively. All regressions adopt robust standard error and are clustered at the company level.

1) Enterprise ESG Performance (ESG_{it})

The explanatory variable of this paper is enterprise ESG performance (expressed by ESG score). Referring to the practice of the existing literature [15], the quarterly ESG score of the China Securities Exchange is weighted to obtain the ESG performance level of the enterprise in that year.

2) Shares Held by Social Security Fund (S_fund_{it})

The explanatory variable of this paper is the holding of social security funds S_fund_{it} . Referring to the practice

of existing literature [16], the proportion of shares held by the social security fund in the total shares of the company is used to measure the proportion of shares held by the social security fund.

C. CONTROL VARIABLES

In order to accurately investigate the impact of social security fund holdings on enterprise ESG performance, the following control variables are added by referring to the practices of existing literature. See Table 1 for the specific definition of variables.

TABLE 1. Variable definition table

Variable type	Variable name	Symbol	Measurement description
Explained variable	Enterprise ESG performance	ESG	Assign a value of 1–9 according to ESG level
Core explanatory variables	Shares held by social security fund	S_fund	Percentage of the company's total shares held by the Social Security Fund $\times 100$
Control variable	Enterprise size	Size	Natural logarithm of total assets at the end of the year
Control variable	Financial leverage	Lev	Total annual Liabilities / total assets at the end of the year
Control variable	Profitability	Roa	Annual net profit / total assets at the end of the year
Control variable	Growth rate	Growth	Growth rate of operating revenue
Control variable	Enterprise age	Age	The natural logarithm of the company's actual listing years plus 1
Control variable	Nature of property rights	SOE	The value of state-owned enterprises is 1, and that of non-state-owned enterprises is 0
Control variable	Equity concentration	Top5	Shareholding ratio of top five shareholders
Control variable	Board size	Director	Add 1 to the total number of directors at the end of the year to take the natural logarithm
Control variable	Size of independent directors	Indep	Number of independent directors / total number of directors
Control variable	Shareholding ratio of Senior executives	Manager	Number of shares held by senior executives in total shares of the company
Control variable	Audit opinion	Opinion	If the annual audit report is unqualified, take 1, otherwise 0

IV. EMPIRICAL RESULTS AND ANALYSIS

A. DESCRIPTIVE STATISTICS

Table 1 shows the descriptive statistics of the main variables. Among them, the maximum value of enterprise ESG is 9 and the minimum value is 1, indicating that the ESG performance of different listed companies varies greatly; The average value is 4.174, indicating that the ESG performance of most enterprises is generally acceptable. The

average value of social security fund investment (s_fund) is 0.419, and the standard deviation is 1.020, indicating that there is a certain heterogeneity in the proportion of social security fund investment among different enterprises and different years, which lays a good foundation for the regression analysis of this paper. The descriptive statistics of the remaining variables are similar to the existing studies and are within a reasonable range.

TABLE 2. Descriptive statistics of main variables

Variable name	Symbol	Number of samples	Mean value	Standard deviation	Median value	Minimum	Maximum
Enterprise ESG performance	ESG	13648	4.174	1.010	4.000	1.000	9
Shares held by social security fund	S_fund	13648	0.419	1.020	0.000	0.000	10.520
Enterprise size	Size	13648	22.433	1.267	22.233	19.760	26.430
Financial leverage	Lev	13648	0.425	0.196	0.420	0.031	0.925
Profitability	Roa	13648	0.041	0.071	0.039	-1.856	0.604
Growth rate	Growth	13648	0.179	0.385	0.119	-0.660	4.330
Enterprise age	Age	13648	11.107	6.562	10.000	3.000	31.000
Nature of property rights	SOE	13648	0.340	0.474	0.000	0.000	1.000
Equity concentration	Top5	13648	0.532	0.146	0.531	0.175	0.892
Board size	Director	13648	2.132	0.192	2.197	1.609	2.708
Size of independent directors	Indep	13648	0.374	0.054	0.333	0.286	0.600
Shareholding ratio of senior executives	Manager	13648	0.133	0.189	0.010	0.000	0.708
Audit opinion	Opinion	13648	0.985	0.122	1.000	0.000	1.000

B. BASELINE REGRESSION RESULTS

Table 3 reports the baseline effect of Social Security Fund holdings on corporate ESG performance. Model (1) shows

the impact of Social Security Fund holdings on corporate ESG performance when other factors are not controlled for; the coefficient is 0.084 and is significant at the 1% level;

Furthermore, Models (2), (3), and (4) report the effects of SSF holdings on corporate ESG performance after controlling for firm-level characteristics and governance factors, respectively. The coefficients are 0.049, 0.043, and 0.047, all of which are significant at the 1% level. Taking Model (4) as an example, its economic interpretation is that a one-standard-deviation change in the Social Security Fund's

equity holding leads to an average improvement of 0.047 standard deviations in corporate ESG performance [change in the relative standard deviation of the dependent variable = beta coefficient $\times$ standard deviation of the independent variable / standard deviation of the dependent variable = $0.047 \times 1.02 / 1.01 = 0.047$], thereby confirming Hypothesis H1a.

TABLE 3. Benchmark regression results

	(1)	(2)	(3)	(4)
S_fund	0.084*** (0.013)	0.049*** (0.012)	0.043*** (0.012)	0.047*** (0.012)
Size		0.286*** (0.017)	0.295*** (0.017)	0.293*** (0.017)
Lev		-1.083***	-1.025*** (0.103)	-0.992*** (0.102)
Roa		1.305*** (0.199)	1.438*** (0.210)	1.307*** (0.212)
Growth			-0.108*** (0.023)	-0.111*** (0.023)
Age			-0.020***	-0.016*** (0.003)
SOE			0.253*** (0.042)	0.280*** (0.044)
Top5				-0.082 (0.115)
Director				0.222** (0.094)
Indep				1.813*** (0.288)
Manager Opinion				0.424*** 0.367*** (0.082)
Constant	4.139*** (0.018)	-1.851*** (0.347)	-1.935*** (0.354)	-3.483*** (0.419)
Year	yes	yes	yes	yes
Industry	yes	yes	yes	yes
N	13646	13646	13646	13646
F	42.540	118.598	79.651	55.610
R ²	0.098	0.189	0.204	0.216

Note: *p<0.1, **p<0.05, ***p<0.01, the standard error of clustering robustness at the company level is in brackets, the same below.

C. ENDOGENEITY TEST

Although the benchmark regression confirmed that the holding of social security funds can significantly improve the ESG performance of enterprises. However, there may be reverse causality in this conclusion. For example, enterprises with better ESG performance will form a star effect, transmit positive market signals to investors, and in turn cause the attention and investment of social security funds. In this paper, instrumental variable method, Heckman two-stage regression, PSM regression and double difference method are used to overcome the possible endogenous problems.

1) Instrumental Variable Regression

Select "the number of listed enterprises in each province" as the first instrumental variable of social security fund shareholding, recorded as *iv_firm* [17]. The reasons are as follows: the more listed enterprises in the province, the fiercer the competition for social security fund investment. Therefore, the number of listed enterprises affects the capital scale of social security fund investment and meets the relevant requirements. At the same time, the number of

regional listed enterprises serves as a proxy for the supply-side competition for institutional capital rather than regional economic level. To ensure the exogeneity of this instrument, we controlled for regional economic development (*Pergdp*) and marketization indices in the robustness tests. These tests confirm that the number of listed enterprises influences ESG only through the channel of Social Security Fund selection pressure, satisfying the exclusion restriction. At the same time, this paper selects "the shareholding level of the social security fund industry (except the enterprise)" as the second instrumental variable, which is recorded as *iv_ifund*. The reasons are as follows: the shareholding of social security funds has a certain industry conglomeration effect, so the shareholding ratio of social security funds of sample enterprises usually has a certain correlation with the shareholding of social security funds of peers in the same year; Generally, the shareholding ratio of social security funds of other enterprises will not have a direct impact on the ESG performance of the sample companies, meeting the exogenous requirements. Table 4 (1) and (2) report the instrumental variable regression results of social security

fund holdings on enterprise ESG performance. The second stage regression shows that the coefficient of *s_fund* on enterprise ESG is 0.321, which is significant at the 1% level; The one-stage regression shows that the two instrumental variables are strongly correlated with the holding of social

security funds, and the Cragg Donald Wald F and Hansen J values are greater than the corresponding critical values, indicating that the selection of instrumental variables is relatively appropriate. In general, the regression results of instrumental variables supported the benchmark conclusion.

TABLE 4. Endogeneity Test 1: *lv_2sls* vs. Heckman_2sls

	(1)	(2)	(3)	(4)
Dependent variable	<i>S_fund</i>	ESG	<i>D_Sfund</i>	ESG
Processing method	<i>Iv_2sls</i>	<i>Iv_2sls</i>	Heckman_2sls	Heckman_2sls
Regression stage	Phase I	Phase II	Phase I	第二阶段
<i>S_fund</i>		0.321*** (0.121)		0.037*** (0.010)
<i>IV_firm</i>	1.009***			
<i>IV_ifund</i>	0.0004*** (0.000)			
IMR				1.519*** (0.401)
Hansen J P		0.644		
KP rk LM P		0.000		
C-D Wald F		29.581		
K-P Wald F		30.685		
F/Wald-chi ²	30.69	158.479	–	1116.77
CVS	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	13646	13646	13648	13648
R ² /Pseudo R ²	–	0.058	0.073	–

Note: the control variables in the first stage of *iv_2sls*/heckman_2sls regression include enterprise size, financial leverage, profitability, growth rate, enterprise age, property right nature, equity concentration, board size, independent director size, senior management shareholding ratio, audit opinions, etc., the same below.

2) Heckman Regression

There may be a problem of sample selection bias in this paper. Specifically, social security fund investors tend to have a preference for stock selection, which is more biased towards a certain type of listed companies. In other words, the final conclusion of this paper may be driven by some factors of peer listed companies, rather than the shareholding of social security funds. In order to avoid the impact of this problem on the benchmark regression results, this paper uses the Heckman two-stage model to test with reference to the research of Chang Li, et al. Table 4 (3) and (4) further report the Heckman two-stage regression of social security fund holdings on enterprise ESG performance. The results of the second stage showed that the effect of *s_fund* on ESG performance was 0.037, which passed the statistical significance level; And the corresponding inverse mills ratio

IMR is also significantly positive, indicating that the main effect has obvious sample selection bias. According to this judgment, Heckman regression results further support the benchmark regression conclusion, and hypothesis H1a is further verified.

3) Propensity Score Matching (psm-ols)

This section further alleviates the endogenous problem caused by selection errors by building psm-ols models. The samples of companies with social security fund investment were taken as the treatment group, and propensity score matching grouping was carried out using 1:1 nearest neighbor matching, kernel matching and radius matching methods to find a control group with similar characteristics for the treatment group.

TABLE 5. Endogeneity test 2: PSM and DID

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	ESG	ESG	ESG	ESG	ESG	ESG
Method	1:1 nearest neighbor	Nuclear matching	Radius matching	(-1,1)	(-1,2)	matching
<i>S_fund</i>	0.033***	0.044*** (0.0118)	0.044*** (0.0118)			
Treat × post				0.080*** (0.023)	0.090*** (0.023)	0.094*** (0.023)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
ATT	0.074***	0.100***	0.093***	–	–	–
T	2.61	4.75	4.37	–	–	–
N	4905	13631	13629	7394	8139	8588
R ²	0.226	0.218	0.218	0.229	0.227	0.224

Table 5 (1) (2) (3) reports the regression results after psm-ols. First, under the three matching methods, the average treatment effect (ATT) of enterprise ESG performance is positive, with values of 0.074, 0.100, and 0.093, which are significant at the 1% level. This shows that the ESG performance of listed companies with social security fund investors is on average 0.089 higher than that of listed companies with similar characteristics¹. On this basis, the regression test was carried out on the samples of the treatment group and the matched control group, and the results showed that the coefficient of social security fund investment (s_fund) was significantly positive at the 1% level, which was consistent with the benchmark regression conclusion.

4) Difference in Difference

Double difference test. In order to further alleviate the endogenous problem caused by selection bias, this paper reconstructs the samples based on the social security fund entering "the first year to the next year, the first year to the next two years, and the first year to the next three years", and carries out the double difference test. This shows

that compared with the companies that are not held, the companies holding social security funds have better ESG performance after the entry of social security funds, and the original conclusion is robust.

D. ROBUSTNESS TEST

1) Change the Measurement Method

First of all, change the measurement method of social security fund holdings, use the ratio of social security fund holdings to stock market value (sfund_mv) and the ratio of social security fund holdings to circulating shares (sfund_ts) to measure social security fund holdings [18,19], and see Table 6 for the corresponding regression results in model (1) and model (2); Secondly, change the measurement method of dependent variables. One way is to measure the annual ESG performance of enterprises (esg_1) by using the median quarterly ESG score of the Chinese securities market, and the other way is to measure the ESG performance of enterprises (esg_2) by using the ESG score published by Bloomberg. See Table 6 models (3) and (4) for the regression results.

TABLE 6. Robustness test 1: change the measurement method

	(1)	(2)	(3)	(4)
Dependent variable	ESG	ESG	ESG_1	ESG_2
Method	Sfund_MV	Sfund_TS	Change dependent	Change dependent
Sfund_MV	0.009** (0.004)			
Sfund_TS		2.092*** (0.733)		
S_found			0.049*** (0.012)	0.348**
Control variable	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	13646	13646	13646	13646
F	54.175	54.743	56.056	228.307
R ²	0.215	0.215	0.204	0.503

2) Adjusting the Sample Range

In order to eliminate the interference of extreme samples on the estimation results, the robustness test will be carried out by adjusting samples in this section. Specifically, three sample adjustment methods are adopted: first, eliminate the samples of central cities, including the samples of Companies in Chongqing, Shanghai, Beijing, Tianjin, Chengdu, Shenzhen, Wuhan, Guangzhou, Hangzhou, Shenzhen and

other cities, and then return. See Table 7 (1) for details; Third, eliminate the top quarter of companies with good ESG performance and then regress. See Table 7 (3) for details; Fourth, remove the sample of the top quarter of companies with large scale, and then return. See Table 7 (4) for details. In general, the sample adjusted estimation results are still consistent with the benchmark regression.

TABLE 7. Robustness test 2: adjusted sample range

	(1)	(2)	(3)	(4)
Dependent variable	ESG	ESG	ESG	ESG
Sample adjustment method	Excluding central cities	Only sample of social security shareholding	Eliminate high ESG samples	Eliminate large-scale samples
S_fund	0.060*** (0.0202)	0.037***	0.039*** (0.0134)	0.041*** (0.0128)
Constant	-2.909*** (0.6851)	-3.819*** (0.5420)	-3.455*** (0.4864)	-3.473*** (0.5168)
CVS	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	6108	9151	10018	10511
F	18.712	33.754	38.817	36.645
R ²	0.183	0.226	0.165	0.173

3) Changing Model Settings

To further rule out the influence of differences in model specifications on the benchmark findings, we conducted robustness tests using two approaches: adjusting for fixed dimensions and adding new control variables. First, we modified the model specification by adjusting the fixed dimensions. While holding industry and year effects constant, we further fixed city, firm, and provincial effects, respectively, and then reran the regression. The results show that the coefficients for the Social Security Fund's equity holdings

on corporate ESG performance remain significantly positive, with values of 0.050, 0.023, and 0.023, respectively. See Models (1), (2), and (3) in Table 8 for details; Second, we modified the model by adding a new control variable. Building on the baseline model, we introduced "per capita GDP by city (Pergdp)" as a control variable and re-ran the regression (see Model (4)). The coefficient of S_fund on ESG remained significantly positive, with a value of 0.047. Clearly, the results of these model adjustments continue to strongly support the baseline conclusions.

TABLE 8. Robustness test 3: changing model settings

	(1)	(2)	(3)	(4)
Dependent variable	ESG	ESG	ESG	ESG
Method	Change model settings	Change model settings	Change model settings	Add control variable
S_fund	0.050***	0.023** (0.0107)	0.023** (0.0107)	0.047*** (0.0116)
Pergdp				0.113*** (0.0424)
Constant	-3.147*** (0.6069)	-3.832*** (1.0672)	-3.832*** (1.0672)	-4.716***
CVS	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	NO
Firm	NO	Yes	Yes	NO
Prov	NO	NO	Yes	NO
N	8835	8685	8685	13646
F	27.476	10.955	10.955	52.420
R ²	0.285	0.679	0.679	0.218

4) Change the Estimation Method

The benchmark regression results are based on the mean model, reflecting the average effect of social security fund holdings on enterprise ESG performance. However, the distribution of ESG performance of different enterprises may have obvious asymmetry, so the mean model cannot accurately describe the relationship between them. There-

fore, the estimation method is adjusted to quantile regression model for further robustness test. The results show that table 8 (1), (2) and (3) respectively report the quantile estimation results of $q=0.20$, 0.40 , 0.60 and 0.80 . Obviously, the three component quantile regression results still significantly support the benchmark conclusion.

TABLE 9. Robustness test 4: change the estimation method

	(1)	(2)	(3)	(4)
Dependent variable	ESG	ESG	ESG	ESG
Quantile value	0.20	0.40	0.60	0.80
S_fund	0.045*** (0.0129)	0.036***	0.042*** (0.0111)	0.040*** (0.0113)
Constant	-3.939*** (0.3619)	-2.368*** (0.0716)	-3.235*** (0.3078)	-1.312*** (0.3606)
CVS	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	13648	13648	13648	13648
Pseudo R ²	0.072	0.036	0.084	0.051

E. HETEROGENEITY ANALYSIS

To further examine whether the impact of Social Security Fund (SSF) holdings on corporate ESG performance varies across different external environments, this study conducts heterogeneity analysis from three dimensions: market competition, environmental regulation, and regional digital economy development. The results are reported in Table 10.

TABLE 10. Heterogeneity Analysis

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	ESG	ESG	ESG	ESG	ESG	ESG
Ext Environment	HHI High	HHI Low	ER High	ER Low	Dig High	Dig Low
S_fund	0.050*** (0.0130)	0.034 (0.0230)	0.056*** (0.0151)	0.027 (0.0176)	0.065*** (0.0151)	0.022 (0.0139)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
N	10202	3366	8659	4981	8136	5427
F	40.935	26.949	43.586	16.280	40.309	33.405
R ²	0.199	0.287	0.246	0.205	0.212	0.256

1) Market Competition (HHI)

When firms operate in highly competitive industries, SSF investors tend to pay more attention to the establishment of long-term competitive advantages. They strengthen supervision over managerial short-termism and encourage firms to increase investment in R&D and ESG activities, thereby ensuring competitive positioning. In addition, market competition itself is regarded as an effective corporate governance mechanism, which further reinforces the monitoring role of SSF. Based on this reasoning, the effect of SSF holdings on ESG performance is expected to be stronger in industries with higher levels of competition. To test this hypothesis, this paper follows the existing literature [20] and adopts the Herfindahl–Hirschman Index (HHI) to measure industry competition. A lower HHI value indicates a higher level of competition. Table 10 columns (1) and (2) report the heterogeneous effects of SSF holdings on corporate ESG performance under different levels of market competition. Column (1) shows that in highly competitive industries, the estimated coefficient of S_fund on ESG is 0.050, which is higher than the full-sample benchmark estimate (0.047). In contrast, column (2) shows that in industries with lower competition, the effect of S_fund on ESG is smaller (0.034) and statistically insignificant. These results indicate that market competition strengthens the positive impact of SSF holdings on corporate ESG performance.

2) Environmental Regulation (ER)

According to organizational strategy theory, changes in the external environment can trigger internal organizational transformation and adjustment [21]. With the increasing attention of governments to environmental issues, SSF investors become more sensitive to environmental risks, such as potential penalties for non-compliant environmental behavior. In this context, SSF investors are more likely to guide firms to adjust their development strategies and promote the transformation toward socially responsible strategies, thereby aligning firm value with national objectives of environmental optimization and reducing operational uncertainty caused by environmental risks [22]. In summary, the positive effect of SSF holdings on ESG performance is expected to be more pronounced in regions with stronger environmental regulation. To test this hypothesis, this paper

measures environmental regulation intensity (ER) using the ratio of environment-related keyword frequency to total word frequency in government work reports [1, 23], and divides the sample into high- and low-regulation groups for heterogeneity analysis. Table 10 columns (3) and (4) report the heterogeneous effects of SSF holdings on corporate ESG performance under different levels of environmental regulation. Column (3) shows that in regions with stronger government environmental attention, the estimated coefficient of S_fund on ESG is 0.056, which is higher than the benchmark estimate (0.047). In contrast, column (4) shows that in regions with weaker environmental regulation, the effect of S_fund on ESG is smaller (0.027) and statistically insignificant. These results indicate that stronger environmental regulation enhances the positive impact of SSF holdings on corporate ESG performance.

3) Digital Economy Development

In general, in regions with more advanced digital economy development, firms tend to exhibit a higher degree of digital transformation, which improves information transparency and enhances the monitoring efficiency of institutional investors such as SSF. Moreover, improvements in the information environment driven by digital development make firms held by SSF more likely to attract external attention. Under such market pressure and reputational concerns, managers are more inclined to reduce irrational decision-making and focus on long-term value creation. In addition, with the advancement of digital technologies, SSF investors can more effectively connect with professional investment teams and social capital, further alleviating financing constraints and enabling firms to allocate more resources to ESG-related activities. Based on this reasoning, a higher level of digital economy development is expected to strengthen the positive impact of SSF holdings on corporate ESG performance. To test this hypothesis, this paper follows the mainstream literature and constructs a digital economy index (Dig) based on five indicators, including internet penetration, employment in digital-related industries, digital output, mobile phone penetration, and the digital financial inclusion index [24,25]. Principal component analysis is then applied to reduce dimensionality, and the sample is divided into high- and low-level groups for heterogeneity analysis. Table

10 columns (5) and (6) report the heterogeneous effects of SSF holdings on corporate ESG performance under different levels of digital economy development. Column (5) shows that in regions with a higher level of digital economy development, the estimated coefficient of *S_fund* on ESG is 0.065, which exceeds the benchmark estimate (0.047). In contrast, column (6) shows that in regions with lower digital economy development, the effect of *S_fund* on ESG is smaller (0.022) and statistically insignificant. These findings indicate that the development of the digital economy strengthens the positive effect of SSF holdings on corporate ESG performance.

V. CONCLUSION AND ENLIGHTENMENT

Using a sample of Chinese A-share listed companies (2011–2021), this study examines how Social Security Fund (SSF) shareholdings impact corporate ESG performance. Specifically, we analyze this relationship through internal and external governance lenses. We further investigate heterogeneous effects across varying market competition, environmental regulations, and digital economic levels. Finally, the study utilizes a mediation model to explore the resulting economic consequences. The study ultimately reaches the following conclusions: First, Social Security Fund holdings significantly improve corporate ESG performance; second, heterogeneity analysis reveals that in regions with higher levels of market competition, government environmental regulation, and regional digital economic development, the positive impact of Social Security Fund holdings on corporate ESG performance is more pronounced; third, the mechanisms through which this impact is realized include improved corporate governance, alleviated financing constraints, and increased external scrutiny.¹

AUTHOR CONTRIBUTIONS

Conceptualization – Junjie Chen and Shihan Lai; methodology – Junjie Chen and Shihan Lai; investigation – Junjie Chen and Shihan Lai; writing-original draft preparation – Junjie Chen and Shihan Lai. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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