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The Dual Impact of Corporate Social Responsibility and Digitalization on Bank Financial Stability Efficiency

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Abstract

This study investigates the joint effect of corporate social responsibility (CSR) and digitalization on the financial stability efficiency of banks in Vietnam from 2010 to 2022. We construct a CSR index using principal component analysis and employ a one-step stochastic frontier analysis to compute bank stability efficiency based on a forward-looking Z-score. The relationship between CSR, its components, and bank stability efficiency is derived simultaneously through the stable stochastic frontier estimation. Findings reveal a U-shaped relationship between CSR and financial stability efficiency. While CSR investments may initially increase bank instability, aligning with the trade-off theory, they enhance long-term stability. Results underscore that bank managers and board members must commit to CSR initiatives, as the benefits materialize over time. Additionally, this study highlights the moderating role of digitalization, demonstrating that advancements in information technology strengthen the positive relationship between CSR and financial stability efficiency. Further analyses confirm the robustness of findings across state-owned and listed banks and during the COVID-19 pandemic. This research contributes novel insights by integrating CSR, digitalization, and financial stability efficiency, providing actionable strategies for banking sector policymakers and practitioners. The study emphasizes the strategic importance of balancing short-term trade-offs with long-term gains through CSR implementation and leveraging technology to ensure sustainable financial stability.

Keywords:
CSR;
Bank Efficiency;
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1- Introduction

Over the past decades, the global banking system has witnessed two critical megatrends, including corporate social responsibility (CSR) and digitalization [1-3]. Forcadell et al. (2020) further emphasized that CSR has become a strategy because of growing competitive, social, and institutional pressures. These pressures force banks to have a bigger impact on communities, societies, and the environment while also embracing digital transformation [1]. However, existing studies have not sufficiently explored how these two forces interact to influence financial stability efficiency, particularly in the context of emerging markets. Initiatives like the Net-Zero Banking Alliance and the growing demand from customers for sustainable, digitally-enabled banking services [4, 5] show that sustainability is becoming more important around the world.

The 2007–2009 global financial crisis and the LIBOR scandal significantly eroded public trust in banks, motivating institutions to adopt CSR strategies to restore their reputation [6, 7]. Similarly, the COVID-19 pandemic has underscored the importance of CSR in supporting bank resilience and creating societal value [2, 8]. Simultaneously, rapid advancements in digital technology have reshaped traditional banking models, reducing information asymmetry and improving operational efficiency [9, 10]. Nevertheless, digital transformation also introduces challenges, such as

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substantial upfront investment costs, data privacy concerns, and reputational risks linked to employee displacement or digital overload [11-13].

Despite the growing focus on CSR and digitalization, the existing literature presents conflicting findings on their individual and combined impacts on bank performance. For instance, Nguyen et al. (2023) and Bian et al. (2023) found that digitalization improves profitability and reduces risk [14-16]. Whereas He et al. (2023) reported contradictory results [17]. Similarly, studies on CSR's influence on bank performance reveal inconsistent outcomes, with some highlighting its positive effects while others emphasize trade-offs [15-18]. This discrepancy shows that we need to learn more about how CSR and digitalization affect each other, especially in developing economies with different market dynamics and regulatory frameworks.

Vietnam offers an interesting case. Vietnam is considered a new economic dragon in Southeast Asia, with its average annual economic growth at 6.10% over the period 2010-2022, just behind China (6.96%) [19]. Even though this country achieved remarkable economic growth with the positive expansion of 4.51% during the impact of the COVID-19 pandemic [20, 21]. This is thanks to the implementation of prompt and appropriate supporting policies from the Vietnamese government [22] but also the sustainable and sound banking system [23]. Therefore, the financial stability efficiency of the Vietnamese banking system has attracted much attention from academics and practitioners. Additionally, the Vietnamese banking system's structure is relatively diverse [24]. The most active players are state-owned commercial banks (SOCBs) and privately owned commercial banks (POCBs). This dominance in deposit and lending shares has been gradually acquired by wholly foreign-owned banks, foreign bank affiliates, and joint venture banks since entry to the World Trade Organization in 2007. On top of it, the Vietnamese market has witnessed a significant growth of fin-tech firms [25]. The Vietnamese authorities further promote fin-tech development by imposing Decision No. 999/2019/QD-TTg on fin-tech regulation sandbox and Decree No. 80/2016/ND-CP for electronic payment and e-wallets. This fierce increase in competition pushes banks to accelerate the digitalization process. The banking industry transformation is also supported by Decision No. 2655/2019/QD-NHNN. In parallel, the State Bank of Vietnam (SBV) has gradually implemented several incentives to boost CSR in the Vietnamese banking system because of its commitments to zero emissions following the requirement of the Prime Minister. For example, SBV provided an action plan for green growth by 2020 as presented in the Decision No.1552/QD-NHNN [26], in particular, environmental–social risk management in credit granting activities in the Directive No. 03/CT-NHNN [27]. However, SBV has not yet provided any specific CSR standard guidelines for Vietnamese commercial banks. Therefore, banks would adopt different ways of CSR activities; thus, the benefits of CSR on bank performance during the digitalization phase are questionable.

This study makes three key contributions to the literature. First, it investigates the combined effects of CSR and digitalization on financial stability efficiency in Vietnam, an emerging market where evidence of this interaction remains scarce [1]. We use a stochastic frontier approach to estimate financial stability efficiency instead of traditional performance metrics like other studies have [28]. This study is the first attempt to consider the effect of CSR and digitalization on bank stability efficiency in the Asia-Pacific. Second, most studies have used ESG data to measure CSR [1]. However, this is unavailable in emerging markets like Vietnam. Several studies in Vietnam found that CSR could be measured by the amount of money donated to charity [29] or by CSR indices made up of three or four ESG pillars without the weighted information disclosure [30]. However, these two measures might not really show how much CSR is being used because they don't look at all the different aspects that are spelled out in the Global Reporting Initiative (2016) standards that Vietnamese banks have been slowly following [31]. Therefore, we follow Zhou et al. (2021) to use principal component analysis (PCA) when constructing the CSR index following GRI 2016 dimensions [32]. Last, this is the first study to investigate the effects of CSR and digitalization in Vietnam using different settings such as bank ownership (SOCBs vs. POCBs), privatization (listed vs. unlisted banks), and the impact of the COVID-19 turmoil. Hence, this study offers crucial implications for bank managers and policymakers.

By filling in gaps in the existing research and using cutting-edge methods, this study offers new insights into how CSR and digitalization affect financial stability and efficiency. These findings are particularly relevant for banks navigating the dual challenges of sustainability and technological transformation in rapidly evolving economic landscapes.

The remainder of our study is organized as follows: Section 2 provides the literature review, and Section 3 presents the methodology and data used. Section 4 discusses empirical findings, while Section 5 concludes.

2- Literature Review

2-1- Digitalization and Bank Performance

The literature on the relationship between digitalization and bank performance can be divided into two strands. The first is digitalization outside of banking, looking at the emergence of new participants in the financial market, such as fin-tech and large technology companies [33-36], or the introduction of central bank digital currencies [37, 38] or digital economy [39]. The second is inside-bank digitalization that considers banks' ability to leverage the advanced innovation. In general, digitalization is a systematic and comprehensive transformation of all factors within banking organizations

[40], including the application of technologies and information based on digital data for operational processes and business activities. Addressing asymmetric information is one of the primary tasks of intermediaries because this issue inhibits the maximization of banks' performance [41]. Allen & Santomero (1997) suggested that reducing information cost can mitigate the information asymmetries between intermediaries and their customers [42]. In the digital age, banks can leverage data to establish their sole information systems that reduce information asymmetries and adverse selection issues, thus enhancing the lending process and their performance [43]. For instance, big data and efficient predictive tools can help banks predict customer behavior better and assess borrowers' creditworthiness more precisely, thus generating more value for banks [44, 45]. A customer-centric digital strategy may help banks understand their customers' needs and enhance their lending decisions via data generated in better credit scoring models. Nonetheless, digitalization can decrease asymmetric information problems, thus improving their performance and efficiency.

The empirical evidence in developed markets is inconclusive. As technology investment (e.g., pure infrastructure and technological development capacity) is a part of the digitalization process, several studies showed that technological progress can reduce banks' agency costs [46] and bad management practices [47] and improve profit productivity [48]. However, others indicate little evidence on the relationship between IT investment and bank efficiency or profitability [49] or insignificant association between them [50]. Similar findings are found in other markets. Favorable effects of IT investment are demonstrated by Ngo & Le (2022) in Vietnam, Dinçer & Yüksel (2020) in Asia, and Appiahene et al. (2019) in Ghana [51-53]. However, others claim mixed effects of IT investment on bank profitability in India. Nguyen et al. (2023) and bank costs in Vietnam [14]. Nonetheless, Le et al. (2022b) found that bank efficiency is positively affected by IT infrastructure and human-related IT investments but negatively associated with IT application investment [54]. Another strand is to focus on ICT-based services and shows confounding results. Most studies exhibit that increasing bank performance is related to the application of online/internet banking [55, 56], automated Teller Machines (ATMs) [57], or a combination of them [58]. Nonetheless, Le and Ngo (2020a) argued that banks should further expand delivery channels (e.g., ATMs and the number of points of sale) to enhance bank profitability [11]. The positive relationship between digitalization (e.g., fin-tech adoption) and bank performance and risk management likely depends on the degree of leveraging technological innovation [59]. However, others reveal opposite evidence [60]. DeYoung (2001) disclosed that internet-based banks may have low operating costs but suffer low profits and core deposits [61].

2-2- CSR and Bank Performance

It is acknowledged that digitalization may cause critical threats to individuals [62], then potentially translate to the economy and society [63]. For instance, asymmetric information associated with the digitalization process may cause consumer vulnerability in terms of privacy loss [64] or cyber risks [65]. Also, others may raise concerns about economic and social inequality as a consequence of the increasing digital divide [66]. Corporate social responsibility (CSR) has recently received much attention from practitioners for its operating effectiveness and sustainable growth. CSR refers to the management of non-financial perspectives, including corporate, social, and environmental (UNIDO, n.d.). Several studies suggest that CSR can decrease asymmetric information [67, 68] due to disclosure requirements of firms' non-financial information. CSR also increases banks' reputation [8, 69], ultimately attenuating information asymmetries between them and their consumers in favor of the latter [70]. Indeed, trustworthiness induced by reputation [71] psychologically expects to reduce an agent's opportunistic behaviors [72]. Trust enhances long-term commercial relationships, in particular, in the case of intangible products/services and no physical contact (e.g., online transactions). Therefore, CSR could influence bank performance and risk management since increased reputation due to a negative effect of CSR on information asymmetries improves transparency and reliability [73] and mitigates the risk of a bank's opportunistic behavior [74].

The evidence on the correlation between CSR and bank performance is inconclusive. Certain studies indicate a beneficial effect of CSR on banking performance in industrialized nations [1, 75], across a cross-country sample [76], or in developing markets such as India [77]. Similarly, Belasri et al. (2020) argued that the favorable effect of CSR likely performs in the markets with vigorous investor protection and great stakeholder orientation [78]. However, others found that CSR adoption may reduce financial performance [79]. The reason is that CSR practices may require the diversion of resources away from maximizing shareholder wealth, thus reducing the opportunity to generate greater earnings [80, 81]. Nonetheless, CSR activities are associated with substantial costs [82] and lower financial performance [77]. Because ESG reflects CSR, several studies considering ESG dimensions indicate mixed results. Three components generally contribute to cost savings, but social performance and corporate governance are more responsible for deposit expenses [83]. A positive relationship between ESG and bank risk varies with the operator's characteristics [84]. In contrast, Yuen et al. (2022) found that three ESG components first reduce and then increase bank profitability [2].

2-3- The Joint Effect of Digitalization and CSR on Bank Performance

As mentioned above, the literature shows mixed evidence on the direct effects of digitalization and CSR on bank performance. However, Forcadell et al. (2020) advocated that the asymmetric information can be reduced on the banks' side (e.g., digitalization) and on the customers' side (e.g., corporate sustainability), thus contributing to increasing economic and market efficiency/performance [1]. Indeed, digitalization permits banks to acquire valuable customer

information, which may cause potential client vulnerabilities [64]. Su et al. (2016), however, CSR may help mitigate this asymmetric information. CSR signals non-financial elements, which help stakeholders understand banks' future behavior [85]. Thus, reputation-induced CSR activities can alleviate potential consumers' concerns regarding asymmetric information in favor of banks. In this sense, information asymmetries brought about by digitalization can be addressed through CSR-based reputation [1]. Therefore, the first hypothesis is formed as follows:

H1: The combination of corporate social responsibility and digitalization has no impact on banks' financial stability efficiency.

Due to the mixed effect of CSR components on bank performance as discussed in Section 2.2, the second hypothesis is constructed as follows:

H2: The combination between corporate social responsibility components and digitalization has no impact on banks' financial stability efficiency.

3- Methodology and Data

3-1- Methodology

3-1-1- Measuring Bank Stability Efficiency

The literature presents many metrics for assessing bank risk, including the percentage of non-performing loans [86], loan loss provisions relative to total loans, projected default risk [87], and the bank Z-score [88]. Because banks face different risk sources [28], we use Z-score as a standard measure of bank risk to cover the characteristics of various risk sources [89]. Hafeez et al. (2022) highlighted that a forward-looking z-score can better forecast banks' downward risk than the conventional z-score [90]. Therefore, a forward-looking z-score is adopted in our study.

We use a 4-year forward-looking moving window to construct a forward-looking z-score. The forward-looking moving window consists of actual values of the z-score elements (e.g., total assets, equity, and net income) for the latest three years (e.g., three previous years and the current year) and the analysts' estimates of relevant elements provided in the current year. Hence, the forward-looking z-score is computed from the sum of the moving mean values of ROA over a 4-year forward-looking moving window and the implied values of the equity-asset ratio for the 4th year, divided by the standard deviation of ROA over the four-year forward-looking moving window. In this way, the forward-looking z-score captures not only time-varying bank risk but also incorporates financial forecasts. The calculation of the forward-looking z-score is formed as follows:

$$Fz - score_{it} = \frac{\frac{\sum_{n=1}^{T} ROA_{i,t+1-n} + \widehat{ROA}_{it}}{T+1} + \widehat{ETA}_{it}}{\sigma(ROA_{i,t+1-T} \ldots\ldots ROA_{it}.\widehat{ROA}_{it})} \quad (1)$$

where $Fz - score_{it}$ is the forward-looking Z-score for bank i at time t (t being the current period). $\sum_{n=1}^{T} ROA_{i,t+1-n}$ is the sum of the ROA during the previous T year (including the current year), and T equals 3 for the 4-year forward-looking moving window. $\widehat{ROA}_{it}$ is analysts' forecasts of ROA for bank i at time t. $\widehat{ETA}_{it}$ is the implied equity-asset ratio for bank i at time t. The denominator $\sigma(ROA_{i,t+1-T}, \ldots, ROA_{it}, \widehat{ROA}_{it})$ represents the standard deviation of ROA, including the set of ROA for bank i at time $[t+1-T, t]$ and $\widehat{ROA}_{it}$.

It is acknowledged that the Z-score is an absolute measure of a bank's financial stability. It reflects little about how close individual banks (decision-making units) are to the most financial stability among them [28]. The X-efficiency concept is widely used in the banking literature to examine how banks in the sample perform compared to best-practice (fully efficient) banks regarding cost minimization or profit maximization [91]. We follow Fang et al. (2014) to incorporate the forward-looking z-score into the stochastic frontier model to estimate relative stability efficiency [28]. Therefore, we use the non-standard profit function of Berger & Mester (1997) to fit the forward-looking z-score frontier [92]. The specification of the translog cost function is as follows:

$$\ln(Fz - score) = lnf_t^j(X_{it}) + \vartheta_{it} + u_{it} \quad (2)$$

$$\ln\left(\frac{Z-score_{it}}{w_3}\right) = \alpha_0 + \sum_{g=1}^{3} \alpha_g \ln(y_{git}) + \sum_{m=1}^{2} \beta_m \ln\left(\frac{w_{mit}}{w_3}\right) + \frac{1}{2}\sum_{g=1}^{3}\sum_{h=1}^{2} \gamma_{gh} \ln(y_{git}) \ln(y_{hit}) + \frac{1}{2}\sum_{m=1}^{2}\sum_{n=1}^{2} \delta_{mn} \ln\left(\frac{w_{mit}}{w_3}\right) \ln\left(\frac{w_{nit}}{w_3}\right) + \sum_{g=1}^{3}\sum_{m=1}^{2} \theta_{gm} \ln(y_{git}) \ln\left(\frac{w_{mit}}{w_3}\right) + \vartheta_{it} + u_{it} \quad (3)$$

and

$$u_{it} = g(z_{i,t}; \alpha) + \varepsilon_{i,t} \quad (4)$$

where $lnZ - score_{i,t}$ is the logarithm of forward-looking Z-score value for bank i in year t; y_g refers to g^{th} output and w_m is m^{th} input price (see Table 1 for definitions of input prices and output quantities). To estimate the stability frontier model in Equation 2 with this translog form, the standard symmetric restrictions are applied to the second–order parameters or translog portion of the model as, $\gamma_{gh} = \gamma_{hg}$ and $\delta_{mn} = \delta_{nm}$.

Table 1. Inputs and outputs used in SFA

Variables	Definition	Previously used in
	Dependent variable	
$Z-score_{i,t}$	The forward-looking Z-score value	[85]
	Outputs (VND billion)	
Y_1 (Total loans)	Total amount of customer loans	[19, 88]
Y_2 (Other earning assets)	Other earning assets comprising loans and advances to banks, other securities	[19, 88]
Y_3 (non-interest income)	Non–interest income consisting of incomes derived from trading and derivatives, other securities, insurance, fees and commissions and other operating income	[88]
	Input prices	
W_1 (Deposits)	The ratio of interest expenses to total deposits	[19, 88]
W_2 (Labour)	The proportion of personnel expenses/number of employees	[19, 88]
W_3 (Physical capital)	The proportion of other operating cost to fixed assets	[19, 87, 88]

To ensure price homogeneity, we follow Fang et al. (2014) that $Z-score$, price of deposits (w_1) and price of physical capital (w_2) are normalized by the price of labour (w_3). α, β, γ, δ, and θ are parameters to be estimated; v_{it} contains the two-sided error $v\sim N\ (0,\sigma_v\ j_2\ )$ capturing the effects of random error or statistical noise, which are independent of u_{it}; and u_{it} is a non–negative random variable, representing the stability inefficiency [28]. The group j^{th} stability efficiency is estimated by the following conditional expectation: $SE_{itj}=\ E(e\ -\ u_{jit}\mid\varepsilon_{jit})$. We estimate the translog stability function and the model of stability inefficiency using a one-step procedure suggested by Battese & Coelli (1995), which is more efficient than a two-step procedure [93-95].

3-1-2- The Determinants of Bank Stability Efficiency

The specific model for examining factors affecting bank stability efficiency is presented in Equation (4). In which α is the vector of unknown coefficients to account for bank stability inefficiency. To test hypothesis 1, Equation 4 is simply expressed as

$$u_{it}=\alpha_0+\alpha_1CSR_{i,t}+\alpha_2SQCSR_{i,t}+\alpha_3X_{i,t}+\alpha_4Y_t+\varepsilon_{i,t} \quad (5)$$

To test hypothesis 2, Equation 4 is modified as:

$$u_{it}=\alpha_0+\alpha_1CSR_{i,t}+\alpha_2SQCSR_{i,t}+\alpha_3GT_{i,t}+\alpha_4CSR_{i,t}*GT_{i,t}+\alpha_5X_{i,t}+\alpha_6Y_t+\varepsilon_{i,t} \quad (6)$$

We first constructed the CSR index. We categorize stakeholders into five components: shareholders, employees, consumers (depositors and lenders), government, environment and society. The definition and calculation of each component are presented in Table 2.

Table 2. Aspects that affect the social responsibility of banks (adapted from Zhou et al. (2021) [32])

Index	Variable	Calculation
Shareholder (SHR)	Dividend payment rate	Dividend payment rate/ EPS
Employee (EMP)	Employee expense ratio	Employee expense/ total income
Customers (CUS)	Mobilization and lending expenses ratio	Expenses related to interest activities on total income
Government	Tax expense ratio and interest rate support	Tax payment amount and interest subsidy amount on total income
Environment and Social (SOC)	Proportion of welfare contributions to the environmental and social community through charity programs and social activities	Community contributions on total income

The majority of previous research has employed content analysis and ranking indexes to quantify CSR. Apply the un-weighted measure method [96] in order to determine the overall CSR score. Nevertheless, these approaches are largely subjective, susceptible to the impact of subjective elements, and insufficiently objective. Principal component analysis is utilized to calculate the proportions of components that influence CSR in order to circumvent this limitation. Principal component analysis is an empirical data-driven one-dimensional statistical reduction technique. Principal component analysis will therefore be more objective. The weight assigned to each indicator in this study is determined by the information it comprises. This purpose may be achieved by using principal component analysis, which involves the following steps: (i) determining the weight of each index using principal component analysis; and (ii) assigning weights to the findings obtained from principal component analysis.

First, the main weight model is determined according to the following formula:

$$F_1 = f_{11}x_1 + f_{12}x_2 + \cdots + f_{1n}x_n$$
$$F_2 = f_{21}x_1 + f_{22}x_2 + \cdots + f_{2n}x_n \quad (5)$$
$$F_m = f_{m1}x_1 + f_{m2}x_2 + \cdots + f_{mn}x_n$$

F1, F2, ..., Fm represent the m principle components obtained from principal component analysis; fij represents the initial factor loadings; and xi stand for the ith standardized index.

Second, the original coefficients are transformed into a coefficient decision matrix:

$$u_{ij} = f_{ij}/\sqrt{\lambda}_j \quad (6)$$

In which, uij represents the choice matrix coefficient; fij is the starting coefficient, λj presents the characteristic solution of the j equation components.

$$F_z = \sum_{j=1}^{m}(\lambda_j/k)F_j = a_1x_1 + a_2x_2 + \cdots + a_nx_n \quad (7)$$

$$k = \lambda_1 + \lambda_2 + \cdots + \lambda_n \quad (8)$$

In conclusion, the calculation for the weight of each index is as follows:

$$w_i = a_1/\sum_{i=1}^{m} a_i \quad (9)$$

Table 3. The results of analyzing the main components of the bank's social responsibility

Variable	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5
SHR	0.0434	0.7373	-0.1186	0.6635	0.0146
EMP	0.4559	-0.4688	0.3121	0.5375	0.4313
CUS	-0.6888	0.0290	0.0427	0.0045	0.7231
GOV	0.5536	0.2972	-0.3478	-0.4406	0.5387
SOC	0.0970	0.3838	0.8751	-0.2771	0.0269
Eigenvalue	1.9104	1.2340	0.9738	0.7082	0.1734
Proportion	0.3821	0.2468	0.1948	0.1416	0.0347

	Eigenvalue
comp1	1.91042
comp2	1.23407
comp3	0.973817
comp4	0.708249
comp5	0.17345
Sum	5.000006

Noted: the results of Table 3.

From the results of Table 3 on the individual values of each component 1 to 5, continue to use equations (7), (8) and (9) according to the PCA method to calculate the density for each component. The results are presented in table 4 as below.

Table 4. Weight of each component

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Fz	Weight
SHR	0.0434	0.7373	-0.1186	0.6635	0.0146	0.26995	23.69%
EMP	0.4559	-0.4688	0.3121	0.5375	0.4313	0.21037	18.46%
CUS	-0.6888	0.029	0.0427	0.0045	0.7231	-0.22198	19.48%
GOV	0.5536	0.2972	-0.3478	-0.4406	0.5387	0.173413	15.22%
SOC	0.097	0.3838	0.8751	-0.2771	0.0269	0.263908	23.16%

Table 4 is presented the calculation results showing that the allocation ratio among shareholders, employees, customers, government, society, community and environment are 23.68%, 18.46%, 19.48%, 15.22%, and 23.16 % accordingly. The weights indicate that the most important factor is the proportion of shareholders in commercial banks. This suggests that if banks prioritize their objectives, they will fulfill around one-third of their societal obligations. Furthermore, the personnel of commercial banks have paramount significance. Given that banks are financial institutions and sectors with low asset intensity, their most valuable resources are their workers. Hence, the organization's obligation

towards its workers has great significance. Moreover, depositors and lenders of a bank have higher significance. This is because the primary method by which banks generate profits is via the acquisition of deposits and subsequent lending activities. In the grand scheme of things, the government has the least amount of influence among all stakeholders. Noncompliance with business income tax is obligatory. The CSR weighting among various stakeholders listed above is both practical and persuasive. Based on these weights, this research establishes a social responsibility index for commercial banks in Vietnam.

Regarding the bank-specific characteristics ($X_{i,t}$), we control for bank property: digitalization (Green investment technology -GT), bank size (SIZE), ownership of state-owned commercial banks (SOCB), banks listed on the stock exchange (Listed), Basel application (BASEL2), COVID-19 pandemic (COVID) and CEO gender (CEOGEN). In which, SIZE is the natural logarithm of total bank assets [60, 88]. SOCB is a dummy variable, equal to 1 if the bank is state-owned and 0 otherwise [97, 98]. GT is measured by the ratio the ratio of amount green investment technology on total assets; Listed is a dummy variable, equal to 1 if the bank is listed on the stock exchange and 0 otherwise [97, 98]; Basel2 is a dummy variable, equal to 1 if the bank applies Basel 2 regulations and 0 otherwise [97, 98]; $COVID$, a dummy variable that takes a value of 1 for the years 2020-2022, and 0 otherwise; CEOGen is a dummy variable, equal to 1 if the bank's CEO is female and 0 otherwise [97, 98].

Regarding macroeconomic characteristics, the author uses the variable GDP growth rate (GDP) in year t compared to year t-1 and inflation rate (INF) as proxies.

3-2- Data

Our research collected 30 Vietnamese commercial banks from 2010 to 2022, which accounts for more than 97% of the total assets of the banking industry. Most of the bank-specific information is taken from the Vietnamese banking database, which we collect from banks' financial statements and annual reports published annually by banks.

The 2010–2022 period was chosen because it represents a transformative era for the Vietnamese banking sector, characterized by major reforms in restructuring, risk management, and the adoption of CSR practices. During this time, CSR became a crucial component as banks faced increasing pressure from customers, investors, and national policies, such as Decision 1552/QĐ-NHNN, which emphasized environmental and social risk management in credit activities. Simultaneously, the rapid technological advancements fueled extensive digitization efforts, including the implementation of online banking platforms and investments in green technology. The 12-year timeframe allows for the observation of both short-term and long-term impacts, especially in the context of significant events such as the global financial crisis and the COVID-19 pandemic. This selection ensures robust data for analysis, highlights the interplay between CSR and digitization, and facilitates comparisons with international studies in the same domain.

Table 5. Descriptive statistics of variables used in our analysis

Variables	Obs	Mean	Std. Dev.	Min	Max
Dependent variable					
$FZ-score$	390	14.234	8.941	2.185	75.85
Independent variables					
Y_1	390	168,010.321	259,056.288	3,662.84	1,488,150.5
Y_2	390	29.788	88.344	1.954	942.159
Y_3	390	3,039.944	4,891.854	6.994	32,320.006
W_1	390	0.08	0.046	0.024	0.361
W_2	390	492.048	2,333.272	12	25,400
W_3	390	2.655	2.954	0.221	28.353
Environmental variables					
CSR	390	15.283	2.251	7.616	25.925
GT	390	0.303	0.215	0	1.123
SIZE	390	18.609	1.542	15.922	21.455
COVID	390	0.148	0.356	0	1
SOCB	390	0.133	0.34	0	1
LIST	390	0.633	0.482	0	1
BASELII	390	0.184	0.388	0	1
CEOGEN	390	0.848	0.358	0	1
GDP	390	6.101	1.584	2.561	8.020
INF	390	5.324	4.599	0.631	18.677

Notes: $Fz-score$, the value of a bank's forward-looking Z-score; CSR, a bank's corporate social responsibility index; ; GT, the ratio of amount green investment technology on total assets; $SIZE$, the natural logarithm of total assets; ; $COVID$, a dummy variable that takes a value of 1 for the years 2020-2022, and 0 otherwise; SOCB, *a dummy variable that takes a value of 1 for a* state-owned commercial bank and 0 otherwise; LIST, a dummy variable that takes a value of 1 for a listed bank, and 0 otherwise; CEOGEN, *a dummy variable that takes a value of 1 for a male CEO, and 0 otherwise; GDP,* the annual economic growth rate; INF, inflation rate.

The descriptive statistics table provides an overview of the distribution and variation of the variables included in the research model, thereby facilitating a deeper examination of the factors affecting banking stability performance. Below is a detailed analysis of each group of variables presented in Table 5.

First, table 5 indicates that the average CSR score is 15.283 with a high standard deviation, implying significant differences among banks in the level of participation in CSR activities and application among Vietnamese commercial banks. This may be due to differences in the CSR strategies of each bank, especially among banks in different regions and sizes. This result is consistent with the study of Maqbool and Zameer (2018), which indicated that the level of CSR can vary significantly among banks depending on business strategies and market developments [77]. Furthermore, the Fz-score index with the average value of Vietnamese banks is 14.23, with a high standard deviation, indicating a reasonably high degree of financial stability among commercial banks in Vietnam. The financial situation of the companies is significantly different, as the smallest value is 2.185 and the utmost value is 75.85. This disparity may result from the significant changes in their financial stability index that may be caused by the varying sizes, strategies, and business activities of banks.

Regarding the control variables in the banking industry, the mean value of SIZE, bank size, is 18.609, with a standard deviation of 1.542. This indicates that the banks in the sample have significant differences in size, with a minimum value of 15.922 and a maximum of 21.455. Bank size is an important factor affecting bank performance and financial stability, as highlighted in the study of Ho et al. (2023), suggesting that larger bank size can help reduce financial risk. Furthermore, the characteristics of banks are shown by ownership type such as SOCB and POCB, listed and unlisted banks, and gender of the bank CEO [99]. This SOCB variable has an average value of 0.133, indicating that only 13.3% of banks in the sample are state-owned banks. State-owned banks often have different strategies and operational goals than private banks, which can affect their financial performance [99]. The limited representation of state-owned banks in our sample suggests that the financial systems in some of the countries examined may be mostly controlled by private banks. The mean value of the LIST variable is 0.633, indicating that 63.3% of the banks in the sample are publicly listed institutions. This illustrates the concentration of publicly listed banks, which encounter heightened expectations for openness and financial efficiency as a result of stock market laws [35]. The average value of CEOGen is 0.848, with 84.8% of the organizations surveyed being led by male CEOs. This result is in accordance with previous research; this shows that leadership positions in the finance and banking industry are mostly held by men.

The average GDP is 6.101, with a standard deviation of 1.584, indicating differences in economic growth rates across countries in the sample. GDP is an important factor that can affect bank performance, as a rapidly growing economy can facilitate the development of the banking system [11]. Furthermore, the INF variable has a mean value of 5.324 and a standard deviation of 4.599, indicating that there is a large variation in inflation rates among countries. Inflation significantly influences bank profitability, with high inflation likely to increase interest rates and create opportunities for bank profitability [100]. Finally, the COVID-19 pandemic's influence is reflected in a mean value of 0.148, indicating that about 14.8% of the sample pertains to the period from 2010 to 2022. This result illustrates the profound effect of the pandemic on the global banking system, since COVID-19 induced substantial interruptions in banking operations and engendered unparalleled financial issues [23, 54].

In conclusion, the descriptive statistics in Table 5 provide insight into the distribution and variability of variables in the sample. The large variation among variables, especially in terms of bank size, CSR level, and listing status, indicates that the banks in the sample have significantly different characteristics that may affect their performance and financial stability. These findings are consistent with other prior research on bank performance and CSR, while also highlighting the variability of economic environment factors and the impact of COVID-19 on the global banking system.

4- Empirical Findings and Discussion

4-1- The Results of Our Baseline Model

The effect of CSR and CSR's components on bank financial stability efficiency is displayed in Table 6, while Table 7 exhibits the joint effects of CSR/CSR components and digitalization on bank financial stability efficiency.

Table 6. Results of CSR and components on Vietnamese bank stability inefficiency

Variables	CSR	SHR	EMP	CUS	GOV	SOC
lnY1	-1.571 (-1.44)	-2.063** (-2.14)	-1.686* (-1.83)	-1.088 (-1.07)	-1.551* (-1.73)	-1.648* (-1.84)
lnY2	1.636 (1.59)	0.534 (0.52)	1.557* (1.72)	0.665 (0.59)	1.484* (1.63)	1.227 (1.32)
lnY3	-2.080*** (-3.30)	-2.075*** (-3.45)	-1.946*** (-3.49)	-1.556 (-1.46)	-1.890*** (-3.33)	-1.916*** (-3.35)
lnw1	-3.063*** (-3.49)	-3.502*** (-3.97)	-3.210*** (-3.68)	-2.083 (-1.45)	-3.006*** (-3.53)	-2.759*** (-3.22)
lnw2	1.468 (1.39)	2.216** (2.11)	3.656*** (3.61)	1.639 (0.67)	3.216*** (3.17)	3.146*** (3.25)
1/2 lny1*lny1	0.061 (0.57)	0.097 (0.96)	0.091 (0.87)	-0.037 (-0.35)	0.073 (0.74)	0.066 (0.67)
1/2 lny2*lny2	0.066 (0.92)	0.034 (0.46)	-0.020 (-0.27)	0.032 (0.43)	-0.001 (-0.02)	-0.015 (-0.21)
1/2 lny3*lny3	-0.024*** (-4.97)	-0.022*** (-5.41)	-0.019*** (-4.72)	-0.022*** (-4.63)	-0.020*** (-4.88)	-0.019*** (-4.71)
1/2 lnw1*lnw1	0.356*** (4.00)	0.420*** (5.27)	0.416*** (5.83)	0.291*** (2.39)	0.388*** (5.33)	0.394*** (5.30)
1/2 lnw2*lnw2	0.117*** (5.13)	0.119*** (4.95)	0.053** (2.53)	0.042** (2.25)	0.047** (2.16)	0.042* (1.86)
lny1*lnw1	0.225*** (2.61)	0.279*** (3.17)	0.248*** (2.79)	0.100 (0.70)	0.219*** (2.56)	0.208** (2.44)
lny1*lnw2	-0.125 (-1.23)	-0.210** (-2.09)	-0.252*** (-2.65)	-0.072 (-0.30)	-0.221** (-2.28)	-0.213** (-2.28)
lny2*lnw1	-0.103 (-0.88)	-0.043 (-0.37)	-0.030 (-0.28)	-0.036 (-0.37)	-0.017 (-0.17)	-0.020 (-0.20)
lny2*lnw2	0.019 (0.18)	-0.049 (-0.42)	-0.226** (-2.13)	-0.126 (-1.16)	-0.202* (-1.91)	-0.196** (-1.96)
lny3*lnw1	0.052 (0.84)	0.007 (0.11)	0.020 (0.30)	0.123 (1.40)	0.038 (0.61)	0.033 (0.52)
lny3*lnw2	0.014 (0.21)	0.081 (1.20)	0.097 (1.59)	-0.006 (-0.05)	0.085 (1.35)	0.082 (1.33)
lny1*lny2	-0.061 (-0.55)	0.112 (0.90)	0.133 (1.40)	0.164* (1.61)	0.120 (1.26)	0.148 (1.55)
lny1*lny3	0.138*** (3.19)	0.129*** (3.08)	0.118*** (2.87)	0.146*** (4.00)	0.120*** (3.02)	0.123*** (3.03)
lny2*lny3	-0.080 (-0.99)	-0.178** (-1.99)	-0.201*** (-3.00)	-0.232*** (-2.86)	-0.192*** (-2.80)	-0.206*** (-3.03)
lnw1*lnw2	0.201*** (4.22)	0.240*** (5.62)	0.245*** (6.25)	0.172** (2.30)	0.229*** (5.54)	0.240*** (5.98)
Constant	23.003*** (3.34)	26.395*** (4.41)	17.198*** (3.31)	17.266* (1.87)	17.117*** (3.22)	18.915*** (3.54)
Stability inefficiency (u)						
CSR/CSR components	1.052** (2.33)	-0.159*** (-3.81)	0.148 (0.52)	0.314*** (2.98)	-0.843*** (-4.26)	-0.598* (-1.75)
SQCSR/CSR components	-2.900** (-2.14)	0.385** (2.32)	-2.369 (-1.54)	-0.176** (-2.31)	2.540*** (3.81)	3.541* (1.75)
GT	-2.276*** (-3.48)	-3.245*** (-4.76)	-3.270*** (-3.63)	-1.854*** (-2.68)	-3.493*** (-3.14)	-2.752*** (-4.06)
SIZE	0.236 (0.80)	0.007 (0.10)	1.902*** (7.20)	0.400*** (2.12)	0.569** (2.33)	0.048 (0.22)
COVID	1.864** (2.18)	1.494** (2.01)	2.779*** (2.80)	2.620*** (3.13)	4.005*** (3.45)	1.673** (2.18)
SOCB	-1.577** (-2.29)	-0.689* (-1.83)	-27.600*** (-11.06)	-1.447*** (-3.04)	-2.616*** (-2.05)	-0.610 (-0.99)
LIST	-0.421* (-1.90)	-0.339 (-1.43)	-3.825*** (-8.55)	-0.203 (-0.91)	-0.215 (-0.57)	-0.404* (-1.70)
BASELII	1.321*** (4.21)	1.101*** (3.57)	2.968*** (7.25)	2.076** (5.95)	1.927*** (4.42)	0.928*** (3.09)
CEOGEN	1.147*** (3.33)	1.012*** (2.68)	2.458*** (5.58)	1.502*** (4.44)	2.500*** (5.30)	0.992** (2.42)
GDP	0.325* (1.79)	0.253 (1.60)	0.520** (2.41)	0.467*** (2.60)	0.783*** (2.99)	0.294* (1.80)
INF	0.022 (0.83)	0.053** (2.00)	0.106*** (3.04)	0.029 (1.17)	0.148** (3.44)	0.022 (0.92)
Constant	-17.152** (-2.12)	-2.898* (-1.64)	-3.996* (-1.92)	-25.640*** (-4.03)	-18.092*** (-3.59)	-3.928 (-0.92)
$\gamma = \frac{\sigma_{u2}}{\sigma_{v2} + \sigma_{u2}}$	0.273***	0.279***	0.337***	0.271***	0.335***	0.276***
No. Obs	390	390	390	390	390	390

*Note: CSR= corporate social responsibility index; CUS= corporate customer responsibility index; SHR= corporate responsibility index to shareholders; GOV= corporate responsibility index to government; SOC= corporate environmental and social responsibility index; EMP= corporate employee responsibility index; GT=digitalization, the ratio total amount of investment in technology and software on total assets; SIZE= natural logarithm of total assets; SOCB= a dummy variable equal to 1 for state-owned commercial banks and 0 otherwise; Listed= a dummy variable equal to 1 for banks listed on the stock exchange and 0 otherwise; Basel2= a dummy variable equal to 1 for banks that have applied Basel 2 standards and 0 otherwise; Audit4= a dummy variable equal to 1 for audit reports of banks audited by the top 4 firms and 0 otherwise; CEOGEN= a dummy variable equal to 1 for female bank executives and 0 otherwise; GDP= GDP growth rate in year t compared to year t-1; INF= penalty inflation rate in year t compared to year t-1;. Standard errors are in parentheses. *, ** and *** Significant at 10, 5 and 1 % levels, respectively.*

Across frontier models, most coefficients are statistically significant. The formula for determining the inefficiency contribution to the total error of the model is $\gamma = \frac{\sigma_{u2}}{\sigma_{v2}+\sigma_{u2}}$.

The average value of estimated γ in all models is statistically significant, asserting that the stability inefficiency component plays an important role in the analysis of bank performance.

Table 6 presents the regression results for the impact of corporate social responsibility (CSR) and its components on the financial stability inefficiency of Vietnamese banks. These findings reveal a nuanced relationship between CSR factors, digitization (GT), and bank performance. Below is a comprehensive analysis and interpretation of the results, supported by comparisons with prior research.

The coefficients of CSR are positive in Table 6, while those of SQCSR are negative. This suggests that there is a U-shaped relationship between banks' adoption of CSR and their ability to keep their finances stable. These results indicate that the initial adoption of CSR increases inefficiency due to higher costs, which corroborates the trade-off theory. This finding aligns with Brammer and Millington (2008), who argued that CSR investments require significant financial resources that do not yield immediate returns [101]. Similarly, prior studies, such as Le & Ngo (2020b) in China and Avkiran (2011) in a cross-country context, observed similar patterns [11, 97]. These findings challenge Hypothesis 1 and confirm that CSR's long-term benefits outweigh its initial costs, as banks that strategically invest in it can achieve improved stability over time.

When looking at the CSR components, the U-shaped relationship holds true only for the case of employee (EMP) and customer responsibility (CUS). Increasing the responsibility of banks from these two perspectives can attract talented and qualified employees and gain customer support and loyalty. These findings may argue that the adoption of CSR standards requires significant financial commitments to various entities such as customers and employees, which is likely to deplete resources allocated to other areas in the short term and increase the bank's operating costs. Therefore, this partly supports the trade-off theory that CSR is considered an inefficient allocation of resources [98]. However, these investments can gain greater customer loyalty and enhance employee engagement and loyalty to improve productivity in the long run. Therefore, this can improve the financial stability efficiency of banks and aim at sustainable development. More specifically, it is argued that if banks make sufficient commitments to their customers and employees, this can minimize agency costs [101] because managers may not pursue CSR initiatives solely for personal gain but for the best interests of the organization. This supports the legitimacy theory that firms engage in CSR activities to gain social approval to demonstrate the legitimacy of their activities and gain support from the community [102]. Therefore, this can improve the stability performance of banks.

However, responsibilities toward shareholders (SHR), government (GOV), and society/environment (SOC) exhibit an inverted U-shaped relationship with financial stability efficiency. For shareholders and government responsibilities, short-term benefits such as increased investment or government support (e.g., higher lending margins for state-owned enterprises) eventually lead to higher operating costs and reduced stability. This finding adds to what Avkiran (2011) and Le and Ngo (2020b) said, which was that there were short-term benefits but that they were followed by long-term inefficiencies because resources were wasted and costs went up [11, 97]. For environmental and social responsibilities, excessive expenditures on environmental projects and philanthropic activities lead to diminishing marginal returns. This backs up earlier research by Wang et al. (2008), which showed that spending too much on CSR could hurt trust among stakeholders, use up resources, and make things less efficient [103]. These results emphasize the importance of balancing CSR investments to avoid over-commitment, which may erode stability.

The findings demonstrate that digitization (GT) significantly adversely affects banking stability inefficiency, with a coefficient of -2.265 (p-value < 1%). This aligns with prior studies indicating that the deployment of GT digitization enhances the efficiency and stability of banks in Ghana [53] and Vietnam [51] and contributes to financial stability in Europe overall [104]. The findings of our study therefore support the argument that improved information dissemination can reduce bank solvency and enhance stability. Berger and Mester (2003) assert that digitalization helps banks reduce operating costs and improve risk management, thereby improving efficiency and stability [105]. Machkour & Abriane (2020) also highlight the role of digitalization in reducing information asymmetry and enhancing competitive advantage [106].

Among the characteristics of banks, state-owned banks (SOCB) and listed banks (Listed) both have a negative and statistically significant impact on inefficiency, indicating that these banks are more efficient. Stable performance is better than other banks. This finding is consistent with research on banking efficiency in countries such as China

(Ngo & Le, 2022) and Southeast Asia [11], Vietnam [97, 98], and bank stability [51]. One of the main explanations is that SOCBs have benefited from long-term support and subsidies from the Vietnamese government [107]. Similarly, other variables, including banks listed on the stock exchange (listed) [24, 108], exhibit comparable outcomes to the SOCB variable in that they both demonstrate a strong positive correlation and are highly effective in stabilizing banks.

The adoption of Basel II standards (Basel2) and the presence of female CEOs (CEOGEN) both have positive and significant effects on stability inefficiency, suggesting that these factors may increase inefficiency in risk management and financial stability [11, 97]. Regarding macroeconomic factors, GDP growth rate has a negative and significant effect in some models, while inflation (INF) has a positive and statistically significant relationship in all models, suggesting that a high inflation environment may increase the stability inefficiency of banks [109, 110].

Finally, the Wald X^2 test and Log-likelihood indices demonstrate the model's robustness, as evidenced by p-values that are less than 0.01, which confirm the statistical significance of the estimates.

In summary, compared to prior studies, this research offers new insights by highlighting the combined effects of CSR and digitization on financial stability efficiency, particularly in the context of an emerging economy like Vietnam. While prior studies have largely focused on developed markets, this study reveals that CSR and digitization interact uniquely in Vietnam due to its regulatory environment and market dynamics. Policymakers should provide clearer CSR guidelines and incentivize digital transformation to maximize bank stability. Additionally, banks should adopt a strategic approach to CSR by prioritizing components that yield long-term benefits, such as employee and customer responsibility, while carefully managing commitments to shareholders and government mandates.

4-2- The Impact of Digitalization on the Relationship of CSR and CSR's Components on Bank Stability Efficiency

Table 7 presents the findings of the analysis on the simultaneous impact of CSR and digitalization (GT) on the stability efficiency of banks in Vietnam. These results not only confirm the direct relationship between CSR, its components, and bank stability efficiency but also demonstrate how digitalization interacts with CSR to influence bank performance. A detailed analysis and comparison with prior research are provided below.

Table 7 indicates a positive coefficient on (GT), implying that a partial increase in investments in digitalization itself may reduce the stability performance of banks, because newly developed online payment transactions in Vietnam such as paying for goods, electricity and water bills, buying airline tickets, or making online savings deposits or making payments for overseas transactions, etc. require banks to invest in technology systems, computer software or automated teller machines with high investment costs. This shows that digitalization may cause high initial costs and reduce performance in the short term, but it can also optimize risk management and improve operating efficiency in the long term [111]. These initial costs can weigh heavily on banks' financial performance, reducing stability in the short term. However, in the long run, digitalization optimizes risk management, improves operating efficiency, and reduces transaction costs, as previously highlighted by studies on Ghana [53] and Europe [104]. The current findings corroborate these insights, emphasizing that while digitalization may present short-term challenges, its long-term benefits, such as enhanced competitiveness and operational efficiency, outweigh the initial inefficiencies.

However, the negative coefficient on CSR*GT indicates a positive overall impact of CSR and digitalization on the stability efficiency of banks. Since many CSR activities tend to increase the inefficiency of bank stability in the long run, digitalization is considered an effective policy measure to promote the long-term advantage of CSR. As an important part of CSR, digitalization, green technology investment is derived from environmental protection. Therefore, it is closely linked to stakeholders such as the government, savers and borrowers. When green actions are objectively quantified as part of its investment portfolio, banks will gain more reputation, trust and support from stakeholders. Consequently, green technology investment or digitalization can positively affect the relationship between CSR and bank stability. Hence, hypothesis 2 cannot be rejected. This is consistent with the study of Forcadell et al. (2020), which argues that the combination of CSR and digitalization helps to reduce information asymmetry and enhance trust from customers and stakeholders [1]. The above results demonstrate the moderating impact of green technology investment or digitalization on the relationship between CSR and bank profitability in Vietnam.

Finally, we also find similar evidence in banks' responsibility to customers regarding the regulatory role of green technology or digitalization investments, as detailed in Table 7.

Table 7. The joint effects of CSR/CSR components and digitalization on bank stability efficiency

Variables	CSR	SHR	EMP	CUS	GOV	SOC
lnY1	-2.112 (-1.58)	-1.745* (-1.80)	-1.505 (-0.92)	-1.952** (-2.15)	-2.491** (-2.31)	-1.619 (-1.54)
lnY2	1.390 (1.30)	0.250 (0.24)	1.895 (1.12)	0.861 (0.88)	1.540 (1.51)	1.255 (1.15)
lnY3	-1.922*** (-2.91)	-2.247*** (-3.67)	-2.309*** (-2.99)	-1.671*** (-2.83)	-1.996*** (-3.49)	-2.295*** (-3.74)
lnw1	-3.470*** (-2.81)	-3.721*** (-4.32)	-3.385*** (-3.62)	-2.992*** (-3.72)	-4.521*** (-5.20)	-3.657*** (-3.91)
lnw2	1.970 (1.45)	2.409** (2.29)	1.440 (1.34)	0.840 (0.90)	2.835** (2.42)	2.260** (2.08)
1/2 lny1*lny1	0.118 (0.84)	0.084 (0.85)	0.086 (0.67)	0.073 (0.80)	0.205* (1.83)	0.078 (0.69)
1/2 lny2*lny2	0.055 (0.79)	0.045 (0.61)	0.072 (1.04)	0.071 (1.16)	0.022 (0.30)	0 .039 (0.54)
1/2 lny3*lny3	-0.023*** (-4.86)	-0.020*** (-4.85)	-0.022*** (-4.69)	-0.022*** (-4.79)	-0.021*** (-4.78)	-0.022*** (-4.99)
1/2 lnw1*lnw1	0.371*** (4.27)	0.408*** (4.96)	0.389*** (5.06)	0.298*** (4.15)	0.402*** (5.89)	0.383*** (4.43)
1/2 lnw2*lnw2	0.110*** (5.54)	0.116*** (4.95)	0.115*** (5.86)	0.103*** (6.10)	0.124*** (6.41)	0.121*** (5.06)
lny1*lnw1	0.272** (2.15)	0.307*** (3.49)	0.297*** (3.16)	0.218*** (2.60)	0.371*** (4.34)	0.280*** (2.94)
lny1*lnw2	-0.170 (-1.24)	-0.238** (-2.33)	-0.166* (-1.64)	-0.065 (-0.72)	-0.263** (-2.49)	-0.209* (-1.94)
lny2*lnw1	-0.053 (-0.35)	-0.089 (-0.79)	-0.083 (-0.60)	-0.086 (-0.89)	-0.069 (-0.62)	-0.026 (-0.20)
lny2*lnw2	-0.018 (-0.12)	-0.012 (-0.11)	-0.024 (-0.21)	0.033 (0.36)	-0.049 (-0.46)	-0.054 (-0.43)
lny3*lnw1	0.009 (0.10)	-0.002 (-0.04)	-0.012 (-0.17)	0.051 (0.84)	-0.032 (-0.50)	0.009 (0.13)
lny3*lnw2	0.046 (0.46)	0.097 (1.43)	0.075 (1.15)	-0.014 (-0.25)	0.105 (1.57)	0.078 (1.04)
lny1*lny2	-0.008 (-0.05)	0.123 (0.98)	-0.049 (-0.25)	-0.015 (-0.15)	-0.037 (-0.33)	0.035 (0.25)
lny1*lny3	0.117** (2.14)	0.136*** (3.31)	0.128*** (2.63)	0.123*** (3.25)	0.092** (2.09)	0.135*** (2.92)
lny2*lny3	-0.105 (-0.90)	-0.198** (-2.22)	-0.098 (-0.87)	-0.090 (-1.16)	-0.063 (-0.82)	-0.127 (-1.34)
lnw1*lnw2	0.210*** (4.65)	0.226*** (5.24)	0.212*** (5.46)	0.157*** (4.26)	0.243*** (5.87)	0.224*** (5.21)
Constant	25.243*** (3.46)	24.099*** (3.90)	23.187** (2.18)	26.062*** (4.13)	24.993*** (3.87)	22.764*** (3.77)
Stability inefficiency (u)						
CSR/CSR components	1.861** (2.11)	-0.129** (-2.18)	-0.291* (-1.72)	0.504*** (4.52)	-0.548** (-2.38)	0.655 (1.18)
SQCSR/CSR components	-4.978** (-1.99)	0.784** (2.25)	0.429 (0.46)	-0.290*** (-3.85)	4.605*** (2.86)	2.603 (1.21)
(CSR/CSR components)*GT	-0.642** (-2.17)	-0.498* (-1.76)	0.213 (1.40)	-0.151*** (-3.59)	-1.934 (-1.06)	-6.666** (-2.16)
GT	7.275* (1.68)	-2.898*** (-4.46)	-4.861** (-2.51)	7.790*** (2.98)	-2.185* (-1.68)	-2.184*** (-3.68)
SIZE	0.057 (0.20)	0.001 (0.02)	-0.003 (-0.07)	0.423** (2.35)	0.566*** (2.66)	0.005 (0.07)
COVID	2.052*** (2.62)	1.355* (1.84)	1.810* (1.79)	2.777*** (3.45)	3.295*** (3.46)	1.472** (2.06)
SOCB	-1.102 (-1.29)	-0.649* (-1.71)	-0.439 (-0.48)	-1.401*** (-3.01)	-1.561** (-2.50)	-0.594 (-1.36)
LIST	-0.456** (-2.03)	-0.386 (-1.60)	-0.389 (-1.49)	-0.260 (-1.18)	-0.445 (-1.54)	-0.346 (-1.50)
BASELII	1.315*** (4.06)	1.136*** (3.53)	1.136*** (2.82)	2.145*** (6.52)	1.356** (2.23)	0.866*** (3.03)
CEOGEN	1.023** (2.04)	0.972** (2.32)	1.302** (2.02)	1.514*** (3.79)	2.609*** (4.94)	0.879*** (2.64)
GDP	0.372** (2.20)	0.231 (1.45)	0.339* (1.71)	0.516*** (3.00)	0.582*** (2.75)	0.255* (1.64)
INF	0.010 (0.44)	0.056** (2.21)	-0.011 (-0.43)	0.021 (0.84)	0.106** (2.47)	0.023 (1.00)
Constant	-21.443* (-1.85)	-2.668 (-1.60)	-1.183 (-0.59)	-33.755*** (-5.32)	-16.698*** (-4.02)	-2.867 (-1.45)
$\gamma = \frac{\sigma_{u2}}{\sigma_{v2} + \sigma_{u2}}$	0.268***	0.279***	0.282***	0.264***	0.337***	0.258***
No. Obs	390	390	390	390	390	390

Note: CSR= corporate social responsibility index; CUS= corporate customer responsibility index; SHR= corporate responsibility index to shareholders; GOV= corporate responsibility index to government; SOC= corporate environmental and social responsibility index; EMP= corporate employee responsibility index; ; $CSR * GT$, the interaction term between CSR and GT; $SIZE$, the natural logarithm of total assets *GT=digitalization, the ratio total amount of investment in technology and software on total assets;; LnTA= natural logarithm of total assets; CIR, The ratio of operating expenses to total revenue; Bomsize, Number of members of the board of directors of bank; SOCB= a dummy variable equal to 1 for state-owned commercial banks and 0 otherwise; Listed= a dummy variable equal to 1 for banks listed on the stock exchange and 0 otherwise; Basel2= a dummy variable equal to 1 for banks that have applied Basel 2 standards and 0 otherwise; Audit4= a dummy variable equal to 1 for audit reports of banks audited by the top 4 firms and 0 otherwise; CEOGen= a dummy variable equal to 1 for female bank executives and 0 otherwise; GDP= GDP growth rate in year t compared to year t-1; INF= penalty inflation rate in year t compared to year t-1;. Standard errors are in parentheses. *, ** and *** Significant at 10, 5 and 1 % levels, respectively.*

In summary, the study highlights that investments in green technology or digitalization, as part of CSR, can enhance a bank's reputation and build stronger stakeholder relationships. By actively adopting green practices, banks demonstrate their commitment to environmental and social causes, leading to improved trust and loyalty from stakeholders, including customers, regulators, and investors. This finding is consistent with Wang et al. (2008), who argue that corporate philanthropy and green initiatives enhance stakeholder relations, provided that the marginal costs of CSR investments do not exceed their marginal benefits [100].

4-3- Robustness Check

We run several robustness checks to validate our findings above. We only report results on the joint impact of CSR and digitalization on bank stability performance, as these two strategies are of primary interest.

Table 8. The results of robustness checks

Variables	LARGE	SOCB	LIST	COVID
lnY1	-2.292** (-2.53)	-1.797 (-0.08)	-1.672 (-1.22)	-1.573 (-1.45)
lnY2	1.523 (1.51)	1.328 (0.17)	1.570 (1.51)	1.637 (1.59)
lnY3	-1.949*** (-3.39)	-2.033 (-0.47)	-2.034*** (-2.98)	-2.077*** (-3.30)
lnw1	-3.470*** (-4.06)	-3.315 (-0.16)	-3.103*** (-3.23)	-3.060*** (-3.47)
lnw2	2.040** (2.11)	1.821 (0.07)	1.506 (1.29)	1.465 (1.38)
1/2 lny1*lny1	0.125 (1.26)	0.083 (0.03)	0.070 (0.54)	0.061 (0.57)
1/2 lny2*lny2	0.058 (0.80)	0.052 (0.44)	0.064 (0.89)	0.066 (0.92)
1/2 lny3*lny3	-0.023*** (-5.07)	-0.022 (-0.48)	-0.023*** (-4.58)	-0.024*** (-4.97)
1/2 lnw1*lnw1	0.352*** (3.98)	0.339 (1.01)	0.356*** (3.91)	0.357*** (3.96)
1/2 lnw2*lnw2	0.113*** (5.68)	0.115 (0.83)	0.117*** (4.99)	0.117*** (5.13)
lny1*lnw1	0.258*** (3.00)	0.244 (0.12)	0.230** (2.53)	0.225*** (2.61)
lny1*lnw2	-0.174* (-1.84)	-0.154 (-0.06)	-0.129 (-1.19)	-0.125 (-1.23)
lny2*lnw1	-0.039 (-.035)	-0.061 (-0.02)	-0.099 (-0.79)	-0.103 (-0.88)
lny2*lnw2	-0.033 (-0.30)	-0.009 (-0.00)	0.018 (0.16)	0.019 (0.18)
lny3*lnw1	0.020 (0.33)	0.033 (0.02)	0.048 (0.70)	0.052 (0.84)
lny3*lnw2	0.048 (0.79)	0.032 (0.02)	0.016 (0.24)	0.014 (0.21)
lny1*lny2	-0.010 (-0.09)	-0.017 (-0.01)	-0.054 (-0.46)	-0.061 (-0.55)
lny1*lny3	0.119*** (2.94)	0.129 (0.16)	0.135*** (2.77)	0.138*** (3.19)
lny2*lny3	-0.103 (-1.26)	-0.093 (-0.06)	-0.084 (-1.02)	-0.081 (-0.99)
lnw1*lnw2	0.217*** (4.53)	0.202 (0.69)	0.201*** (4.22)	0.201*** (4.22)
Constant	26.909*** (4.72)	23.984 (0.25)	23.521*** (2.90)	23.00*** (3.33)
Stability inefficiency (u)				
CSR	0.786** (2.15)	0.917 (0.09)	0.990* (1.69)	1.055** (2.29)
SQCSR	-2.098* (-1.93)	-2.459 (-0.08)	-2.732 (-1.56)	-2.911** (-2.10)
CSR *GT* LARGE	-0.009 (-0.11)			
CSR *GT* SOCB		-0.269 (-0.21)		
CSR *GT* LIST			0.041 (0.44)	
CSR *GT* COVID				0.006 (0.07)
GT	-2.400*** (-3.28)	-2.029*** (-3.49)	-2.598*** (-2.77)	-2.295*** (-3.15)
LARGE	-0.224 (-0.61)			
SIZE		0.081 (0.01)	0.203 (0.42)	0.237 (0.81)
COVID	2.155*** (2.78)	1.912 (0.42)	1.859** (2.09)	1.836** (1.96)
SOCB	-0.872** (-2.47)	-0.420 (-0.01)	-1.509 (-1.36)	-1.581** (-2.30)
LIST	-0.455** (-1.99)	-0.347 (-0.65)	-0.580 (-1.41)	-0.423* (-1.90)
BASELII	1.339*** (4.50)	1.270 (0.38)	1.293*** (3.95)	1.323*** (4.19)
CEOGEN	1.002*** (3.05)	0.996 (0.14)	1.140*** (2.79)	1.145*** (3.36)
GDP	0.378** (2.28)	0.334 (0.40)	0.325* (1.72)	0.325* (1.79)
INF	0.014 (0.58)	0.015 (0.12)	0.024 (0.82)	0.022 (0.83)
Constant	-10.678*** (-2.91)	-13.255 (-0.05)	-15.903 (-1.21)	-17.194** (-2.10)
$\gamma = \frac{\sigma_{u2}}{\sigma_{v2} + \sigma_{u2}}$	0.273***	0.264***	0.271***	0.273***
No. Obs	390	390	390	390

Note: CSR= corporate social responsibility index; CUS= corporate customer responsibility index; SHR= corporate responsibility index to shareholders; GOV= corporate responsibility index to government; SOC= corporate environmental and social responsibility index; EMP= corporate employee responsibility index; ; $CSR * GT * LARGE$, the interaction term among CSR, GT, and $LARGE$; $CSR * GT * SOCB$, the interaction term among CSR, GT, and $SOCB$; $CSR * GT * LIST$, the interaction term among CSR, GCR, and $LIST$; $CSR * GT * COVID$, the interaction term among CSR, GCR, and $COVID$; $LARGE$, a dummy variable that takes a value of 1 for a bank with total assets of of above VND 100 trillion, and 0 otherwise; *GT=Green Technology, the natural logarithm of total amount of investment in technology and software; LnTA= natural logarithm of total assets; CIR, The ratio of operating expenses to total revenue; Bomsize, Number of members of the board of directors of bank; SOCB= a dummy variable equal to 1 for state-owned commercial banks and 0 otherwise; Listed= a dummy variable equal to 1 for banks listed on the stock exchange and 0 otherwise; Basel2= a dummy variable equal to 1 for banks that have applied Basel 2 standards and 0 otherwise; Audit4= a dummy variable equal to 1 for audit reports of banks audited by the top 4 firms and 0 otherwise; CEOGen= a dummy variable equal to 1 for female bank executives and 0 otherwise; GDP= GDP growth rate in year t compared to year t-1; INF= penalty inflation rate in year t compared to year t-1;. Standard errors are in parentheses. *, ** and *** Significant at 10, 5 and 1 % levels, respectively.*

First, we examine whether this relationship might differ across bank sizes. In contrast to previous studies, in which large and small banks are defined as having assets above and below the median, respectively [34], our analysis followed the classification of State Bank of Vietnam (2018) which large and small banks are determined as those with average quarterly total assets of above and below VND 100 trillion, respectively. Therefore, we include LARGE, a dummy variable that takes the value 1 for large banks and 0 for large banks, and its interaction term, LARGE*CSR*GT, in the base model. Note that SIZE was dropped from our analysis to avoid multicollinearity. Table 8 presents a negative coefficient for LARGE*CSR*GT, indicating that larger banks get more advantages from implementing a digital strategy in comparison to smaller banks. This is due to their superior risk management and more varied revenue sources. Investing in green technology or digital software systems and adopting corporate social responsibility not only mitigates hazards but also bolsters the financial stability of the bank.

Second, we investigate whether this general effect may vary across bank ownership. The interaction terms between bank ownership (SOCB and LIST) and CSR*GT were included in the model. Table 8 shows a negative coefficient on LIST*CSR*GT, implying that listed banks with higher CSR and digitalization have a more stabilizing impact than private banks. Listed banks regularly comply with corporate governance regulations and prioritize the interests of stakeholders. As a result, listed banks demonstrate a higher level of corporate social responsibility (CSR) practices and their investments in digitalization are more valuable than those of unlisted banks [112]. Our findings do not offer sufficient evidence to suggest that listed banks have a minimal impact on the mutual impact of digitalization and CSR on bank stability. Table 8 displays a negative coefficient for LARGE*CSR*GT, suggesting that implementing a digital strategy is most beneficial for larger banks compared to smaller banks. This is due to more diverse income streams and improved risk management. Practicing corporate social responsibility (CSR) and investing in green technology or digital software systems not only minimizes risks but also improves the financial stability of banks.

Finally, when examining the impact of COVID-19 disruption, the interaction term between CSR*GT and COVID is included in our model. The coefficient of CSR*GT*COVID is negative but not statistically significant. The early development of digitalization and the inconsistent adoption of CSR across banks may not help banks overcome the negative impact of COVID-19 disruption in general.

5- Conclusion

This study investigates the impact of CSR and digitalization on bank stability efficiency in Vietnam from 2010 to 2022. Several key findings and implications are highlighted as follows. First, these findings indicate that CSR has a non-linear impact on bank stability efficiency, with a U-shaped relationship. Initially, CSR implementation may increase costs and reduce performance, but as CSR is enhanced to a higher level, it may yield long-term benefits. This is consistent with the trade-off theory, where initial CSR investments may result in high costs without immediate benefits, but in the long run, it may help improve financial stability. These findings confirm the study of Brammer & Millington (2008) [101] as well as the studies of Le & Ngo (2020b) in China and Avkiran (2011) at the country level. Furthermore, digitalization (GT) has a significant impact on reducing the stability inefficiency of banks [97]. This is consistent with previous studies such as Berger & Mester (2003) and Machkour & Abriane (2020), which found that digitalization reduces operating costs, enhances risk management capabilities, and improves long-term bank efficiency [105, 106]. This result suggests that policies to encourage banks to invest in digitalization are necessary, especially when banks face pressure to balance the short-term costs and long-term benefits of CSR. In addition, the interaction effect between CSR and digitalization suggests that when these two factors are combined, they can optimize the stability performance of banks. Digitalization not only helps reduce information asymmetries but also reinforces the long-term advantages of CSR. Policy should aim to support banks to invest in both CSR and digitalization as part of their sustainability strategy. This is consistent with the study by Forcadell et al. (2020), which asserts that the combination of CSR and digitalization can improve customer trust and reduce operational risks [1].

On the other hand, we also find mixed findings across CSR components. These findings indicate that employee responsibility (EMP) and customer responsibility (CUS) have a positive impact on stability, especially when banks have long-term commitments to these stakeholders. Policymakers and bank managers should consider investing in employee- and customer-focused CSR programs to enhance loyalty and performance. However, shareholder responsibility (SHR) and government responsibility (GOV) have an inverted U-shaped relationship with performance, implying that over-investment in these activities may result in costs that exceed benefits.

Finally, the impact of macroeconomic factors: these findings also demonstrate that macroeconomic factors such as GDP growth have a positive impact on bank stability, while inflation has a negative impact. Therefore, economic policies should be designed to maintain stable growth and control inflation to ensure stable performance of banks in the future. Although the study has provided important findings, there are still some limitations. First, the study focuses on banks in Vietnam, and the data is limited to a certain period of time. This may limit the ability to generalize the results to other banking markets, especially in countries with different economic and regulatory conditions. Extending the study to other markets could help verify the generalizability of the results. Furthermore, the research has not analyzed in detail the impact of cultural and corporate governance factors on the relationship between CSR, digitalization, and bank performance. These factors can play an important role in shaping how banks implement CSR and digitalization strategies.

6- Declarations

6-1- Data Availability Statement

The data presented in this study are available in the article.

6-2- Funding

The author received no financial support for the research, authorship, and/or publication of this article.

6-3- Institutional Review Board Statement

Not applicable.

6-4- Informed Consent Statement

Not applicable.

6-5- Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the author.

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