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How Does the Digital Transformation of Banks Improve Efficiency and Environmental, Social, and Governance Performance?

Yongjie Zhu and Shanyue Jin *

College of Business, Gachon University, Seongnam 13120, Republic of Korea
* Correspondence: jsyrena0923@gachon.ac.kr

Abstract: In the era of the digital economy, traditional industries have begun to realize digital transformations. For commercial banks, digital transformation is a trend and a requirement and is the only way to achieve sustainable development. At the same time, at the helm of the enterprise, executives play an essential role in the development of commercial banks. This study explored the relationship between digital bank transformation and bank efficiency, environment, society, and corporate governance (ESG) through empirical analysis, and how executives' innovation awareness and executive technical background affect the relationships between digital bank transformation, bank efficiency, and ESG. This study used the regression method of fixed effects to conduct empirical research on the data of China's A-share listed banks from 2011 to 2021. The research results show that the digital transformation of banks has improved efficiency and promoted the ESG performance of commercial banks. At the same time, executives' innovation consciousness and technical background have played a positive regulatory role in banks' digital transformation to promote bank efficiency and ESG. The main research object of this study was Chinese commercial banks. The bank's digital transformation results were examined and the research was expanded to digital transformation and ESG. At the same time, this study has particular significance for investors who have a financial interest in banks.

Keywords: digital transformation of banks; bank efficiency; ESG; executive innovation awareness; executive technical background

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1. Introduction

With the development of digital technologies such as artificial intelligence, big data, and blockchain, the world has gradually entered the era of digital economy [1]. The advancement of science and technology has promoted the innovation of traditional industries; digital transformation has gradually become a trend [2]. In China, the People's Bank of China issued two fintech development plans in 2019 and 2022, emphasizing that financial institutions should accelerate digital transformation [3]. In the banking industry, the emergence of intelligent robots, intelligent point-of-sale machines, cash recycling machines, and coin exchange machines is the response policy of commercial banks and the only way to achieve sustainable development.

As a traditional industry, commercial banks are the pioneers of informatization [4]. Facing the advent of the digital economy, commercial banks are actively or passively carrying out digital transformation [5]. By accelerating banks' digital transformation, commercial banks have achieved income diversification, "overtaking on corners", and building a "century-old bank." At the same time, the digital transformation of banks has also played a role in promoting the financial performance of commercial banks. Thus, how does the digital transformation of banks affect bank efficiency? The existing literature gives answers from different angles.

First of all, based on the perspective of financial technology, the analysis was carried out through the transmission mechanism. Fan, et al. [6] identified that financial technology

has promoted banks' digital transformation through financial innovation and technology spillover. After the digital transformation of banks, the efficiency of lending has been accelerated, and the financing efficiency of small- and medium-sized enterprises has been improved [7]. Shou [8] pointed out that financial technology has promoted the digital transformation of banks and improved the efficiency of banks by reducing the level of risk management and control. The literature review indicated that, recently, scholars have researched the digital transformation of banks from the perspective of financial technology, and pointed out that the digital transformation of banks has improved the efficiency of banks and further improved the financial performance of commercial banks.

Second, through the spillover effect, banks' digital transformation improves commercial banks' efficiency. Hoehle, et al. [9] pointed out that the digital transformation of banks can improve the service model of traditional commercial banks, thereby promoting the transformation and upgrading of commercial banks. From the perspective of heterogeneity, commercial banks will undergo mergers and acquisitions under the impact of digital transformation, and the total factor productivity of restructured commercial banks can be improved to a certain extent. Large commercial banks have a greater digital technology absorption capacity than small commercial banks. Chen [10] took 20 Chinese commercial banks as a sample and compared and analyzed the changes in profit efficiency before and after the establishment of WeBank, China's first online merchant bank. The study found that after MYbank was established, the bank's profit efficiency increased significantly.

At the same time, in recent years, glaciers have melted, sea levels have risen, and smog has appeared, emphasizing the global importance of environmental protection. In order to achieve ecologically sustainable development, the "double carbon" goals (carbon peak and carbon neutrality) have been included in Chinese government work reports and included in the overall layout of ecological civilization construction to promote the transformation of the national economy to be low carbon and green. For commercial banks, it is a new requirement to realize their development while protecting the ecological environment. Investors, governments, the media, etc., are all paying close attention. Therefore, in the era of the digital economy, how can commercial banks improve ESG performance through bank digital transformation?

ESG reflects the social responsibility of commercial banks. In China, state-owned commercial banks undertake part of their social responsibilities when developing their businesses, including environmental governance and poverty alleviation projects. For joint-stock commercial banks, undertaking social responsibilities will require additional investment, increase the cost of commercial banks, and reduce the profits of commercial banks. Therefore, passive social responsibility leads to poor ESG performance. Zhao, et al. [11] pointed out that ESG should be incorporated into application decision-making as a nonfinancial factor to avoid short sightedness and achieve long-term sustainable development. Some scholars also believe that ESG should be included in leadership and corporate culture during digital transformation. This can not only enhance the reputation of commercial banks but also improve the operating performance of commercial banks [12].

The impact of bank digital transformation on commercial banks is multifaceted, specifically reflected in bank efficiency and operational capabilities. However, there needs to be more relevant research on how banks' digital transformation affects corporate ESG performance. Therefore, in the era of a green economy, it is necessary to study the impact of bank digital transformation on ESG. At the same time, banks' digital transformation is affected by many factors, such as COVID-19, the nature of banks, and the life cycle of enterprises [13]. In addition, at the helm of commercial banks, executives play an essential role in the daily operation and management. Executives with innovation awareness and a technical background will actively promote digital transformation when the digital economy comes. Li, et al. [14] pointed out that many commercial banks have constructed and launched mobile banking. Mobile banking is one of the important achievements of banks' digital transformation. Mobile banking can improve the service efficiency and business efficiency of commercial banks.

This study drew on the Leviäkangas [15] research method and used meta-analysis to organize the existing literature; see Figure 1 for details. In the Scopus and Web of Science (WOS) databases, 1527 results were obtained after inputting the keywords "digital transformation of banks". After the screening, 1183 results were obtained after filtering those in the English language. Furthermore, after searching for the related research topics of "bank efficiency" and "ESG" and deleting duplicate articles, 163 results were obtained. Finally, after filtering out irrelevant articles, 34 results were obtained. In total, 36 results were obtained after adding 2 unindexed related research articles through Google Scholar.

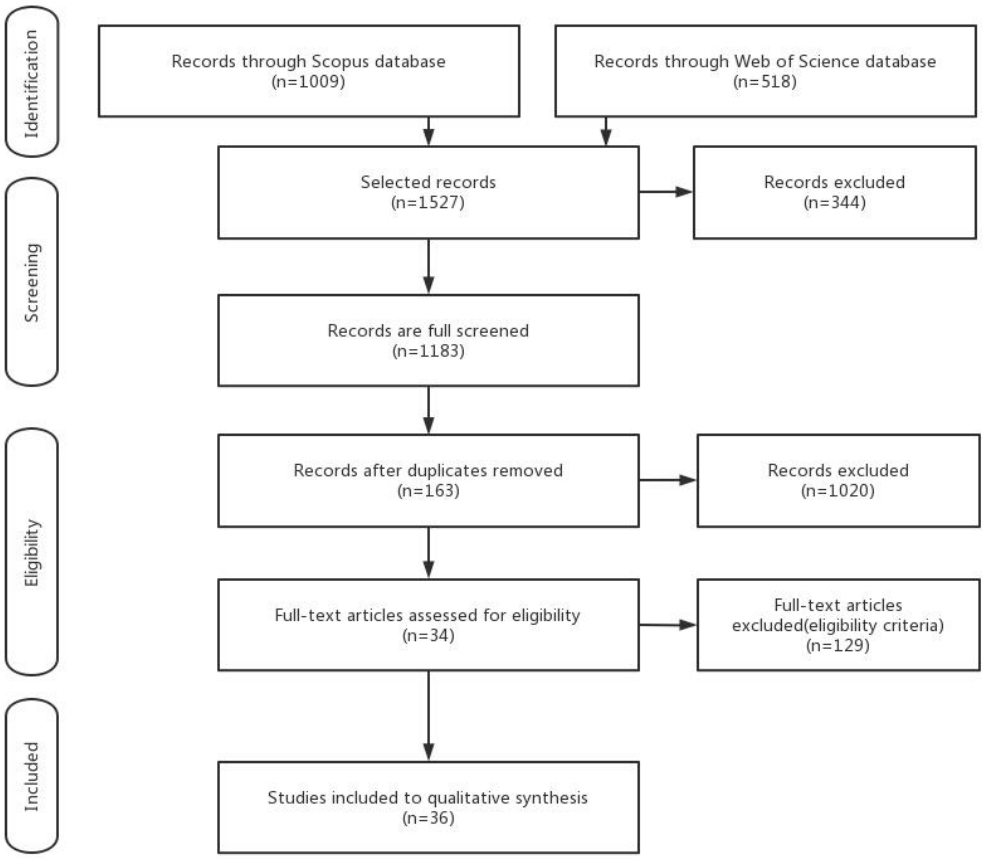

Figure 1. PRISMA flowchart.

Through the literature review, it was found that there are few studies on the digital transformation of banks. Some literature studies have measured the digital transformation of banks. Some scholars studied the impact of financial technology on banks' digital transformation; others have studied the impact of banks' digital transformation on commercial banks' financial performance.

Moreover, bank digital transformations have even less impact on bank efficiency and ESG. The existing literature was reviewed using the case-analysis method; very few studies have taken China's listed A-shares as the research object. Part of the reason is that only 40 commercial banks are listed on China's A-share market. Therefore, this study explored the relationship between bank digital transformation and bank efficiency and ESG through empirical analysis. At the same time, the executives' innovation awareness and executives' technical background were introduced as adjustment variables; empirical research was carried out using the data of China's commercial banks.

Compared with the existing literature, this paper has the following contributions: first, research on digital transformation is enriched by taking the digital transformation of banks as an entry point; second, through the digital transformation of banks, the research on bank efficiency and ESG is expanded; third, attention is paid to the role of executive cognition, and the impact of bank digital transformation on bank efficiency and ESG is analyzed;

fourth, this study provides a reference for investors with a financial interest in banks and has good practical significance.

The structure of this study is as follows. The Section 1 is the introduction, which summarizes the research background, purpose, and significance. The Section 2 is the theoretical background and hypothesis derivation. The Section 3 introduces sample selection, data source, variable definition, and the research-model design. The Section 4 reports the results of the empirical analysis. The Section 5 presents the robustness test. The Section 6 presents the discussion, conclusion, management significance, and future research directions of this study.

2. Literature Review and Theoretical Hypotheses

The digital transformation of banks refers to the continuous expansion and application of digital technologies represented by artificial intelligence and big data in commercial banks, accelerating business optimization, upgrading, and innovation transformation, transforming traditional kinetic energy and cultivating new kinetic energy, and realizing the process of transformation, upgrading, and innovation [16]. Conceptually, in the medium and long term, banks' digital transformation is conducive to improving operational efficiency, strengthening innovation, and reducing costs [17,18]. Technically speaking, banks' digital transformation is based on the advancement of information technology. At the same time, artificial intelligence, big data, blockchain, and the internet of things are also applied to banks' digital transformation. For example, based on artificial intelligence, intelligent robots have appeared, which release some lobby managers and improve service efficiency; based on internet of things technology, cloud flash payments have appeared; based on blockchain technology, digital RMB appeared; based on big data, mobile phones banks have realized "thousands of faces". The emergence and application of new technologies have improved the operational capabilities of commercial banks and reduced banking costs.

The theory of externalities shows that there are certain externalities in the operating activities of commercial banks and the digital transformation of banks can reduce the negative externalities caused by the operating activities of commercial banks [19]. At the same time, it is beneficial for commercial banks to realize operating activities with higher efficiency and lower cost. The digital transformation has laid the foundation for the technological innovation capabilities of commercial banks. With the continuous improvements in technology, the cost of commercial banks' operation activities has been reduced and efficiency has been improved.

The theory of technological innovation implies that the development of digital technology has promoted the innovation of commercial banks [14,20]. The deep integration of digital technology with the real economy can record the business activities of commercial banks while using extensive data analysis for tracking and management of internal information of commercial banks [21]. Thereby, costs are significantly reduced and efficiency is improved in information collection, decision support, operation management, and other aspects.

The banking efficiency of commercial banks concentrates on the customer-service efficiency of commercial banks [22]. Banking efficiency is a concentrated expression of the competitiveness of commercial banks. Improving bank efficiency can prevent financial risks and promote commercial banks' sustainable development [23].

After the digital transformation of banks, the customer-service efficiency of commercial banks can be improved. After the bank's digital transformation, customers can go to bank outlets to handle business. They can make an appointment in advance through the WeChat official account or mobile banking, and the business can be handled at the store without waiting for customers [24]. After the "reduction of the face and pressing counters", some liberated tellers are engaged in customer service manager posts, who can guide customers to handle business, discover customer needs, and introduce effective customers for account managers. After the bank's digital transformation, customers can lock large deposit certificates and wealth-management products through mobile and online banking.

They can also snap up treasury bonds and precious metals through mobile and online banking. After a bank's digital transformation, it can then meet the needs of customers to handle business across provinces and countries, coordinate services, and better realize the service promise of "one bank, one customer." After the bank's digital transformation, the types of business can be enriched, and introducing express delivery can improve the efficiency of sales and services.

When the digital transformation of banks develops to a certain extent, it can enhance the technological spillover effect and improve the efficiency of banks. Therefore, this study proposes hypothesis 1:

Hypothesis 1 (H1). *Bank digital transformation improves bank efficiency.*

The advent of digital transformation has changed the business landscape. With the indepth research of scholars, digital transformation is also affecting commercial banks. Leviäkangas [15] identified six dimensions and seventeen categories of digital transformation through a metareview. At the same time, the research points to organizational, technological, and social dimensions that remain key to digital transformation. Future research could address sustainability and smart cities. However, as far as commercial banks are concerned, this study has also performed a simple exploration of the impact of bank digital transformation on society and the environment. Traditional corporate governance theory holds that commercial banks aim to maximize profits and shareholder value [25]. Modern corporate governance theory and stakeholder theory require commercial banks to be responsible to shareholders and creditors, employees, the government, and the environment [26]. At the same time, commercial banks should focus on external governance, pay attention to more stakeholders, and maximize the overall interests of stakeholders. Although undertaking social responsibility will increase the cost of commercial banks, it will establish an excellent reputation for commercial banks [27]. Priority financing theory shows that when investors invest, they are more inclined to choose commercial banks with social responsibility [28]. At the same time, the better the ESG performance, the better the reputation effect, and the better the stock price of commercial banks.

Banks' digital transformation is based on a new generation of digital information technology. The digitization of the real economy and the materialization of digital technology has dramatically impacted current production and lifestyle. At the same time, green sustainable development and balanced development have become current thematic and development trends. The value of banks' digital transformation is reflected in not only the improvement of efficiency and financial performance but also the noneconomic performance of commercial banks such as ESG. First, the digital transformation of banks can promote the technological innovation of commercial banks, especially the innovation and application of green technologies, thereby enhancing the contribution of commercial banks to the environment and sustainable development. Second, digital technology is conducive to reducing information asymmetry and transaction costs. Improving the transparency of commercial bank information will help commercial banks improve their governance and better fulfill their social responsibilities. Third, applying big data can enable mobile banking to realize "thousands of faces." Launching exclusive products and services for different customer groups can reduce resource waste and improve commercial banks' ESG performance. Fourth, one of the critical results of banks' digital transformation is mobile banking. Customers purchase wealth management and funds through mobile banking, which can realize the online process, reduce paper waste, and contribute to environmental protection, thereby improving the ESG performance of commercial banks. Fifth, using artificial intelligence and big data will help commercial banks screen green-credit targets, thereby contributing toward dual-carbon goals and improving the ESG performance of commercial banks.

In summary, banks' digital transformation is helpful to commercial banks' ESG performance. The better the ESG performance, the lower the reduction in the profits of commercial

banks, and in the long run, it will increase the stock prices of commercial banks. Therefore, this paper proposes research hypothesis 2:

Hypothesis 2 (H2). *The digital transformation of banks improves the ESG performance of commercial banks*.

The high-echelon theory points out that the operation of commercial banks is directly affected by the background and cognition of executives and other characteristics. With the advent of the digital economy, digital transformations have begun in all walks of life. Alternatively, operational efficiency is improved through innovation, or operating costs are reduced through process optimization [29]. For commercial banks, the advancement of technology has promoted the digital transformation of banks and innovation. At the helm of commercial banks, executives largely determine the business direction.

First, executives have a sense of innovation and will support R&D expenses and R&D personnel input during the bank's digital transformation. Executives have a sense of innovation, which means that they value the innovation of commercial banks and are willing to invest in innovation activities, thereby promoting banks' digital transformation. Through digital transformation, commercial banks can improve operational efficiency, reduce operating costs, and increase environmental protection performance, thereby improving the ESG performance. Therefore, compared with noninnovative executives, innovative executives play a positive role in the impact of digital bank transformation on bank efficiency and ESG.

Second, executives with a technical background can promote the progress of the bank's digital transformation, thereby affecting the bank's efficiency and ESG performance. Executives with a technical background have an inevitable accumulation of knowledge about R&D innovation activities, are familiar with the development trend of commercial banks, and can make reasonable judgments and expectations for the risks and benefits of different R&D projects, which will help commercial banks make full use of innovation elements [30]. The technical background of executives is the embodiment of their experience, an essential source of knowledge and information that executives can use and affects the experience and skills of executives. At the same time, executives with technical backgrounds are essential participants in the strategic decision-making of commercial banks and can provide professional guidance and suggestions for commercial bank innovation [31]. Executives of commercial banks with technical backgrounds rely on their accumulated social capital to gain information and resource advantages in innovation, which are conducive to integrating resources and ensuring their optimal allocation, thereby improving bank efficiency. In addition, executives with a technical background pay more attention to the long-term development of commercial banks and tend to increase the proportion of investment in human capital and R&D expenditures to promote innovation [32], thereby improving the ESG performance of commercial banks. Compared with executives without a technical background, executives with a technical background have a more vital risk-taking ability for innovation, a higher tolerance for innovation failure, and encourage employees to try new ideas [33]. Executives with technical backgrounds can not only give full play to their professional advantages and reduce the uncertainty in the corporate innovation process but also tend to invest considerably in R&D innovation projects. Therefore, the technical background of executives can provide support and guidance for the digital transformation of commercial banks. At the same time, executives with technical backgrounds play an active role in the impact of bank digital transformation on bank efficiency and ESG.

In summary, executives with innovation consciousness and technical background play a supporting role in banks' digital transformation, thus affecting the relationship between bank digital transformation, bank efficiency, and ESG. Therefore, this paper proposes research Hypotheses 3–6:

Hypothesis 3 (H3). *Executives' awareness of innovation plays a positive moderating role in the bank's digital transformation to improve bank efficiency*.

Hypothesis 4 (H4). *The technical background of executives plays a positive moderating role in the bank's digital transformation to improve bank efficiency.*

Hypothesis 5 (H5). *Executives' awareness of innovation plays a positive moderating role in the improvement of commercial banks' ESG performance through digital bank transformation.*

Hypothesis 6 (H6). *The technical background of executives plays a positive moderating role in the improvement of commercial banks' ESG performance through the bank's digital transformation.*

Figure 2 is the study model.

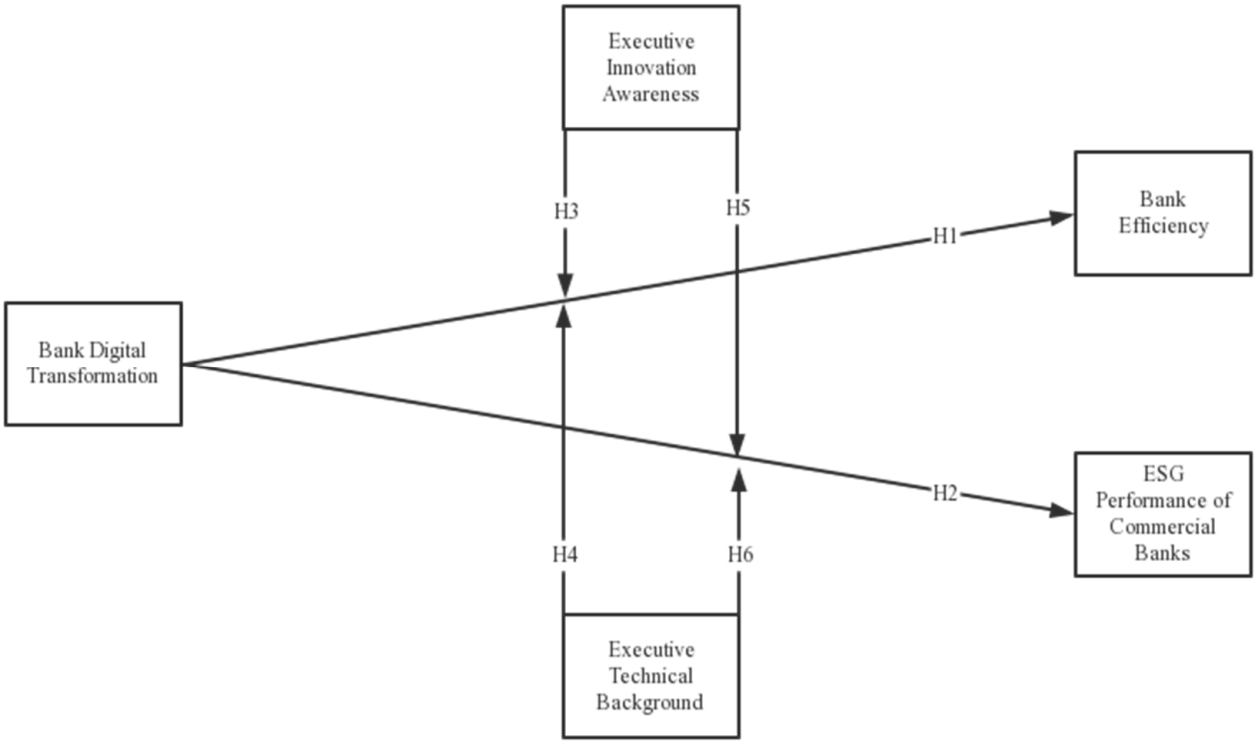

Figure 2. The study model.

3. Research Design

3.1. Sample Selection and Data Sources

This study selected Chinese A-share listed banks from 2011 to 2021 as the research object and obtained 296 samples. The sample data were processed as follows: (1) eliminate samples with missing data and (2) eliminate ST-listed banks. Finally, 253 sample values were obtained. The digital transformation data of banks in this study resulted from the "Bank Digital Transformation Index" compiled by the research group of the Digital Finance Research Center of Peking University. Executives' innovation awareness and executives' technical background were obtained from the company's annual report using Python. The remaining data came from the Guotaian database.

In order to alleviate the high collinearity between the interaction term and the independent and moderator variables, these variables were centralized in this study [34]. In order to eliminate the impact of outliers on this study, the sample data were shrunk by 2%. At the same time, to reduce heteroscedasticity interference, some key continuous variables were logarithmized in this study.

3.2. Variable Definition

3.2.1. Dependent Variable Bank Efficiency and ESG Performance of Commercial Banks

Commercial banks, regulators, and most scholars usually measure banking efficiency (BE) through the ratio of revenue to cost [35]. However, the income-to-cost ratio is a reverse indicator. In order to conform to the research of this study, the income-to-cost ratio was multiplied by minus one as a proxy variable of bank efficiency.

To measure ESG indicators, academic circles mostly use the Thomson Reuters database [27], Bloomberg ESG data, etc. The research content of this paper was Chinese commercial banks; therefore, according to China's national conditions, China's third-party institution system for ESG indicator construction could be improved. Therefore, this study drew on the practice of Zhang and Jin [36] and selected ESG data from the relatively mature and authoritative Bloomberg Consulting Company. The data not only included ESG total scores but also corporate environmental responsibility (E) and social responsibility (S), as well as each score for corporate governance (G).

3.2.2. Independent Variable Bank Digital Transformation

Bank digital transformation (BDT) is the technical innovation and digital transformation of commercial banks based on the development of digital technology. Since this study focuses on Chinese commercial banks, it does not select commonly used proxy variables for corporate digital transformation, such as the frequency of the word "digital transformation" in annual reports. At the same time, due to the characteristics of commercial banks, we can choose the number of monthly active customers (MAU) of mobile banking instead [37]. However, MAU is only a manifestation of the digital transformation of banks and cannot fully reflect the degree of digital transformation of commercial banks. Therefore, this study draws on the research results of Xie and Wang [38] and uses the Peking University China Commercial Bank Digital Transformation Index as a proxy variable for the bank's digital transformation.

3.2.3. Moderated Variables

Executive innovation awareness and technical background built on the research conducted by Song, Nahm, and Song [31]. Specifically, executive innovation consciousness was measured using Python technology to calculate the frequency of innovative terms proposed by executives in the annual reports of listed companies. In order to eliminate discrepancies, this study adopted the practice of industry averages and used dummy variables for measurement. If the word frequency of the sample was greater than the average of all sample word frequencies, it took a value of one; otherwise, it took a value of zero. Executive technical backgrounds were assessed using dummy variables. If one of the executives had a technical background, it took a value of one; otherwise, it took a value of zero.

3.2.4. Control Variables

In order to exclude the interference of other factors on the results, this study drew on the practices of Liu, et al. [39]. Selected bank size (size), solvency (lev), growth (gro), ownership concentration (top1), bank nature (soe), capital intensity (CI), and net profit growth rate (NPR) were control variables of the study. Additionally, year effects (year) were controlled. Table 1 details specific variables and their definitions.

Table 1. Variable definitions.

Variable Type	Variable Name	Variable Code	Variable Definitions
Dependent Variable	Bank Efficiency	BE	Business management fee/operating income × (−100%)
	ESG Performance of Commercial Banks	ESG	Bloomberg ESG score
Independent Variable	Bank Digital Transformation	BDT	Peking University Digital Finance Research Center
Moderator	Executive Innovation Awareness	EIA	Dummy variable, the average frequency of innovative words mentioned by executives in commercial bank annual reports, 1 if more excellent than the average, 0 for others
	Executive Technical Background	ETB	As a dummy variable, executives with technical background take 1, others take 0
Control Variable	Bank Size	SIZE	The natural logarithm of the total assets at the end of the year
	Solvency	LEV	Total liabilities at the end of the year/total assets at the end of the year
	Growth	GRO	Operating income growth rate
	Concentration of Ownership	TOP1	Shareholding ratio of the largest shareholder
	Bank Nature	SOE	Dummy variable, 1 for state-owned holdings, 0 otherwise
	Capital Intensity	CI	Total assets/operating income × (−100%)
	Net Profit Growth Rate	NPGR	(Net profit for the current period − Net profit for the previous year)/Net profit for the previous year) × 100%
	Annual Effect	YEAR	Year dummy variable

3.2.5. Model Construction

In order to support hypothesis 1 of this study, i.e., that the digital transformation of banks improves bank efficiency, a regression model (Equation (1)) that controlled the annual effect was constructed.

$$BE_t = \beta + \beta_1 \times BDT_t + \Sigma\beta \text{Control}_t + \varepsilon \quad (1)$$

In order to support hypothesis 2 of this study, i.e., that the digital transformation of banks improves the ESG performance of commercial banks, a regression model (Equation (2)) that controlled the annual effect was constructed.

$$ESG_t = \beta + \beta_1 \times BDT_t + \Sigma\beta \text{Control}_t + \varepsilon \quad (2)$$

In order to further explore the moderating role of executives' innovation consciousness and executives' technical background in bank digital transformation, bank efficiency, and ESG, i.e., to verify assumptions 3–6, a regression model (Equations (3)–(6)) was constructed to control the annual effect.

$$BE_t = \beta + \beta_1 \times BDT_t + \beta_2 \times EIA_t + \beta_3 \times BDT_t \times EIA_t + \Sigma\beta \text{Control}_t + \varepsilon \quad (3)$$

$$BE_t = \beta + \beta_1 \times BDT_t + \beta_2 \times ETB_t + \beta_3 \times BDT_t \times ETB_t + \Sigma\beta \text{Control}_t + \varepsilon \quad (4)$$

$$ESG_t = \beta + \beta_1 \times BDT_t + \beta_2 \times EIA_t + \beta_3 \times BDT_t \times EIA_t + \Sigma\beta \text{Control}_t + \varepsilon \quad (5)$$

$$ESG_t = \beta + \beta_1 \times BDT_t + \beta_2 \times ETB_t + \beta_3 \times BDT_t \times ETB_t + \Sigma\beta \text{Control}_t + \varepsilon \quad (6)$$

Here, BE represents the dependent variable of bank efficiency, ESG represents the dependent variable of commercial banks' ESG performance, BDT represents the independent

variable of digital bank transformation, EIA represents the moderator variable of executive innovation awareness, ETB represents the moderator variable of executive technical background, control represents the control variable, β–β_3 represents the coefficient of each variable, t represents the study year, and ε is the random disturbance term.

4. Research Results

4.1. Descriptive Statistics

The descriptive statistics of the data are shown in Table 2. The bank efficiency dependent variable mean, standard deviation, minimum, and maximum were −29.60, 4.534, −41.78, and −21.86, respectively. The data show some differences in the banking efficiency of commercial banks; however, the degree of dispersion is small. The mean, standard deviation, minimum, and maximum values of the dependent variable of commercial banks' ESG performance were 38.45, 9.464, 19.32, and 55.76, respectively. The data show that the ESG performance of commercial banks varies greatly, and the overall performance could be improved. The independent variable bank digital transformation's mean, standard deviation, minimum, and maximum values were 99.91, 38.91, 23.56, and 169.8, respectively. The data show that the degree of digital transformation among commercial banks varies greatly and the data are relatively scattered. The average value, standard deviation, minimum, and maximum values of the adjustment variable executives' innovation awareness were 0.407, 0.492, 0, and 1, respectively. The average, standard deviation, minimum and maximum values of the adjustment variable executives' technical background were 0.344, 0.476, 0, and 1, respectively.

Table 2. Descriptive statistics.

VARIABLES	N	Mean	Sd	Min	Max
BE	253	−29.60	4.534	−41.78	−21.86
ESG	253	38.45	9.464	19.32	55.76
BDT	253	99.91	38.91	23.56	169.8
EIA	253	0.407	0.492	0	1
ETB	253	0.344	0.476	0	1
SIZE	253	28.59	1.433	25.69	30.97
LEV	253	0.928	0.0104	0.908	0.948
GRO	253	0.0201	0.0528	−0.0872	0.144
TOP1	253	27.51	17.58	8.170	67.13
SOE	253	0.427	0.496	0	1
CI	253	38.28	5.733	27.50	52.46
NPGR	253	11.86	10.82	−5.885	41.62

4.2. Correlation Analysis

The correlation analysis of the sample is shown in Table 3. The data show that there is a significant positive correlation between the dependent variable bank efficiency (BE) and the independent variable bank digital transformation (BDT), with a correlation coefficient of 0.410 (1% level), to a certain extent. This supports hypothesis 1 of this study, i.e., that banks' digital transformation improves bank efficiency. A significant positive correlation exists between the dependent variable commercial bank ESG performance (ESG) and the independent variable bank digital transformation (BDT). Digital transformation improves the ESG performance of commercial banks. The variance inflation factors (VIFs) were all lower than 4, with an average value of 2.61. This means that multicollinearity is negligible for the primary outcome of this study.

Table 3. Correlation analysis.

VARIABLES	BE	ESG	BDT	EIA	ETB	SIZE	LEV	GRO	TOP1	SOE	CI	NPGR
BE	1											
ESG	0.235 ***	1										
BDT	0.410 ***	0.623 ***	1									
EIA	−0.0960	−0.0710	0.145 **	1								
ETB	−0.0960	0.00800	0.118 *	0.874 ***	1							
SIZE	0.231 ***	0.616 ***	0.335 ***	−0.426 ***	−0.267 ***	1						
LEV	−0.251 ***	−0.446 ***	−0.592 ***	−0.108 *	−0.0690	−0.0940	1					
GRO	0.0620	−0.215 ***	−0.143 **	0.0920	0.0580	−0.204 ***	0.126 **	1				
TOP1	−0.0480	0.395 ***	0.0940	−0.233 ***	−0.163 ***	0.634 ***	−0.0420	−0.106 *	1			
SOE	−0.104 *	0.102	−0.114 *	−0.146 **	−0.103	0.256 ***	0.154 **	−0.163 ***	0.291 ***	1		
CI	0.256 ***	−0.175 ***	0.213 ***	0.287 ***	0.196 ***	−0.220 ***	0.0110	0.0750	−0.292 ***	−0.177 ***	1	
NPGR	−0.322 ***	−0.488 ***	−0.571 ***	0.00900	0.0390	−0.292 ***	0.504 ***	0.227 ***	−0.138 **	0.0640	−0.0730	1

Notes: "*", "**", and "***" in the table represent significance at the 10%, 5%, and 1% levels, respectively.

4.3. Regression Analysis

According to the Hausman test results, the *p*-value was less than 0.05. Therefore, a fixed effect model that controlled for the year effect was selected for empirical analysis. The regression analysis results are shown in Table 4. Column (1) shows a positive and significant correlation between bank efficiency (BE) and bank digital transformation (BDT), with a correlation coefficient of 0.036 (1% level). This shows that the bank's digital transformation had improved its efficiency. Thus, hypothesis 1 was further supported. Column (2) shows a positive and significant correlation between commercial bank ESG performance (ESG) and the bank digital transformation (BDT), with a correlation coefficient of 0.049 (1% level). This shows that banks' digital transformation improves commercial banks' ESG performance. Thus, hypothesis 2 was further supported.

Table 4. Regression analysis.

VARIABLES	(1) BE	(2) ESG	(3) BE	(4) BE	(5) ESG	(6) ESG
BDT	0.036 ***	0.049 ***	0.032 **	0.035 ***	0.042 **	0.046 **
	(2.67)	(2.67)	(2.44)	(2.62)	(2.29)	(2.53)
EIA			−1.497 **		1.548 *	
			(−2.53)		(1.88)	
BDT *EIA			0.033 **		0.035 *	
			(2.26)		(1.69)	
ETB				−1.373 **		1.518 **
				(−2.48)		(1.99)
BDT *ETB				0.027 *		0.034 *
				(1.83)		(1.67)
SIZE	0.960 ***	3.021 ***	0.873 ***	0.913 ***	3.407 ***	3.191 ***
	(3.38)	(7.71)	(2.92)	(3.22)	(8.21)	(8.14)
LEV	−101.048 ***	33.438	−89.102 **	−93.994 **	32.188	33.617
	(−2.74)	(0.66)	(−2.44)	(−2.57)	(0.64)	(0.67)
GRO	15.173 ***	0.780	15.144 ***	15.304 ***	−0.386	−0.221
	(3.01)	(0.11)	(3.05)	(3.07)	(−0.06)	(−0.03)
TOP1	−0.053 ***	0.027	−0.051 ***	−0.053 ***	0.016	0.020
	(−2.85)	(1.06)	(−2.79)	(−2.88)	(0.61)	(0.78)
SOE	−0.311	0.776	−0.230	−0.170	0.788	0.916
	(−0.59)	(1.06)	(−0.44)	(−0.32)	(1.09)	(1.25)
CI	0.247 ***	−0.487 ***	0.226 ***	0.226 ***	−0.540 ***	−0.530 ***
	(4.72)	(−6.74)	(4.18)	(4.20)	(−7.19)	(−7.13)
NPGR	0.003	−0.109 *	0.018	0.023	−0.106 *	−0.115 **
	(0.07)	(−1.93)	(0.46)	(0.57)	(−1.89)	(−2.03)
Constant	25.466	−69.947	16.637	20.003	−78.086 *	−73.511
	(0.74)	(−1.48)	(0.49)	(0.59)	(−1.66)	(−1.57)
Year FE	YES	YES	YES	YES	YES	YES
Observations	253	253	253	253	253	253
R-squared	0.343	0.713	0.372	0.366	0.721	0.722

Note: *t*-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

In column (3), the dependent variable bank efficiency (BE) is positively and significantly correlated with the independent variable bank digital transformation (BDT), with a correlation coefficient of 0.032 (5% level). At the same time, the interaction term of digital bank transformation (BDT) and executive innovation awareness (EIA) is significantly positively correlated with bank efficiency (BE) at the 5% level and the regression coefficient is 0.033. This shows that executives' innovation awareness has played a positive regulating role in the bank's digital transformation to improve bank efficiency. Therefore, hypothesis 3 was supported.

In column (4), the dependent variable bank efficiency (BE) is positively and significantly correlated with the independent variable bank digital transformation (BDT), with a correlation coefficient of 0.035 (1% level). At the same time, the interaction terms of digital bank transformation (BDT) and executive technical background (ETB) are significantly positively correlated with bank efficiency (BE) at the 10% level, and the regression coefficient is 0.027. This shows that the technical background of executives plays a positive moderating role in the bank's digital transformation to improve bank efficiency. Therefore, hypothesis 4 was supported.

In column (5), the dependent variable commercial bank ESG performance (ESG) is positively and significantly correlated with the independent variable bank digital transformation (BDT), with a correlation coefficient of 0.042 (5% level). At the same time, the interaction terms of digital bank transformation (BDT) and executive innovation awareness (EIA) are significantly positively correlated with commercial bank ESG performance (ESG) at the 10% level. The regression coefficient is 0.035. This shows that executives' awareness of innovation plays a positive moderating role in the improvement of commercial banks' ESG performance in the bank's digital transformation. Therefore, hypothesis 5 was supported.

In column (6), the dependent variable commercial bank ESG performance (ESG) is positively and significantly correlated with the independent variable bank digital transformation (BDT), with a correlation coefficient of 0.046 (5% level). At the same time, the interaction terms of the bank digital transformation (BDT) and executive technical background (ETB) are significantly positively correlated with commercial bank ESG performance (ESG) at the 10% level. The regression coefficient is 0.034. This shows that the technical background of senior executives has positively moderated commercial banks' ESG performance through the bank's digital transformation. Therefore, hypothesis 6 was supported.

5. Robustness Check

In order to test the robustness of the above conclusions, this study used a robustness test based on the two-stage least squares model (2SLS) method.

Considering the bias caused by omitted variables and endogenous problems, this study referred to the practice of Gao and Jin [40], selected the bank digital transformation (BDT) lagged one period (LBDT) as an instrumental variable, and used the 2SLS method to carry out a robust sex test.

The regression model (Equation (7)) was the first-stage model of 2SLS, and (Equations (8) and (9)) are the second-stage models of 2SLS.

$$BDT = \beta + \beta_1 LBDT + \beta_2 \Sigma\text{Control} + \Sigma\text{Year} + \varepsilon \quad (7)$$

$$BE = \beta + \beta_1 BDT + \beta_2 \Sigma\text{Control} + \Sigma\text{Year} + \varepsilon \quad (8)$$

$$ESG = \beta + \beta_1 BDT + \beta_2 \Sigma\text{Control} + \Sigma\text{Year} + \varepsilon \quad (9)$$

Among them, LBDT is the data lagged by one period of BDT.

The regression results of 2SLS are shown in Table 5. In the first stage (column 1), the regression coefficient between the BDT and LBDT is 0.692 (1% level); in the second stage (column 2), the regression coefficient of BDT after the simulation of BDT and LBDT

and bank efficiency BE is 0.052 (1% level); in the second stage (column 3), the regression coefficient of digital bank transformation BDT and commercial bank ESG performance (ESG) after the simulation of BDT and LBDT in the first stage is 0.079 (1% level). In addition, in Table 5, the underidentification test (Kleibergen–Paap rk LM statistic) statistic is 46.855 (0.0000), indicating that the instrumental variable is identifiable. At the same time, the Cragg–Donald–Wald statistic is 187.455, more significant than the critical value of the weak Stock–Yogo ID test with a 10% judgment level of 16.38; thus, there is no weak instrumental variable problem. The above results show that after considering endogenous issues, banks' digital transformation is still significantly positively correlated with bank efficiency and ESG performance of commercial banks, which once again verifies the correctness of assumptions 1 and 2.

Table 5. Robustness test regression analysis.

	(1)	(2)	(3)
	First Stage	Second Stage	
VARIABLES	BDT	BE	ESG
LBDT	0.692 ***		
	(13.69)		
BDT		0.052 ***	0.079 ***
		(2.60)	(2.97)
SIZE	4.176 ***	0.631 *	2.768 ***
	(3.84)	(1.79)	(5.95)
LEV	217.606	−101.496 **	57.526
	(1.48)	(−2.49)	(1.07)
GRO	26.795	14.405 ***	4.242
	(1.40)	(2.69)	(0.60)
TOP1	−0.045	−0.046 **	0.019
	(−0.64)	(−2.41)	(0.75)
SOE	−0.612	−0.364	1.372 *
	(−0.31)	(−0.67)	(1.93)
CI	0.089	0.226 ***	−0.553 ***
	(0.44)	(4.07)	(−7.57)
NPGR	−0.379 **	0.007	−0.104 *
	(−2.41)	(0.16)	(−1.75)
Constant	−277.758 **	31.011	−75.111
	(−2.03)	(0.80)	(−1.48)
Year FE	Yes	Yes	Yes
Observations	220	220	220
R-squared	0.877	0.301	0.715
Underidentification test (Kleibergen–Paap rk LM statistic)	46.855(Chi-sq (1) *p*-val = 0.0000)		
Weak identification test (Cragg–Donald–Wald F statistic)	187.455		
(Kleibergen–Paap rk Wald F statistic)	164.199		
10% maximal IV size	16.38		

Note: *t*-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

6. Discussion and Conclusions

6.1. Discussion

The digital transformation of banks is a segmented field. Scholars have derived different definitions due to the differences between digitalization and digital transformation. Leviäkangas [15] identified the difference between digitization and digital transformation through a metareview and meta-analysis. In general, digital transformation is the application of information technology to the operation and management of enterprises to improve operational efficiency [41]. Nevertheless, it is undeniable that the emergence of artificial intelligence and big data has promoted the digital transformation of the industry, including commercial banks. Commercial banking is a traditional industry and a pioneer of informatization. In order to consolidate their market position and achieve overtaking in corners, many commercial banks have already started the digital transformation. Moreover, in China, the People's Bank of China has asked commercial banks to accelerate their digital transformation. Therefore, commercial banks are actively or passively carrying out digital transformation. Many scholars have developed different approaches on how to measure the digital transformation of banks. However, the digital transformation of banks is different from the digital transformation of other industries. Based on this, Xie and Wang [38] contributed the theoretical basis and data sources to the digital transformation of banks through the subdimensional measurement of the digital transformation of commercial banks. At the same time, Xie and Wang [38] also studied the impact of bank digital transformation on commercial bank performance. The results show that the digital transformation of banks has no significant impact on the overall performance of commercial banks. However, it significantly affects the profitability and bank efficiency of commercial banks. This is consistent with the research results of this paper. At present, the impact of the digital transformation of banks on the banking efficiency of commercial banks is still relatively small. Existing research results show that the digital transformation of banks improves bank efficiency. This is analyzed from the perspective of financial technology and spillover effects. The impact of bank digital transformation on commercial banks is not only reflected in the internal performance of commercial banks but also in ESG performance. Therefore, there is a certain gap in the research on the digital transformation of banks. This study focuses on the impact of bank digital transformation on bank efficiency; at the same time, it also focuses on the ESG performance of commercial banks. The research results can not only expand the research on the digital transformation of banks but also expand the research on ESG.

At the same time, based on the high-echelon theory, this study introduces moderator variables of executive technical background and executive innovation awareness. From the perspective of executive cognition, further research should be performed on the impact of bank digital transformation on bank efficiency and commercial bank ESG performance. The conclusion shows that the executives' technical background and innovation awareness play a significant positive moderating role. In addition, paying attention to the cognition of executives has a key impact on the degree of banks' digital transformation. Specifically, banks' digital transformation has exhibited some progress but further indepth transformation is needed in the future. Through online digitization, intelligence, and openness, the digital transformation of banks can be improved, thereby improving the efficiency and performance of commercial banks. Therefore, the results presented in this paper also provide a new research direction. In the future, the impact of artificial intelligence on bank efficiency and environmental protection could be studied.

6.2. Research Conclusions

6.2.1. Theoretical Contributions

This study sampled commercial banks listed in China's A-share market from 2011 to 2021 to test the impact of digital bank transformation on bank efficiency and commercial bank ESG performance through empirical analysis. At the same time, the moderating variables of executive innovation awareness and executive technical background were introduced and the following conclusions were drawn.

First, the digital transformation of banks has improved bank efficiency. This is manifested explicitly in commercial banks' internal governance efficiency, customer service efficiency, and business handling efficiency. Banks' digital transformation improves efficiency, reduces operating costs, increases noninterest income, and promotes the growth of the financial performance of commercial banks. At the same time, through digital transformation, the nonfinancial performance of commercial banks, namely, ESG performance, has also been significantly improved. This is because digital technology has promoted the digital transformation and green innovation of commercial banks, thereby allowing commercial banks to reduce operating costs, save resources, and promote commercial banks' environmental protection and internal governance.

Secondly, the high-echelon theory makes scholars aware of the importance of executive cognition. This study further examines the relationship between bank digital transformation on bank efficiency and commercial bank ESG performance by introducing moderator variables of executive innovation awareness and executive technical backgrounds. The research results show that executives have a sense of innovation and technical background, which significantly and positively affects the relationship between digital bank transformation, bank efficiency, and commercial bank ESG.

6.2.2. Managerial Contributions

As Leviäkangas [15] stated, digital transformation has been extended to many industries. The digital transformation of commercial banks has achieved specific results but this still needs to be strengthened. In the future, the digital transformation of banks will become the norm. In the short term, banks' digital transformation requires commercial banks to invest considerable expenses and personnel. However, in the medium and long term, the digital transformation of banks has improved bank efficiency, reduced bank costs, and improved operational capabilities, thereby improving the financial performance of commercial banks [42]. Therefore, commercial banks should avoid short sightedness. Focusing on the sustainable development of commercial banks would continue to deepen the progress and scope of bank digitalization, thereby enhancing the comprehensive competitiveness of commercial banks.

The various policies introduced by the Chinese government are still being determined, such as environmental protection laws. Commercial banks, small- and medium-sized banks, and private banks need to understand and promptly respond to the policies introduced. At the same time, commercial banks can also learn from other institutions in the same industry, e.g., the five largest state-owned banks. Due to their state ownership, it takes more time to obtain information. In addition, for bank practitioners, there must be a sense of crisis. The advancements in information technology will lead to changes in the industry, and the "iron rice bowl" era will gradually disappear. Therefore, in addition to enhancing their competitiveness, bank employees must prepare for re-employment.

6.3. Limitations and Future Research Directions

Bank digital transformation is a comprehensive study field of digital transformation. The research objects in this study were Chinese commercial banks. In China, most commercial banks are state-owned and relatively large in scale. Therefore, Chinese commercial banks differ from commercial banks in other countries and have Chinese characteristics. Therefore, the conclusions of this study apply to China's national conditions but are not necessarily applicable to other countries. In addition, in China, the number of listed

commercial banks is minimal; there are only about 40. Therefore, more data are needed. Compared with developed countries such as the United States, there are still relatively few listed commercial banks in China in comparison with the total number of banks. At the same time, the measurement of bank digital transformation in this study applies to commercial banks in China, not necessarily to other countries.

In China, ESG disclosure is optional; however, more and more companies are actively disclosing ESG reports, especially environmental reports. In China, commercial banks are primarily state owned or local government backed; therefore, they are more active in ESG disclosure. It is undeniable that companies will "greenwash" to comply with regulations. Therefore, it is necessary to use third-party ESG scores to research avoidance of the "green cleaning" behavior of enterprises. Currently, ESG data sources in China mainly include Bloomberg Consulting, ESG scores from Hexun, and SynTao Green Finance. However, based on the background of this study, we adopted the ESG rating of Bloomberg Consulting. Although Bloomberg Consulting's sources of ESG data are nonacademic disclosures, Bloomberg is a leading provider of global business, financial information, and financial intelligence. Many Chinese scholars have evaluated such provided ESG scores; the data are robust. At the same time, to enhance the robustness of the data, we can determine the performance of corporate social responsibilities through the media, the public, and other external regulatory agencies in the future to further expand ESG research.

With the introduction of the green economy and sustainable development theory, "green" has become a hot topic. At the same time, digital transformation based on artificial intelligence, blockchain, and big data plays a vital role in the green economy. Enterprises use digital transformation to enhance their comprehensive competitiveness. After combing the relevant literature, the suggested future research direction is as follows: we could extend banks' digital transformation to digital technologies; specifically, the impact of artificial intelligence and the internet of things on the environment and social governance can be studied.

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