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Abstract: As the leader of green technological advancement, China has implemented policies and strategies for companies to use green technological innovations in their production line. Earlier studies focused on the investment in technological innovation, innovation-driven policies, and the relationship between competitiveness and technological innovation. There is a literature gap in examining the effect of technological innovation on environmental and financial performance for textile manufacturing companies listed in China. This study therefore seeks to address the literature gap by analysing the impact of technological innovation on environmental and financial performance for textile manufacturing companies listed in China. Panel data for 61 textile manufacturing companies from 1990 to 2020 was used for the empirical analysis. The authors utilised the generalised methods of moments (GMM) estimator. The findings from our study highlights how technological innovation is contributing to environmental and financial performance of firms.

Keywords: technological innovation; environmental performance; financial performance; textile manufacturing companies; China.

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1 Introduction

With the development of global economic integration, an essential indicator of a country's comprehensive strength is technological innovation. As technological innovation is reshaping the structure of the global economy, entrepreneurs and firms have gradually realised the importance of technological innovation (Omri, 2020, Chen and Lee, 2020). Through technological innovation activities, enterprises can reduce production costs and improve production efficiency (Liu et al., 2020). In addition, when companies increase their technological innovation efforts, they can quickly seize new market, which will reflect in the operational and financial performance of the company (Xu et al., 2019). Technological innovation does not only help companies gain a leading position in the market competition but help the country in the international market. Investing in research and development (R&D) is a significant way of ensuring technological innovation. R&D of enterprises help to enhance innovative strength and comprehensive competition that ultimately improve firms' environmental and financial performance (Zuo et al., 2019).

The Chinese government has realised the importance of innovation-driven development. Therefore, the dynamic development strategy has become the key to the steady growth of enterprises and the realisation of industrial upgrading and transformation. This has influenced the Chinese government to propose an independent innovation and technological progress that will be placed at a certain strategic height (Arranz et al., 2019).

The economic development method advocated in most developing countries, including China, is sustainable development (Kongkuah et al., 2021b). However, China's economic development model is mainly high input, low output, high-energy consumption, and high pollution (Wang et al., 2020b). This kind of economic development method violates the theory of sustainable development. In addition, the rapid growth of textile manufacturing industries has brought about a lot of monetary wealth to companies and also contributed to environmental contamination due to carbon emissions from production plants (Yadav et al., 2020). R&D investment consumes many human and financial resources but does not bring high returns to the enterprise in the short term. This therefore affect the financial position of firms in the short term. Hence, technological innovation affect the environmental performance and the financial performance of businesses.

Due to the increasing usage of inorganic fabrics like polyester and nylon as opposed to organic cotton and linen in the textile manufacturing industry, there is the need to examine the impact of technological innovation on environmental and financial performance of the textile industry in China as China advances the green production agenda.

Moreover, in the existing literature, most studies only focus on the investment in technological innovation and innovation-driven policies (Yasmeen et al., 2020). Other studies in their empirical analysis examined the relationship between corporate competitiveness and comprehensive financial performance (Gallegos and Miralles, 2021, Hanelt et al., 2021). Very few studies tried to explore the effect of technological innovation on financial performance for developing economies such as China. Even with the few studies, the authors did not consider taking the textile industry in China.

Based on the above literature gaps, the main research objective is to analyse the effect of technological innovation on environmental and financial performance for textile manufacturing companies listed in China.

The authors utilised a quantitative research design. Due to the nature of the research objectives, the study used secondary data for the empirical analysis. Majority of the data were readily available on ifind database. Hence, the authors relied on ifind to extract most of the data for the empirical analysis. Data that were not readily available on ifind were extracted manually from the sampled textile manufacturing companies' financial statements and annual reports. The study covered thirty-one year period from 1990 to 2020. The authors employed Stata and EViews Statistical software to run the empirical analysis. For the multiple regression analysis, the authors employed the generalised methods of moments (GMM) estimator since it uses a dynamic panel instead of the static panel, which helps in controlling for possible endogeneity issues. In addition, utilising the GMM estimator deals with possible heteroscedasticity and autocorrelation among the study variables.

The findings from the study revealed a positive but insignificant relationship between technological innovation investment and environmental performance. An inverse but insignificant relationship was found between green technological innovation and return on investment. Contrarily, a positive and statistically significant relationship was found at a 5% significance level between green technological innovation and environmental performance. In addition, the results revealed a positive connection between technological innovation investment and return on investment at the 1% significance level. Lastly, return on investment and environmental performance was found to have a positive slope relationship at the 5% significance level.

The study is arranged as follows; the first part presents the introduction of the study. The second part reviews related literature on the topic. Also, the theoretical and empirical review are covered in the second part. The third part focuses on the materials and methods employed in the research. The authors presented the findings from the study in part four. The final part presents the summary and conclusion of the study.

2 Literature review

2.1 Definitions of concepts

2.1.1 Technological innovation

Since economist Schumpeter first proposed that technological innovation is economic development, technological innovation has always received much attention (Chen and Lee, 2020, Diaconu, 2011, Omri, 2020). Scholars believe that technological innovation increases opportunity and corporate profit growth Zuo et al. (2019), the birth of high value-added innovative products Xu et al. (2019), and healthy competition among companies (Gallegos and Miralles, 2021). According to Chen et al. (2020), technological innovation gives birth to new changes. This change expands the investment and production materials, reflecting the enterprise's high operational performance. The demand for new products promotes technological progress and ultimately boost economic growth. Input is the essential element of technological innovation. The investment of enterprise technological innovation generally includes all human resources, material resources and financial resources incurred in technological innovation activities (Zhang et al., 2019).

2.1.2 Environmental performance

Environmental performance is concerned with reducing the negative impact on the ecology as a result of business activities. According to Das Neves Almeida and García-Sánchez (2017), environmental performance is the measurement of a company's compliance with environmental protection regulations. The authors indicated that high compliance with ecological regulations implies a high environmental performance. The study by Abbas et al. (2021) characterised ecological performance as the quantifiable aftereffects of an organisations impact on the ecology. Environmental performance can be characterised as the measure of how effective a firm is in reducing and limiting its effect on the environment.

2.1.3 Financial performance

Performance is a broad term, with different historical stages of development and other analysis targets. The operational and financial performance of a company reflects the company's operations, profitability and future growth capabilities. According to Liu et al. (2021a), the ability of a company to use assets to repay liabilities shows how the company is performing. Possessing moderate liabilities can keep companies' operations well, which is conducive to the profitability of companies. The profitability of a company reflects the company's use of various resources to obtain returns. The company's managers pay attention to its operating status, the ability to make profits, and, more importantly, the net profit margin (Gartenberg et al., 2019).

The financial performance is influenced by various factors that can be grouped as internal and external. Notable internal factors include utilising technical applications, innovation capability, operation management, human resources, and property rights structure. The external environment includes the socio-economic environment, legal environment, credit environment, competition in the industry, regulatory and business compliance and others (Centobelli et al., 2019).

2.1.4 Textile manufacturing industry

Manufacturing company is any firm that utilises human labour or machinery to process raw materials into finished or semi-finished products (Ghobakhloo, 2018). The study by Yeung and Mok (2005) opined that manufacturing is the large-scale assembling or production of components into finished products such as textile, computers, consumer electronics, electrical equipment, heavy machinery, refined petroleum products, just to mention but a few. The textile industry mainly involves yarn, fabric, garment design, manufacturing, and distribution (Chen and Xing, 2015). The source material for textile manufacturing may be natural or synthetic, using chemical industry products.

2.2 Theoretical review

2.2.1 Technological innovation theory

The theory of technological innovation began in the early 20th century. Omri (2020) believe that innovation is a non-stop mechanism that realises production factors and production conditions. That is a new combination that has never been seen before, shockingly affecting the original production system. Due to the wide range of innovative activities, the process is very complicated, and the starting points and premises of many scholars' are different. The academic circles have not yet reached a unified conclusion on the concept of technological innovation. Most of the research on technological innovation theory is combined with economic growth (Walrave and Raven, 2016). Feki and Mnif (2016) believed that technological progress is an endogenous economic variable and the continuous accumulation of knowledge.

Coccia (2018) believes that entrepreneurs and the national innovation system jointly promote technological progress. Although there are many branches of technological innovation theory, in general, technological innovation is promoted by entrepreneurs or governments to bring about changes in organisational forms and management methods that affect the environmental performance and financial performance of firms. According to Xu et al. (2019), the adaption of environmentally friendly plants in the production line leads to green innovation technologies by companies. Implementing the green innovation technology investment has both positive and negative impacts on organisations' environmental performance and financial performance management.

2.2.2 Capital investment decision-making theory

Capital investment refers to investing capital now and expecting to obtain it in the future (more than one year). Investing in technological innovation is an aspect of capital investment decision-making. Usually, capital investment cannot be compensated by the current sales income but needs to be converted into expenses in each future period and get compensation from each period's income (Zhang, 2012). The capital investment decision is also called the capital expenditure decision or capital budget (Dhankar, 2019).

Capital investment project involves a long production cycle, require huge amounts of capital, and will determine the company's long-term profitability. If an enterprise wants to develop a new technological innovation investment project, it must make investment decisions in fixed assets such as purchasing plants and equipment (Dhankar, 2019). When making capital investment decisions such as technological innovation, enterprises consider the level of profitability of such investments.

In the case of textile manufacturing companies listed in China, the firms have to invest in technological innovation in their production line, bringing about technological investment. The textile manufacturing companies need to continuously increase their innovation and increase the proportion of research and development investment in order to occupy a place in today's increasingly fierce economic environment. Companies that cannot keep up with the trend of the times and prompt R&D innovation investment to promote the product and industrial upgrades are likely to be eliminated by the market, affecting their profitability (Zhang, 2012).

2.2.3 Corporate social responsibility (CSR) theory

Corporate social obligation implies that when organisations expand their economic benefits, they likewise need to thoroughly consider the duty to society, such as protecting the environment. CSR alludes to duties that organisations bear the effect of their financial exercises on society, like buyers, employees, and the ecology (Osei et al., 2017). CSR accentuates that endeavours ought to zero in on the development of benefits and focus on ecological at different angles (Scherer, 2018). The natural duty that the firm should consider the legitimate and moral commitments. As far as legitimate commitments, organisations should hold fast to the laws given by the state in regards to ecological assurance. Regarding moral commitments, organisations should make an honest effort to decrease environmental pollution by utilising ecological plants and strategies in their production line (Advantage, 2020).

In textile manufacturing companies, the firms have to use environmental-friendly plants that will minimise the rate of greenhouse-gas emissions. In addition, the companies have to treat their wastewater and reuse them. Finally, textile manufacturing firms have to adapt to environmentally friendly materials in their production line. As a responsibility for textile manufacturing companies, their interest should be on financial gains and minimise the environmental issues related to their production.

2.3 Empirical review and hypotheses development

2.3.1 Technological innovation and environmental performance

Technological innovation implementation promotes the environmental performance of enterprises. However, the conclusions of existing studies are not entirely consistent. For example, Lee and Mo (2011), using game theory analysis, pointed out that the increase in technological innovation has a positive slope relationship with the environmental performance of the sample companies. Similarly, Wang et al. (2020a) employed the CCEMG estimator to explore the impact of technological innovation investment on environmental performance for listed manufacturing companies in Singapore from 2000 to 2015 and found that a positive and statistically significant relationship exists between technological innovation investment and environmental performance of firms.

The result of empirical research on pollution-intensive industries under green technological innovation is that systematic environmental policies promote a win-win situation between green technological innovation and environmental performance (Singh et al., 2020). The implementation of green technological innovation as a result of environmental compliance improves the environmental performance of industrial companies (Kraus et al., 2020). However, Ai-jun et al. (2009) empirical research in Xinjiang found that government environmental regulations are not conducive to energy efficiency improvement. Hence, green technological innovation have no impact on the environmental performance of companies in Xinjiang. Following the findings from the majority of previous studies, this study hypothesises that:

H1: A positive relationship exists between research and development investment intensity and the environmental performance of listed textile manufacturing companies in China.

H2: There exists a positive slope connection between green technological innovation and the environmental performance of textile manufacturing companies listed in China.

2.3.2 Technological innovation and financial performance

The economic consequences and influencing factors of investment in industrial technology innovation have been explored by previous studies. Most researchers focused on the company's size, the company's accounting choices, or the company's management's motivations for technological innovation (Černe et al., 2015, Yang et al., 2020, Xu et al., 2019). Yuan and Zhang (2020) empirical results show that the company's performance positively correlates with technological innovation investment using GMM estimator for manufacturing firms in Nanjing as a sample size for the period 2000 to 2018. The results of the research are consistent with those of Xu et al. (2019). Sempere-Ripoll et al. (2020) researched technological innovation investment and operational performance using British listed companies. The authors found a positive and statistically significant relationship between the two. That is, the production growth rate of the company is positively correlated with technological innovation.

Increasing the rate of R&D investment promotes the increase of operational performance and subsequently incorporates financial performance to a certain extent. The empirical result of Yang et al. (2020) opined that technological innovation investment positively affects corporate operational performance. Lau and Lo (2019) used private enterprises in Hong Kong as a research sample and concluded that there is an inverted U-shaped relationship between technological innovation investment and financial performance.

Basing on Zhejiang high-tech small and medium-sized enterprises, Černe et al. (2015) obtained the research results that an increase in the green technological innovation investment positively promotes performance in the long-term of business. This is conducive to the development of the company. Li et al. (2019), taking green technological innovation and the profit rate as the measurement indicators of technological innovation and financial performance respectively, concluded that green technological innovation investment is significantly positively correlated with financial performance.

Notwithstanding the positive correlations between technological innovation and financial performance, some scholars found an inverse or no relationship between the two. (Ping, 2010) took the manufacturing industry listed in Nigeria as a research sample and concluded that an inverse relationship exists between technological innovation and the operational performance of companies. De Azevedo Rezende et al. (2019) research concluded that there is a non-linearity between technological innovation input and corporate performance relationship. Following the findings from the majority of previous studies, this study hypothesises that;

H3: A positive relationship exists between research and development investment intensity and the financial performance of listed textile manufacturing companies in China in the long-term.

H4: There exists an inverse connection between green technological innovation and the financial performance of textile manufacturing companies listed in China in the long-term.

2.3.3 Return on investment and environmental performance

According to Zhang et al. (2020), environmental performance is susceptible to financial performance for several reasons. Firstly, a solid standing in the social field, as reflected by more broad and target high environmental performance aids customers in patronising products of the firm, thereby increasing profitability. Ecological performance likewise assists a firm with drawing in and retaining employees and improve representative assurance and, consequently, profitability (Lahouel et al., 2020).

Environmental performance possibly influences an organisation's future incomes and financial performance. Memon et al. (2020), use Kenya organisations as a sample and reasoned that there is a positive relationship between firms' environmental performance and financial performance (ROE) by employing the fully modified least squares (FMOLS) for the long-run relationship analysis for a sample of 429 observations. Aslam et al. (2021) report on the corporate environmental performance with capital business sectors in Western nations proposed a positive connection between environmental performance and corporate financial performance proxy by the return on investment. Consequently, the authors assumed that,

H5: An affirmative relationship subsists between environmental performance and return on investment.

3 Materials and methods

3.1 Research design

The authors adopted a quantitative research design for this research. Due to the nature of the study, the study utilised secondary data. The secondary sources of information were extracted from the financial statements and annual reports of the sampled textile manufacturing companies.

Based on previous studies, the authors selected appropriate variables for the empirical analysis. In terms of environmental performance, the authors proposed an environmental performance index to assess the environmental performance of the listed textile manufacturing companies. Return on investment was used as an indicator of financial performance in the empirical analysis. For the independent variables, the authors selected technological innovation investment intensity and green technological innovation as the proxies for technological innovation. Most of the data were readily available on ifind database. Hence, the authors relied on ifind to extract most of the data for the empirical analysis. Data that were not readily available on ifind were extracted manually from the sampled textile manufacturing companies' financial statements and annual reports.

This study is designed to cover data from 1990 to 2020. The authors considered this period frame due to data availability from ifind database for the empirical analysis. Most of researchers in economics and finance employed Stata (Kongkuah et al., 2021a, Agyemang et al., 2021) and EViews Agyemang et al. (2020) for their empirical analysis. Similarly, this study also utilised Stata version 13 and EViews version 10 for the empirical analysis.

3.2 Population and sampling techniques

The authors selected China as the study population since China is championing green production in the last two years Cabral et al. (2021). There have been an increase in the call for academic and industry to suggest policies in enhancing the green technological agenda which was put forth during the celebration of Chinese seventy anniversary in 2019 as suggested by Lewis et al. (2021).

There are three main stock exchanges in China: the Shanghai, Shenzhen, and Hong Kong Stock Exchange. The purposive sampling technique was used to select the highest capitalisation among the three stocks for the year 2020. In effect, Shanghai Stock Exchange (SSE) was selected as the population for the study, since its market capitalisation was the highest in 2020 with over 6.95 trillion US dollars (Arshad, 2021). This made the Shanghai Stock Exchange the largest bourse based on market capitalisation in the Greater China region.

With regards to the sample size, the authors used purposive sampling to select textile manufacturing industries listed on the Shanghai Stock Exchange. This is because technological innovation is mostly implemented at companies that are into the production or manufacturing of products (Diaconu, 2011). The textile industry mainly involves fabrics, garment designs, manufacturing, and distribution (Bullón et al., 2017). The source material for textile manufacturing may be natural or inorganic. Both natural and inorganic sources have impact on the environment and the financial performance of the firms. This is because; sustainable development theory of utilising natural resources effectively for the current generation so that future generation can have enough of such natural resources sets in whenever a firm is using more natural resources for their production. In addition, the usage of inorganic fabrics such as polyester and nylon bring about eco-friendly issues since they are petroleum-based products and takes about one hundred years to biodegrade (Nagalakshmaiah et al., 2019). This, therefore, calls for the treatment of waste properly so that the economic gains of the textile industry will not affect the ecology. Based on these reasons, the textile manufacturing industry was selected as the sample size.

As of December 2020, the Shanghai Stock exchange had eighty-eight companies listed under textile manufacturing companies. This accounted for about 45.83% of the total textile manufacturing industries listed on China's three main stock exchanges (Arshad, 2021). To get strongly balanced panel data that will support all the statistical analysis, the authors considered listed textile manufacturing companies that had readily available data on the ifind database from 1990 to 2020. In effect, twenty- seven of the listed textile manufacturing companies were excluded from the study. Therefore, the final sample was made up of sixty-one textile-manufacturing companies listed on the Shanghai Stock Exchange.

3.3 Data sources

The authors utilised secondary data for the empirical analysis. With the exception of environmental performance and green technological innovation variables, the other variables were extracted from the financial statements of the sampled textile manufacturing companies listed on the Shanghai Stock Exchange. All the data were readily available on ifind database; hence, the authors extracted the financial statements data from the ifind database.

The authors used the content analysis technique to score marks for the environmental performance index. The authors adopted and modified the Environmental Performance Index (EPI) by Agyemang et al. (2021) which was used to measure the environmental performance of listed mining companies in China. The EPI consisted of four indicators to measure the environmental performance of the sampled textile manufacturing companies listed on the Shanghai Stock Exchange. 3 scores were allocated to the item if it is fully reported. 1 point was assigned to the item if it was fairly reported, while 0 was allocated if not reported. The scores were then summed as a proportion to the total score of 12. The four indicators are:

a the firm was not engaged with 'The Report on Punishment for Environmental Pollution'

b the firm embraced ISO 14001 or other pertinent natural administration frameworks

c the firm was granted the honour of 'Public Environmentally Friendly Enterprise' at the MEP's common levels

d the firm was granted the honour of 'Public Environmentally Friendly Enterprise' at the MEP's public levels.

The authors used a dummy variable to represent the green technological innovation after reading the environmental reporting part of the annual report. If the sampled company recorded eco-friendly technological innovation, 1 was assigned while 0 was assigned if the company does not report on environmentally friendly technological innovation.

The strongly balanced panel data consisted of sixty-one textile manufacturing companies for thirty-one years was used for the empirical analysis.

3.4 Model specification

To test for the empirical relationship between technological innovation on environmental and financial performance of textile manufacturing companies listed on the Shanghai Stock Exchange, the authors adopted and modified a model by Chege et al. (2020) which is given as:

$$EPI_{it} = \beta_0 + \beta_1 RD_{it} + \beta_2 GTI_{it} + \beta_3 CS_{it} + \beta_4 MSR_{it} + \varepsilon \quad (1)$$

$$ROI_{it} = \beta_0 + \beta_1 RD_{it} + \beta_2 GTI_{it} + \beta_3 CS_{it} + \beta_4 MSR_{it} + \varepsilon \quad (2)$$

$$EPI_{it} = \beta_0 + \beta_1 ROI_{it} + \beta_2 CS_{it} + \beta_3 MSR_{it} + \varepsilon \quad (3)$$

Where EPI represents environmental performance index. ROI represents the return on investment, RD denotes the percentage of research and development investment to total revenue of the sample companies, GTI represents the presence or absence of green technological innovation, which was measured by a dummy variable, CS denotes the capital structure, and MSR represents the percentage of management shareholding. β_0 denotes constant while the symbol ε denotes the error term. *i* and *t* represent the sample country and year, respectively.

Equation (1) was used to evaluate the impact of technological innovation on environmental performance. Hence, the environmental performance index (EPI) was used as the dependent variable in equation (1). In equation (2), the impact of technological innovation on financial performance was examined. Return on investment was used as the proxy to measure the financial performance in equation (2). Finally, equation (3) was used to explore the effect of return on investment on environmental performance of textile manufacturing companies listed on the Shanghai Stock Exchange.

3.5 Variable description

The data used for the study is summarised in Table 1. It presents the dependent, independent and control variables used in the model for the empirical analysis.

Table 1 Summary of study variables

Category	*Variable name*	*Symbol*	*Description*	*Expected sign*
Dependent variable	Environmental performance index	EPI	Calculated by evaluating the environmental performance of each of the textile manufacturing companies	
	Return on investment	ROI	Evaluate the efficiency or profitability of an investment	
Independent variables	Technological innovation investment	RD	Percentage of research and development investment to total revenue of the company	+
	Green technological innovation	GTI	If the company invests in green technological innovation, we assign 1 while we assign 0 if the company does not invest in green technological innovation	+
Control variables	Capital structure	CS	Total liabilities divided by total assets	+
	Management shareholding	MSR	Percentage of management members who hold shares in the company	+

3.6 Data processing

The authors first performed descriptive statistics and correlation matrix analysis. In order to select an appropriate estimation technique, a cross-sectional dependency test was performed. Cross-sectional reliance emerges if the n in the sample are not freely drawn perceptions yet influence each other's result. In addition, the authors performed stationarity and cointegration tests. The findings from the cross-sectional dependency, stationarity and cointegration tests influenced the authors to select the GMM estimator for the multiple regression analysis. The GMM uses a dynamic panel instead of the static panel in the regression analysis. The usage of the dynamic panel helps in controlling for possible endogeneity issues. In addition, utilising the GMM estimator deals with possible heteroscedasticity and autocorrelation among the study variables.

4 Findings and discussion

4.1 Descriptive statistics

Table 2 shows the descriptive statistics for the research variables. The dependent variable, EPI, showed an average of 0.7370, suggesting that most Chinese textile manufacturing companies listed on the SSE comply with environmental protection regulations. Hence, there is a high environmental performance for the sample companies. Notwithstanding the mean EPI, which is very encouraging, the minimum EPI value of 0.0700 indicates that very few textile manufacturing companies listed on the SSE do not comply with environmental protection regulations. The median EPI of 0.7400 is close to the mean, suggesting a symmetrical distribution.

Table 2 Summary of the descriptive statistics

Statistics	*EPI*	*ROI*	*RD*	*CS*	*MSR*
Mean	0.7370	18.1327	6.7820	0.5873	0.0065
Median	0.7400	17.8300	5.7500	0.5868	0.0070
Maximum	0.8800	41.1200	21.1800	0.6493	0.0150
Minimum	0.0700	4.9600	0.8750	0.5183	0.0000
Std. Dev	0.2980	5.1265	4.1274	0.0151	0.0017
Skewness	0.0829	0.8202	1.1381	–0.0948	0.1561
Kurtosis	3.1264	4.9240	3.8691	5.3561	5.8773
Observations	1891	1891	1891	1891	1891

Moreover, ROI, which was used as a dependent variable in equation (2), revealed mean and median values of 18.1327% and 17.8300% respectively. The closeness of the mean and median values suggest that the data is symmetrically distributed. The maximum return on investment value of 41.1200% suggests that some few textile manufacturing industries listed on the Shanghai Stock Exchange are making good returns for their shareholders. The minimum ROI of 4.9600% indicates that all the textile manufacturing companies are making positive returns on their investment which is a good sign of growth in the industry.

With regards to the independent variables, technological innovation investment intensity (RD) recorded a mean of 6.7820% with maximum and minimum values of 21.1800% and 0.8750% respectively. This implies that textile manufacturing companies invest a good proportion of their total income into research and development to bring about innovations in their end product. The high investment of technological innovation is the cause of the industry recording positive returns on their investment. Since a dummy variable represented green technological innovation, it was excluded in the descriptive statistics.

For the control variables, the capital structure that measures the degree of debt to equity financing revealed mean and standard deviation values of 0.5873% and 0.0151% respectively. The mean figure shows that the textile manufacturing companies listed on the SSE are approximately 0.6%. The low level of debt to equity ratio implies that most textile manufacturing companies use equity financing compared to debt financing. Employing equity finance prevents the companies from paying interest on loans, and possible foreign exchange losses, which could reduce the profitability of the companies. Hence, the high equity financing helps the textile manufacturing companies to make more profit that reflected in the positive return on investment for all the sample companies. The smaller standard deviation than the mean value indicates that the dataset is widely dispersed from the mean.

The average shareholding proportion for management was 0.0065%, suggesting that less than 1% of shares are held by management. The minimum and maximum values recorded further affirm that the proportion of management holding shares in the companies are very low. The standard deviation of 0.0017 recorded indicates that the data is widely dispersed from the mean.

Regarding skewness, EPI and CS recorded fairly symmetrical, while ROI recorded moderate skewness. Only RD and MSR recorded high skewness. Moreover, only CS recorded negative skewness suggesting a longer tail on the left side of the distribution. The other study variables recorded positive skewness indicating that the mean is greater than the median. In terms of kurtosis, all the study variables recorded values above 3.0, which suggest that the dataset has heavier tails than the normal distribution.

4.2 Correlation matrix and multicollinearity analysis

The spearman matrix of correlations is presented in Table 3. The matrix revealed a mixture of weak, average and high correlations among the pairs. MSR and RD recorded the least absolute correlation of 0.0456, while MSR and CS recorded the highest absolute correlation of 0.8386. With the exception of capital structure (CS) which revealed an inverse correlation with EPI for the sample companies, the other study variables revealed a positive and statistically significant correlation with environmental performance. In addition to the correlation matrix, Table 3 also presents the results of the multicollinearity test. The VIF is used to determine the presence or absence of multicollinearity among the study variables. A mean-variance inflation factor of 2.97 is evidence for the absence of multicollinearity in our data. However, the high correlation between MSR and CS is likely to show the presence of multicollinearity. To deal with possible multicollinearity, the authors employed the GMM estimator.

Table 3 Spearman correlation and multicollinearity test

Variables	*EPI*	*ROI*	*RD*	*CS*	*MSR*	*VIF*	*1/VIF*
EPI	1.0000						
ROI	0.4114***	1.0000				1.29	0.7763
RD	0.1015*	–0.1056**	1.0000			1.02	0.9838
CS	–0.1100*	0.5005***	–0.0635	1.0000		5.98	0.1672
MSR	0.1430***	–0.4486***	0.0456	–0.8386***	1.0000	5.57	0.1795

*, **, *** shows significance at 10%, 5%, and 1% level respectively.

4.3 Preliminary tests

4.3.1 Cross-sectional dependency analysis

A cross-sectional dependency (CD) impact on estimate depends on many factors, including the magnitude and kind of cross-sectional correlations. Ignoring cross-sectional dependence may result in a substantial loss in estimation efficiency (Bi et al., 2020a). Table 4 presents the results of Friedman's test of cross-sectional dependency.

Table 4 Friedman's test of cross-sectional independence

Test	*Statistics*	*Probability*
Using fixed effect (FE)	34.465	0.0440
Using random effect (RE)	33.007	0.0618

From Table 4, the probability values of 0.04 and 0.06 were recorded for fixed effect (FE) and random effect (RE) models respectively. This implies that the test results are significant at the 5% and 10% levels for FE and RE models. Since both the FE and RE recorded statistically significant probability values, the null hypothesis of no CD is rejected while the alternative hypothesis of CD is accepted. This indicates that a shockwave in one of the textile manufacturing companies is most likely to result in the other textile manufacturing companies.

4.3.2 Stationarity analysis

The stationarity of the series is a prerequisite for the cointegration test. Hence, after obtaining the presence of CD among the study variables, the authors performed the Cross-sectional Im Pesaran Shin (CIPS) unit root test. The results of the stationarity test are presented in Table 5.

Table 5 CIPS unit root test

Variables	*Level*		*First difference*	
	Constant	*Trend and constant*	*Constant*	*Trend and constant*
EPI	–2.569	–3.083	–3.33	–3.585
ROI	–2.984	–2.814	–3.151	–3.281
RD	–1.182	–2.279	–2.83	–2.948
GTI	–0.257	–0.45	–0.988	–1.496
CS	–2.92	–2.666	–3.536	–3.766
MSR	–2.936	–2.986	–3.943	–4.046

From the CIPS unit root test in Table 5, with the exception of the technological innovation investment intensity (RD), all the other study variables were integrated at the level for both constant and constant with trends. RD recorded values that were below the absolute critical values of 2.14 and 2.66 for constant and constant with trends respectively. Since RD was not integrated at level, the authors performed the stationarity test at first difference. After first differencing, all the study variables were integrated at both constant and constant with trends. Therefore, the authors concluded that the study variables are integrated at first difference.

4.3.3 Cointegration test

The cointegration test measures the long-run connection between variables. The test is a prelude to the multiple regression analysis (Tawiah et al., 2021). The absence of cointegration means that there is no long-run relationship among the study variables. Hence, there will not be a need for multiple regression analysis.

The Augmented Dicker Fuller cointegration test results in Table 6 revealed a probability value of less than 0.01, indicating a 1% significance level. Therefore, the null hypothesis of no cointegration is rejected, while the alternative hypothesis of cointegration is accepted. This indicates that the integrated study variables have a long-run relationship.

Table 6 ADF cointegration test

Test	*t-Statistic*	*Prob*
ADF	–3.17648	0.0007

4.4 Multiple regression analysis

In order to explore the long-run effect of technological innovation on environmental and financial performance, the authors employed the GMM estimator for the multiple regression analysis. The GMM estimator uses a dynamic regression technique that helps in resolving possible endogeneity and multicollinearity among the study variables. The authors used the GMM estimator for the empirical analysis as opposed to other estimators such as OLS which were used in previous studies without considering econometrics issues such as endogeneity, multicollinearity, and heteroskedasticity. *Model 1* was used to explore the impact of technological innovation on the environmental performance of textile manufacturing companies (hypotheses 1 and 2) using equation (1). *Model 2* examines the impact of technological innovation on financial performance (hypotheses 3 and 4) using equation (2). *Model 3* explores the impact of financial performance on environmental performance (hypothesis 5) using equation (3). The results of the multiple regression analysis are presented in Table 7.

According to Table 7, the Sargan and AR(2) recorded an insignificant probability for all the four models implying that the over-identifying restrictions in the model are valid. Since the higher p-value of the Sargan test shows how better the model is, the findings from Table 7 revealed high p-values of above 0.25, indicating that the model is appropriate for explaining the impact of technological innovation on environmental and financial performance of textile manufacturing companies listed on the Shanghai Stock Exchange.

From the findings in Table 7, technological innovation investment (RD) revealed a positive relationship with environmental performance (EPI) in *Model 1*. The positive relationship implies that a percentage increase in technological innovation investment reflects in an increase by 1.2934 in the environmental performance level of the textile manufacturing companies. The positive relationship is, however, not statistically significant. Therefore, the first hypothesis is rejected.

Table 7 Multiple regression results

Variables	*Model 1* (*EPI as Dependent*)	*Model 2* (*ROI as Dependent*)	*Model 3* (*EPI as Dependent*)
LnDependentL1	1.2300***	2.1360**	2.0302***
LnROI			3.4145**
LnRD	1.2934	4.1200***	
GTI	2.2314**	–1.0340	
LnCS	0.3045*	0.2060	0.3933*
LnMSR	0.2814	0.086**	0.0212
Obs	1891	1891	1891
Sargant test	25.38	30.22	38.42
AR(2) Test	0.58	0.65	0.75

*, **, *** shows significance at 10%, 5%, and 1% level respectively.

Regarding the relationship between green technological innovation (GTI) and environmental performance (EPI), the findings from *Model 1* revealed a positive and statistically significant relationship between the two. This implies that whenever the firm implements green technological innovation, it corresponds to an increase by 2.2314 in the company's environmental performance. The positive relationship is statistically significant at the 5% level since the p-value recorded was less than 0.05. Therefore, the second hypothesis of the study is accepted.

The results from *Model 2* revealed a positive slope relationship between technological innovation investment (RD) and financial performance proxy by return on investment (ROI). The positive slope relationship implies that a percentage increase in RD influences in an increase of 4.1200 in the ROI. The positive relationship is statistically significant at the 1% significance level. Hence, the authors accepted the third hypothesis because the findings are in line with the assumption.

In addition to the above, the findings from *Model 2* in Table 7 posit a positive but insignificant relationship between green technological innovation (GTI) and return on investment (ROI). This indicates that the implementation of GTI increases the financial performance of the textile manufacturing firms by 1.0340. However, the positive relationship is not statistically significant. Hence, the fourth hypothesis is rejected.

Finally, from *Model 3* in Table 7, a positive relationship, which is statistically significant at the 5% significance level, was found between return on investment (ROI) and environmental performance index (EPI). This implies that a percentage increase in the firm's financial performance influences the level of environmental performance by 3.4145. This is as a result of the fact that when firms are able to generate high profit, they can finance green technological innovation, which will improve their environmental performance in the long run. Based on the findings, the final hypothesis of the study is accepted.

4.5 Discussion

4.5.1 Technological innovation investment and environmental performance

With the advancement and implementation of green economy in China, enterprises have come to accept that technological innovation is the driving force for their sustainable development. This, therefore, calls for companies to increase their investment in technological innovation capabilities, such as capital investment in information communication and technology (ICT) Latif et al. (2018) and increasing investment in R&D funds. Based on this, the authors assumed a positive relationship between technological innovation investment and environmental performance of textile manufacturing companies. From the regression analysis, a positive but statistically insignificant relationship was found between technological innovation investment intensity and environmental performance index. Hence, the first hypothesis is rejected. Our findings are consistent with the findings of Yang et al. (2020), who found a positive but insignificant relationship between technological innovation investment and environmental performance. Our results are contrary to the findings of Sempere-Ripoll et al. (2020), who found a positive and statistically significant relationship between technological innovation investment and environmental performance of British listed companies. Our findings suggest that technological innovation investment has a positive but insignificant relationship with environmental performance of textile manufacturing firms. Notwithstanding, as a leader of clean production, China should still advance in technological innovation investment to minimise carbon emissions which in the long run will reduce consumption-based carbon emissions in the global economy as suggested by (Jijian et al., 2021). That is, to reduce pollution emissions which will ensure in the high environmental performance of the Chinese textile firms.

4.5.2 Green technological innovation and environmental performance

The implementation of green technological innovation as a result of environmental compliance improves the environmental performance of industrial companies. Based on this background, the authors assumed a positive relationship between green technological innovation and the environmental performance of textile manufacturing companies listed on the SSE. The findings are in line with the assumption. Hence, our second hypothesis is accepted. Our findings are consistent with the findings of Singh et al. (2020), who opined that green technological innovation influences environmental performance positively. The findings from our study affirms that, green technological innovation has emerged to ensure environmentally friendly production lines. Hence, as China continues to advance their strategies on green production, emphasis should be made on the compliance of green technological innovation of textile manufacturing companies. The compliance of green technological innovation by textile manufacturing firms in China ensures both economic and ecological protection. This in the long run improves the environmental performance level of the Chinese textile manufacturing firms.

4.5.3 Technological innovation investment and financial performance

The results from the analysis affirmed a positive relationship between technological innovation investment and financial performance of listed textile manufacturing companies in China. That is a positive and statistically significant relationship at 1%

significance level was found between technological innovation investment intensity and return on investment. Hence, hypothesis three was accepted. The findings are consistent with Lee and Mo (2011), who used game theory analysis and pointed out that the increase in technological innovation has a positive slope relationship with financial performance using return on investment as a proxy for financial performance. In addition, the findings from our study affirms that investing in technological innovation through ICT investment promotes efficiency which reflects in the financial performance (Liu et al., 2021b). Our results suggest that when Chinese textile manufacturing firms invest in technological innovation, it helps the companies to improve production and enable the companies to enjoy economies of scale due to the quantity of products produced. With the economies of scale, the companies enjoy competitive pricing and in effect, the products are able to penetrate the global market with ease. This eventually reflect on the financial performance of the companies. Hence, investing in technological innovation promotes the financial performance of the textile firms in the long run.

4.5.4 Green technological innovation and financial performance

The result from the study revealed an inverse but statistically insignificant relationship between green technological innovation and financial performance for textile manufacturing firms. This is because the improvement of green technological innovation ability is not achieved overnight, but a gradual increase process, which requires financial resources, human capital and materials for production (Khan et al., 2021). Concerning human capital, the firm needs to utilise the services of advanced high-level talents to guide technical production and motivate talents to continue the driving force for innovation. Employing such talents will cause a financial burden to the company that will increase the expenditure of the firm. In addition, investing in green technological innovation is capital intensive and such investment will take some years for the firm to recover. Hence, in the short to middle term, investing in green technological investment reduces the financial performance of the Chinese textile manufacturing firms. Therefore, the fourth hypothesis is rejected. Our findings are contrary to the findings of Kraus et al. (2020), who found that the implementation of green technological innovation as a result of environmental regulations improves the financial performance of industrial companies.

4.5.5 Financial performance and environmental performance

The empirical analysis concluded that the return on investment has a significant impact on the textile manufacturing companies' environmental performance. This phenomenon is mainly attributed to the Chinese government's environmental management laws, rules, and regulations. A typical example is granting tax reliefs to environmentally friendly companies, leading to an increase in their financial performance. In addition, the Chinese government's reward and punishment system has ensured that companies comply with environmental disclosure requirements to avoid huge fines that affect their financial performance. Hence, we accept our final hypothesis which assumed a positive relationship between return on investment and environmental performance for textile manufacturing firms listed on the Shanghai Stock Exchange. Our findings are similar to the findings by Memon et al. (2020), who used Kenya organisations as a sample and reasoned that there is a positive relationship between firms' environmental performance and financial performance (ROE) by employing the fully modified least squares

(FMOLS) for the long-run relationship analysis for a sample of 429 observations. In addition, our findings affirm the findings of Bi et al. (2020b) who revealed that environmental performance is a collaborative effort by both government, industries and the community.

5 Conclusion and policy implications

5.1 Conclusion

China's economic growth rate has been ranked among the world's major economies. The continuous reforms and improvements have strengthened the link between economic development and technological innovation. Implementing high-value-added technologies improve market competitiveness, which influences sales and financial performance of companies. Investing in R&D is a significant way of ensuring technological innovations. R&D of enterprises help to enhance innovative strength and comprehensive competition that ultimately improve firms' operational and financial performance. As China is in the implementation state of ensuring technological innovation while obtaining economic gains, textile manufacturing companies listed on the SSE are required to use environmental-friendly plants, which will help to reduce greenhouse gas emissions. Technological innovation has an impact on environmental and financial performance of firms. Based on this background, the authors sought to examine the impact of technological innovation on the environmental and financial performance of textile manufacturing companies listed on the Shanghai Stock Exchange.

The authors employed a quantitative research design by utilising secondary data for the empirical analysis. The authors extracted data from the sample textile manufacturing companies' financial statements and annual reports from 1990 to 2020. Majority of the data was easily accessible on ifind database. The empirical analysis was carried out using Stata and EViews statistical software. The authors employed the GMM estimator for the multiple regression analysis. In addition, utilising the GMM estimator deals with possible heteroscedasticity and autocorrelation among the study variables.

The findings from the study revealed a positive but insignificant relationship between technological innovation investment and environmental performance. Similarly, a positive but insignificant relationship was found between green technological innovation and return on investment. Contrarily, a positive and statistically significant relationship was found at a 5% significance level between green technological innovation and environmental performance. In addition, the results revealed a positive connection between technological innovation investment and return on investment at the 1% significance level. Lastly, return on investment and environmental performance was found to have a positive slope relationship at the 5% significance level.

Based on the findings, it is recommended that management should not downplay the need for investment in the research and development of enterprises in ensuring high financial performance. Textile manufacturing companies should continuously improve their technological innovation investment, especially green technologies, and earnestly perform environmental protection responsibilities. This will help to improve the environmental performance of textile manufacturing companies listed on the Shanghai Stock Exchange. Also, the findings from the study affirm that, in the long run, technological innovation is positively connected to financial performance. Hence, companies should not just look at the short-term losses they will incur but also consider the long-term profit they will gain and, therefore, adopt technological innovations.

Due to the availability and standardisation of data, this paper does not take into account that other small and medium-sized textile manufacturing companies that are not listed on the Shanghai Stock Exchange. Future studies can consider the addition of such companies in their empirical analysis. Also, there are certain omissions in the indicators of technological innovation. Technological innovation includes corporate R&D investment, green technological innovation, the number of R&D personnel invested, and patent applications. The current study only considered technological innovation investment and green technological innovation as proxies. Other essential indicators were not considered due to data availability. Future studies can incorporate such items in their empirical studies.

5.2 Policy implication

The positive slope relationship between technological innovation and environmental performance affirms that the adherence of technological innovation as part of the green production strategy by the Chinese government promotes both environmental and financial performance of textile manufacturing companies. Hence, in advancing the green production strategy, management of textile manufacturing companies need to enforce the compliance of technological innovation which will promote both the financial performance and ecological performance of the textile industry.

Since the findings from the study are in line with the green production strategy, policy makers in other economies can take clue from the Chinese green production strategy and enhance the promotion of green production in their various strategies. When various economies achieve the green production strategy, it will enhance the global effort of green production strategy which the United Nations aim to achieve by 2030.

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