



Corporate ESG Performance, Digitalization, and Human Capital Investment Efficiency: An Empirical Evidence from Chinese Firms

Ghulam Mustafa¹, Altaf Hussain², Muhammad Atiq ur Rehman³, Muhammad Hassan⁴

¹ Research Scholar, Minhaj University, Lahore, Pakistan. Email: mustfa143@gmail.com

² Assistant Professor, Department of Economics, The Islamia University of Bahawalpur, Pakistan. Email: altafhussain@iub.edu.pk

³ Assistant Professor, Department of Economics, Higher Education Department, Punjab and Adjunct Faculty, Superior University, Lahore, Pakistan. Email: atiq164@live.com

⁴ Institute of Business Management, Capital University of Science and Technology Islamabad, Pakistan. Email: muhamadhassan46@gmail.com

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ABSTRACT

This study explores the effect of environmental, social, and governance (ESG) performance and digitalization on human capital investment (HCI) efficiency in Chinese firms. Using data from 319 A-share market-listed Chinese firms for the period 2019-2023, the panel least square approach is used for the estimation. The empirical results show that ESG performance, alongside digitalization, company size, and stock prices, positively influences HCI efficiency in Chinese enterprises. Furthermore, the interaction between ESG performance and digitalization acts as a catalyst in the ESG-human capital relationship by enhancing labor training opportunities and skills driving technological advancements in corporate operations. The relationship between ESG performance and digitalization is multifaceted and dynamic; digitalization can improve ESG performance, while strong ESG performance supports digitalization. Together, these factors synergistically enhance HCI efficiency.

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Corresponding Author's Email: atiq164@live.com

1. Introduction

ESG scores evaluate how companies perform in environmental, social, and governance dimensions. The environmental criteria encompass eco-friendly policies and initiatives of businesses to reduce environmental emissions. Social criteria focus on the relationships between management and employees, including a firm's contributions to staff welfare. Governance criteria pertain to leadership roles, shareholder rights, and internal controls that ensure transparency and accountability in corporate operations. Introduced in 2004, ESG pillars assess a company's performance in these areas, raising awareness among stakeholders such as investors, employees, regulators, and customers. Corporate ESG practices create value for all stakeholders (Wang et al., 2024), rooted in humanity's traditional connection to nature and society. ESG performance is particularly critical in emerging economies as it enhances financial performance, market value, and sustainable growth by attracting investors and building global reputations. Bloomberg projects global ESG investment assets to reach \$40 trillion by 2030. Among BRICS economies, ESG performance is at an intermediate level, with China emerging as a key player. China is the world's second-largest green bond market, driven by efforts toward sustainable development. Human capital refers to a trained, productive workforce, while Human capital investment efficiency refers to the optimal allocation of the human workforce, maximizing returns in terms of innovations, productivity, and organizational performance. Becker (1964) human capital concept highlights the importance of investment in education and training for output growth. After Chinese economic reforms, human capital has contributed 40% to China's economic growth. A company's ESG performance significantly impacts HCI efficiency by positively influencing its social and governance factors. For instance, environmental degradation from carbon emissions harms employee productivity and raises healthcare costs. Companies prioritizing environmental sustainability attract top talent and boost employee engagement. Key

environmental metrics include greenhouse gas emissions, carbon footprint, and renewable energy usage, all of which enhance human capital efficiency by promoting employee welfare, retention, and productivity.

The social pillar of ESG focuses on labor practices, human rights, training, health benefits, community development, and diversity. Positive social practices foster innovation through diversity, equity, and inclusion initiatives. Governance practices, such as board diversity, executive accountability, and transparency, ensure optimal resource allocation and foster employee trust and loyalty. Strong governance underpins sound human capital management, further driving productivity and retention. ESG performance is vital to a firm's long-term success and sustainability (Song, 2024). It reflects the company's environmental, social, and managerial impact, serving as a core indicator of commitment to sustainable and responsible practices. Digitalization, involving the integration of digital technologies into business processes, fundamentally transforms corporate operations. When combined, ESG and digitalization promote the efficiency of human capital investment, fostering skill development and labor optimization. Improved ESG practices and digitalization help companies attract and retain top talent committed to sustainability. ESG promotes employee engagement, productivity, and retention, while digitalization enhances decision-making, risk management, and innovation. Companies that focus on ESG and digitalization have an edge in terms of attracting skilled labor and achieving long-term sustainability. New technologies further build employee competencies, creating a culture of learning, innovation, and sustainable production. It is an emerging research area of how ESG performance, digitalization, and human capital interplay. From the study by Turban & Cable, 2003, it is evident that ESG practices interact with aspects of digitalization to support human capital. Hence, factors such as diversity, equity, and inclusion improve corporate ESG performance and human capital (Hawn, Chatterji, & Mitchell, 2018). Firms that implement these interdependent factors improve reputation, innovation, and capabilities, along with sustainable growth.

2. Literature Review

ESG performance, digitalization, and HCI efficiency are currently hotly debated topics among corporate management and scholars. In the literature review presented below, particular emphasis has been placed on the ESG factors of companies. Current studies show that the positive effect of ESG improves HCI efficiency through organizational culture in support of the welfare, inclusion, and diversity of employees (Boubaker & Elnahass, 2024). Furthermore, digital tools like e-learning podiums increase the effectiveness of such investments (Chen & Xie, 2022). (Boudreau & Ramstad, 2007) assert that human capital is a significant catalyst for the innovation performance of a firm. Employees with superior skills and training are essential for promoting ESG initiatives in the corporate world. Briscoe-Tran (2024) also conducted a survey of 1,000 employees in U.S. firms, showing a positive association between ESG performance and employee engagement. Hartmann (2021) have shown through a case study of a German company that ESG initiatives improve employee engagement and innovations and thus contribute to business success. Kim and Li (2021) conducted a systematic review of 25 papers to demonstrate the positive relationship between ESG factors and human capital. (Lee, Kim, & Lee, 2025), using regression analysis on data from 500 American companies, discovered that governance practices are significant drivers of human capital formation. It has been found through research that the ESG pillars, specifically social factors, significantly influence human capital. According to Eccles, Lee and Strohle (2020) and (Ioannou & Serafeim, 2015), companies that have good ESG practices will be more likely to attract and retain highly productive employees. Bhattacharya and Bhattacharya (2023) found that organizations with high-performing ESG practices have lower rates of employee turnover, as it is an attractive place for talented workers. Furthermore, ESG-centric organizations tend to have diverse workplaces and cultures that are very inclusive and thus spark innovation.

According to Gartner et al. (2024), firms focusing on employee well-being experience better productivity and reduced absenteeism. Recently, researchers and policymakers have given a lot of attention to the relationship between ESG performance and digitalization. Digitalization has revolutionized the business landscape, and ESG performance is now a significant factor for competitiveness. The interaction between ESG and digitalization provides new avenues for organizational growth. According to Westerman, Bonnet and McAfee (2014), digitalization allows businesses to use data analytics, blockchain

technology, and artificial intelligence to increase operational efficiency and transparency. The digitalization supports the effective use of data-driven decision-making, which is the backbone of ESG management. Tapscott (2017) emphasized that digital platforms contribute to enhanced stakeholder engagement through increased communication and feedback mechanisms. These are crucial management mechanisms for the social and governance components of ESG. Eccles, Lee and Stroehle (2020); Khan et al. (2025) pointed out that ESG and digitalization are complementary to each other. Digitalization sophisticates ESG performance by enhancing data gathering and reporting, making companies more transparent. On the other hand, strong ESG practices promote digital innovations in risk management and stakeholder engagement (Bruno & Henisz, 2024). Bhimani et al. concluded that "digitalization has enabled the measuring and reporting of ESG performance," promoting accountability. Henisz et al. further suggested that digitalization forges innovation, and promotes a sustainable product, and services for an organization to grow. A firm's digital approach leads toward sustainability through consideration of ESG factors (Khan et al., 2025). With digitalization come the issues; of cybersecurity and the accentuation of inequalities in society, all of which pose a call to action for responsible ESG principles (Bhimani et al., 2019). The literature on ESG performance at the intersection with digitalization and human capital formation is therefore still limited. Gong et al. (2024) highlighted that ESG performance positively influences human capital by boosting employee motivation, engagement, and retention. Martinz (2020) argued that strong ESG performance mitigates potential adverse effects of digitalization, such as workforce displacement. Bachmann, Silveira and Martins (2024) demonstrated that digitalization enhances data analytics, enabling the monitoring of sustainability metrics like carbon emissions and energy usage, which supports informed decision-making to achieve ESG targets.

3. Data and variables

The yearly data on ESG for 319 A share market listed companies in China for the time 2019-2023 has been compiled. The ESG factors are used to measure the firm's role in the environmental, social, and governance pillars. The researchers experience a lack of any specific measure of ESG performance. However, the data on ESG ratings disclosed by firms and collected by different organizations is used to represent the commitment of a corporation to fulfill the ESG formalities in line with the sustainable development goals (SDGs). There has been an information disclosure issue in firms in China. The companies prefer not to disclose information which creates problems for the data collection and its availability. The ESG performance data comes from the Sustainalytics databases. Human capital investment means an investment of a company in employee training, education, health, and other welfare benefits. Our data on human capital investment (HC) comes from annual reports disclosed by companies showing the medical contribution in percentage provided by the companies for the healthcare of their employees. The medical contribution data on the companies based in three famous industrial cities including Beijing, Shanghai, and Guangzhou has been obtained. Our core explanatory variable is digitalization which represents the speed of adopting digital technologies in firms. The primary measure of digitization signified as DIGI, captures the digitalization level within firm i during year t . The data on digitalization is obtained from Cn Open Data website. The data is drawn by the methodology proposed by Verhoef et al. in which digital-based dictionary words are used by the listed corporations in their annual reports. ESG index is extracted based on international ESG standards which combines China's information disclosure and company's characteristics observing environmental, social, and governance pillars.

3.1. Empirical Methodology

Our econometric specification used in this study is mainly based on analyzing the impact of ESG and digitalization on human capital. The empirical specification can be written as given below.

$$HClit = \alpha_0 + \alpha_1 ESG\ it + \alpha_2 DIGI\ it + \alpha_3 Sizeit + \alpha_4 Stockit + \eta_i + \epsilon_{it} \quad (1)$$

To examine the moderating role of digitalization on the ESG-human capital nexus, we add an interaction term as an independent variable in the regression model.

$$HCI\ it = \delta_0 + \delta_1 ESG\ it + \delta_2 DIGI\ it + \delta_3 ESG\ it * DIGI\ it + \delta_4 Sizeit + \delta_5 Stockit + \eta_i + \epsilon_{it} \quad (2)$$

Where,

HCI = human capital investment

ESG = environmental, social, and governance performance index

DIGI = digitalization

Size = Its size of a company number of employees working in company

Stock = share price of company in us dollars

η_i = firm specific effects

u_{it} = Error term

The company size (Size) and share price (Stock) are the control variables. The company size is measured by the number of employees working in that company. A higher number of employees mean that the company has a larger size. The variable 'Stock' reflects the share price of a company. The larger the price of share, the better the company's corporate reputation and performance. The factors represented by control variables may also influence the corporate human capital investment's efficiency.

4. Empirical Results

Table 1: Descriptive Statistics

Variable	C.S	Mean	Std. Dev.	Min	Max
HCI	319	8.55	1.45	7	10
ESG	319	25.29	6.97	13	38.1
DIGI	319	29.71	29.43	1	140
Size	319	8.56	2.84	6	13
Stock	319	7.01	18.72	0	193.51

Table 2: Pairwise Correlations

Variables	HCI	ESG	DIGI	Size	Stock
HCI	1.000				
ESG	0.027	1.000			
DIGI	-0.006	0.003	1.000		
Size	0.085	0.035	0.007	1.000	
Stock	0.111	-0.07	-0.028	0.122	1.000

4.1. Baseline Regression

Table 3: Impact of ESG and Digitalization on Human capital

HCI	Coef.	St.Err.	t-value	p-value	Significance
ESG	0.1799	0.0151	11.87	0.000	***
DIGI	0.0114	0.0042	2.66	0.008	***
Size	0.3769	0.0480	7.84	0.000	***
Stock	0.0136	0.0045	3.08	0.002	***
R-squared	0.93		Number of cross sec.	319	
F-test	1326.57		Root MSE	2.197	
Prob (F)	0.000				

*** $p < 0.01$

Table 4: Interactive effect of ESG and Digitalization on Human capital Investment

HCI	Coef.	St.Err.	t-value	p-value	Significance
ESG	0.2415	0.0156	15.52	0.000	***
DIGI	0.1136	0.0154	7.36	0.000	***
Size	0.2333	0.0451	5.18	0.000	***
Stock	0.0109	0.0036	3.07	0.002	***
ESG*DIGI	0.0044	0.0006	15.26	0.000	***
Constant	7.81	0.43	7.47	0.000	***
R-squared	0.95		Number of cross sec.	319	
F-test	1329.05		Root MSE	1.93	
Prob (F)	0.000				

*** $p < 0.01$

4.2. Findings and interpretations

To examine the effect of corporate ESG practices on human capital investment efficiency, we used robust regression analysis on the data on 319 Chinese firms. The main purpose of the estimation is to explore the association between corporate ESG performance on firm's human capital investment efficiency. We use human capital investment as a dependent variable. The data on human capital investment is taken from the web sources. The human capital investment

is measured by the percentage of medical contribution provided by the firm. The firms based in different cities contribute different percentages of medical contributions to the employees. For example, the medical contribution in Beijing is more than in Shanghai and Guangzhou. The empirical results using the panel least square approach are presented in the tables. The results in Table 1 reflect that ESG practices affect the efficiency of human capital investment positively and significantly. The magnitude of the ESG coefficient is 0.179 which implies that a 1% increase in ESG rating leads to an increase in HCI efficiency by 0.179% or vice versa. The ESG coefficient is significant at a 1% level of significance. This validates that there is a useful influence of better corporate ESG practices on human capital investment. The companies with better ESG performance may be more profitable by getting more return on human capital investment. It occurs because firms with better ESG practices can offer better training opportunities, competitive remuneration, attractive fringe benefits, and good career development opportunities. The highly skilled and motivated labor force raises the corporate reputation of the company in the long run. The core variable after ESG is the digitalization (DIGI) of a company.

The digitalization data is compiled by the dictionary of words related to digitalization and artificial intelligence. The coefficient on digitalization is positive and statistically significant at a 1% level. One percent increase in the digitalization index leads to an increase in HCI efficiency by 0.01 percent or vice versa. The company size is measured by the average number of employees working in that company. The company size is positively and significantly related to the HCI efficiency because the larger firms have more funds to concentrate on human resource development. The businesses have proper facilities to train their employees. Stock represents the stock prices which are the average price of the company's shares. The empirical results indicate that stock prices are positively related to HCI efficiency. Theoretically, when stock prices increase, the company grows and it has more funds to invest in the training of its employees. So, the expansion of the companies leads to human capital investment efficiency. The R-square value is 0.93 which shows a good fit because 93 percent variations in the human capital are explained by the independent variables. Table 2 presents the interactive effects of environmental, social, and governance factors and digitalization on HCI efficiency. All the variables in the regression model are strongly significant with the positive coefficients. The interaction term between ESG and digitalization is positive and statistically significant at a 1% level of significance. The coefficient of the interaction term is 0.0044 which shows that a one percent increase in the interaction term between ESG and DIGI d leads to improved HCI efficiency by 44 percentage points or vice versa. The regression results exhibit the relationship of ESG performance with human capital investment. Such firms with better ESG performance may garner more profits from investment in human capital. Firms with good ESG performance can offer quality training, remuneration, and other benefits. The high-tech labor force enhances the reputation of the company. Findings therefore support that by boosting the firm's reputation ESG performance contributes positively towards corporate human capital investments in efficiency terms.

5. Conclusion

This study inspects the impact of environmental, social, and governance (ESG) performance on HCI efficiency in Chinese enterprises. Data from Chinese A-share market-listed firms were gathered from various sources for empirical analysis. Using robust regression methods, the study reveals interdependent relationships between ESG performance, digitalization, and human capital investment efficiency. ESG performance, alongside digitalization, positively impacts human capital formation in Chinese enterprises. Furthermore, digitalization in the industrial sector acts as a catalyst in the ESG-human capital relationship by enhancing learning and training opportunities for workers and advancing corporate technological operations. The interplay between ESG performance and digitalization is intricate and multifaceted. Digitalization can improve ESG performance, while strong ESG performance, in turn, promotes digitalization. Together, ESG performance and digitalization work synergistically to enhance human capital investment efficiency. In the energy transition era, businesses and society increasingly acknowledge that metrics beyond economics are needed to assess the performance of enterprises. Social, environmental, and governance features have become more important for enterprise development these days. ESG rating data from this study empirically investigates the role of ESG practices affecting the human capital investment efficiency of corporate firms. This research verifies that there is a significant correlation between corporate

ESG practices and human capital investment efficiency, resulting in improved ESG performance and higher investment efficiency of the human capital of the companies concerned.

References

- Bachmann, J. E. C., Silveira, I. F., & Martins, V. F. (2024, 2024-11-04). Digital Twins for Education: A Literature Review. *Simpósio Brasileiro de Informática na Educação*,
- Becker, G. S. (1964). Human capita. *New York: National Bureau of Economic Research*.
- Bhattacharya, A., & Bhattacharya, S. (2023). Integrating ESG Pillars for Business Model Innovation in the Biopharmaceutical Industry. *Australasian Accounting, Business and Finance Journal*, 17(1), 127-150. <https://doi.org/10.14453/aabfj.v17i1.12>
- Boubaker, S., & Elnahass, M. (2024). *Banking Resilience: New Insights on Corporate Governance, Sustainability and Digital Innovation* (Vol. 09). WORLD SCIENTIFIC (EUROPE).
- Boudreau, J. W., & Ramstad, P. M. (2007). *Beyond HR: The new science of human capital*. Harvard Business Press.
- Briscoe-Tran, H. (2024). Do employees have useful information about firms' Esg practices? *Fisher College of Business Working Paper*(2021-03), 21.
- Bruno, C. C., & Henisz, W. J. (2024). Environmental, Social, and Governance (ESG) Outcomes and Municipal Credit Risk. *Business & Society*, 63(8), 1709-1756. <https://doi.org/10.1177/00076503231220541>
- Chen, Z., & Xie, G. (2022). ESG disclosure and financial performance: Moderating role of ESG investors. *International Review of Financial Analysis*, 83, 102291. <https://doi.org/10.1016/j.irfa.2022.102291>
- Eccles, R. G., Lee, L.-E., & Stroehle, J. C. (2020). The Social Origins of ESG: An Analysis of Innovest and KLD. *Organization & Environment*, 33(4), 575-596. <https://doi.org/10.1177/1086026619888994>
- Gartner, M. A., Grenzfurter, W., Zauner, B., & Gronalt, M. (2024). Job and product rotation for maximising the production output on multi mixed-model assembly lines for element prefabrication in industrialised housebuilding. *Computers & Industrial Engineering*, 190, 110041. <https://doi.org/10.1016/j.cie.2024.110041>
- Gong, E., Wang, Y., Zhou, X., & Duan, J. (2024). ESG factors affecting the asset sustainability of infrastructure REITs in China. *Engineering, Construction and Architectural Management*. <https://doi.org/10.1108/ECAM-06-2024-0738>
- Hartmann, S. P. (2021). *The Impact of ESG Scores on the Firm Value-Evidence from the Airline Industry* Universidade NOVA de Lisboa (Portugal)].
- Hawn, O., Chatterji, A. K., & Mitchell, W. (2018). Do investors actually value sustainability? New evidence from investor reactions to the Dow Jones Sustainability Index (DJSI). *Strategic Management Journal*, 39(4), 949-976. <https://doi.org/10.1002/smj.2752>
- Ioannou, I., & Serafeim, G. (2015). The impact of corporate social responsibility on investment recommendations: Analysts' perceptions and shifting institutional logics. *Strategic Management Journal*, 36(7), 1053-1081. <https://doi.org/https://doi.org/10.1002/smj.2268>
- Khan, S., Ullah, A., Liu, Y., & Kashif, M. (2025). Examining the blockchain and green innovation technologies on sustainability (ESG): the moderating role of global financial integration. *Journal of Sustainable Finance & Investment*, 15(1), 145-181. <https://doi.org/10.1080/20430795.2024.2441204>
- Kim, S., & Li, Z. F. (2021). Understanding the Impact of ESG Practices in Corporate Finance. *Sustainability*, 13(7), 3746. <https://doi.org/10.3390/su13073746>
- Lee, N., Kim, J., & Lee, S. M. (2025). ESG as an innovative practice: global interdisciplinary review with a focus on Asia Pacific. *Asia Pacific Business Review*, 1-24. <https://doi.org/10.1080/13602381.2025.2456997>
- Song, J. (2024). Corporate ESG performance and human capital investment efficiency. *Finance Research Letters*, 62, 105239. <https://doi.org/10.1016/j.frl.2024.105239>
- Tapscott, D. (2017). Declaration of Interdependence Towards a New Social Contract for the Digital Economy/Tapscott D. In: NY.: The Tapscott Group Free Press.
- Wang, N., Pan, H., Feng, Y., & Du, S. (2024). How do ESG practices create value for businesses? Research review and prospects. *Sustainability Accounting, Management and Policy Journal*, 15(5), 1155-1177. <https://doi.org/10.1108/SAMPJ-12-2021-0515>
- Westerman, G., Bonnet, D., & McAfee, A. (2014). *Leading digital: Turning technology into business transformation*. Harvard Business Press.

Appendix

Figure 1: Graphical Representation of variables (mean)

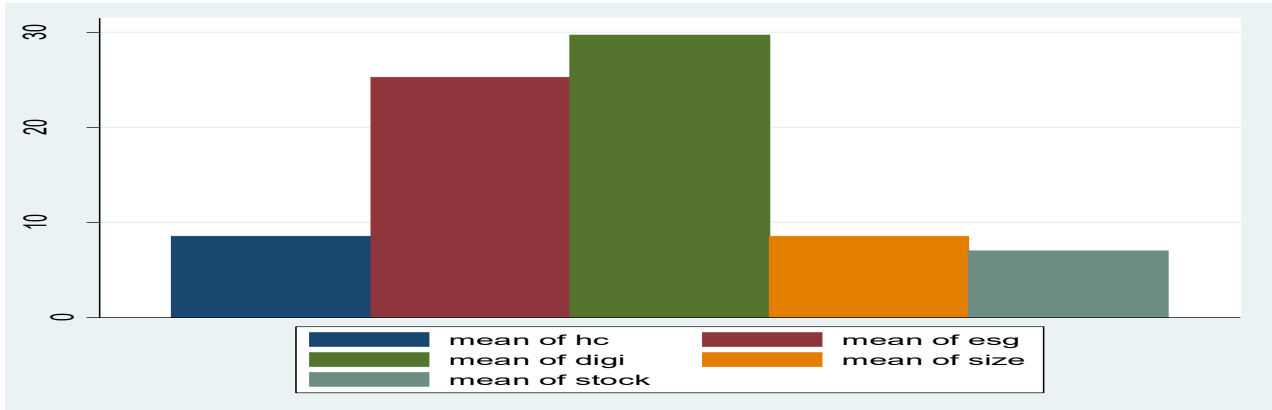


Figure 2: Graphical trend of variables

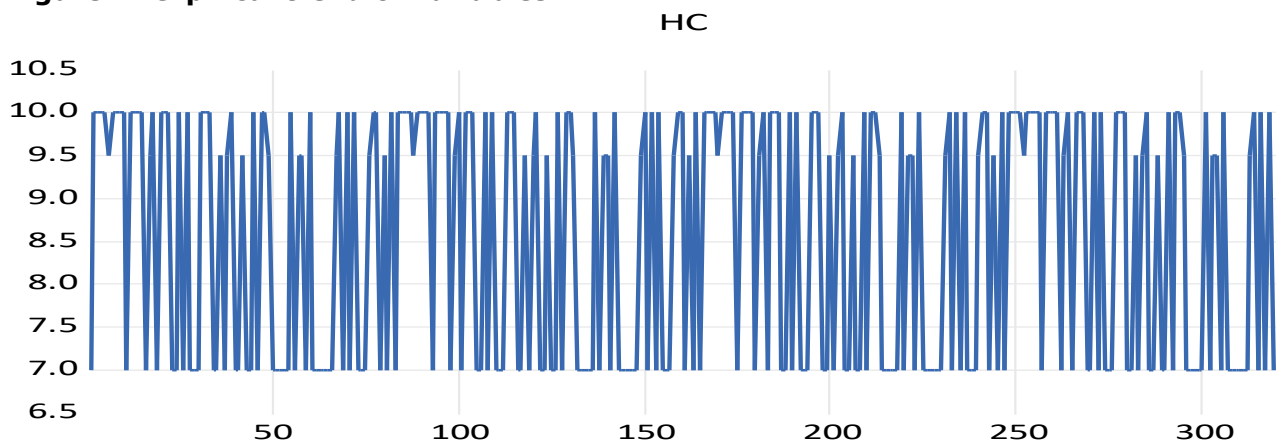


Figure 3

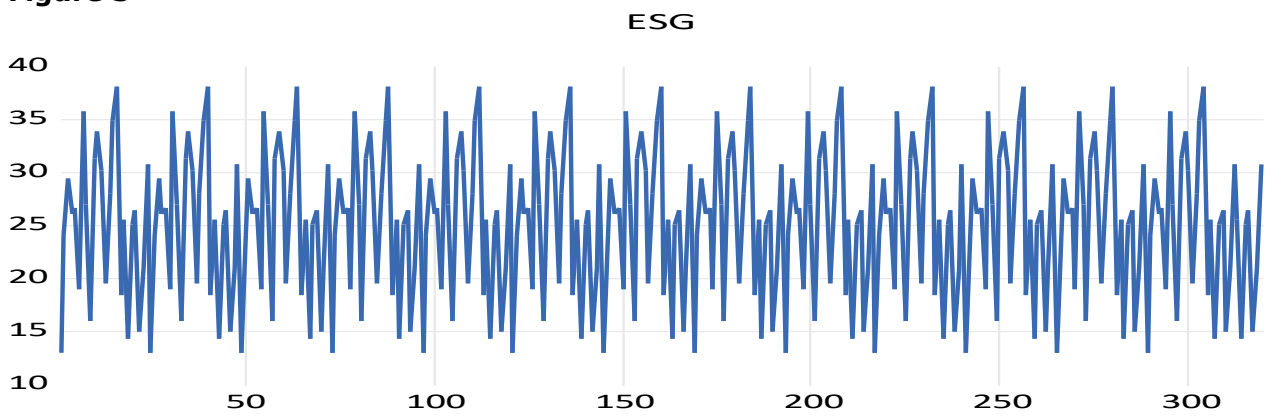


Figure 4

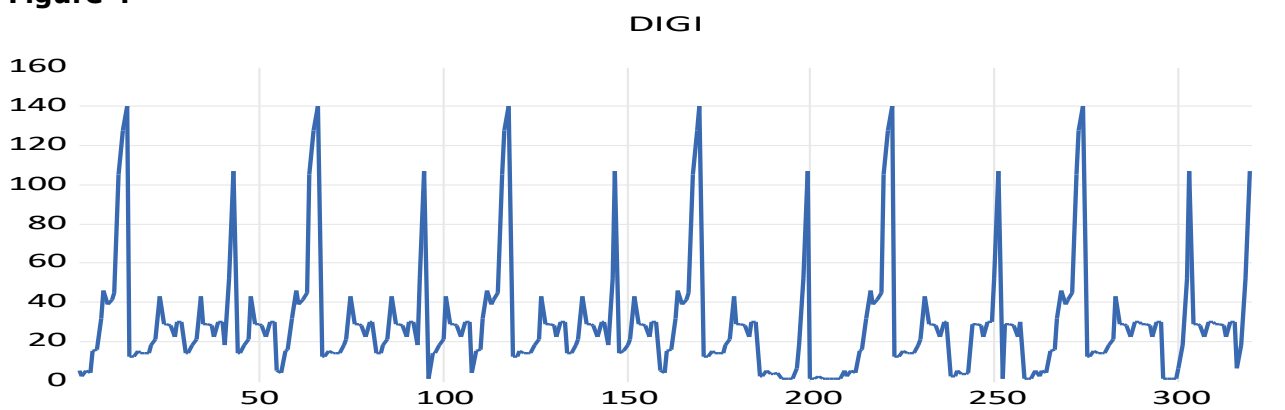


Figure 5

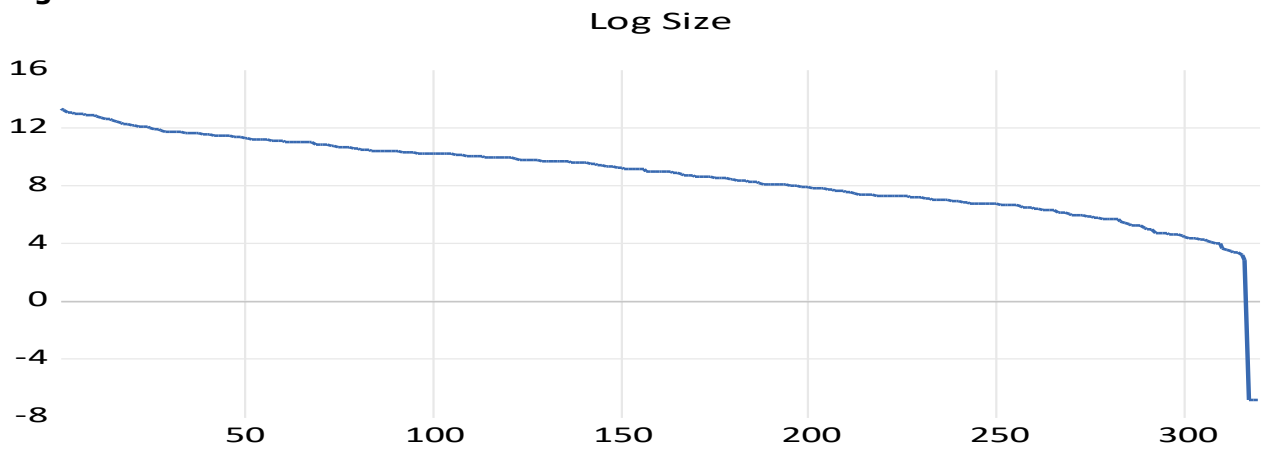


Figure 6

