Research article

Does efficiency influence firm investment size? Evidence from Ghana

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ABSTRACT

Firms commit huge funds into investment in order to maintain their operational capacity, going concern, and to maximize shareholder value. This action in many instances defines the success of the firm. The question is, How do efficiency and free cash flow associate with firm investment? This paper employs fixed and random effects to answer how technical efficiency estimates using the Data Envelopment Analysis technique and free cash flow influence firm investment. The data was sourced from published annual reports of sampled listed companies.

The findings are that technically efficient firms tend to decrease firm investment. Free cash flow to the firm matters in the case of depreciation and amortization for firms. There exists a direct relationship between big size firms and firm investment. Increasing inflation and a depreciating domestic currency do not induce firm investment. The study recommends that inefficient firms must reduce their input mix to match the given level of output if they are to create value for shareholders through reduced firm investment.

This article links technical efficiency to firm investment and depreciation and amortization of listed banks and manufacturing firms and is the first of its kind on Ghana.

1. Introduction

Firms undertake investment to maximize shareholder value. Managers in creating value select from competing investments one that promises the highest net present value considering the firm's internal and external financing constraints. Managers in exercising their discretionary powers may over-invest resulting in little value addition for shareholders. Correspondingly managers may under-invest in high-value-enhancing projects which implies denying shareholders the opportunity of increasing their value. This action of managers deviates sharply from firm investment efficiency and the shareholder value-maximizing principle.

The free cash flow proposition by Jensen (1986) lends credence to this value destroying behavior of managers. The evidence from Germany, Canada, Spain, France, Italy, the UK and the USA, in Lopez-Gutierrez et al. (2015), is that in a financially distressed situation, firm investment varies according to the investment opportunities available to companies. In such situations, companies in difficulties with fewer opportunities have the greatest propensity to underinvest, while firms in difficulties with better opportunities do not present different investment behavior than healthy companies. Danso et al. (2019) makes the case that market sentiments drive corporate investment decision, adding that financial flexibility induces managers to overinvest, while the expectation of future profitability leads firms to underinvest during high sentiment periods. This investment behavior of management is a result of a poor understanding of the capital market.

The free cash flow hypothesis posits that when firms have distributable profit, there is a high likelihood that managers would expropriate value to themselves through valueless projects. This is achieved by pursuing projects with negative net present values, as shareholders bear the cost while managers benefit from such pursuits (Zhang et al., 2016).

Where ownership is separated from control, the classical agency problem manifests, a situation that gives managers (agents) the incentive to pursue their value-enhancing objective against the interest of the shareholders (principal). From the Jensen and Meckling (1976) agency theory, the agent who has control over the firm's resources pursues their interest at the expense of the principal. This behavior of the agent in this corporate setting is evident in empire building, perquisites, overconfidence, herding behavior, and short-termism (Jensen, 1986; Malmendier and Tate, 2005).

Embedded in the firm value creation is efficiency, where the selection and execution of successful projects ride on the efficient allocation of firm resources. Firm investment is in two kinds: real investment, which is investing in tangible assets, and intangible assets. Tangible assets include new plants, equipment, and new products among others, otherwise...
referred to as a capital investment. The intangible assets include trademarks, patents, and goodwill among others. These investments are expected to enhance the firm’s cash flows over the long-term. The other kind of firm investment is a financial investment, which is investment in long-term financial instruments, such as bonds and shares, or in short-term instruments such as treasury bills and commercial papers. Compared to financial investment, real investment involves huge capital outlays and tends to easily influence firms’ success or failure, hence the interest of this study. In the selection of firm investment, managerial expertise, that is technical efficiency, is brought to bear. The expectation is that managers who are technically efficient would execute projects deploying the least resources for a given level of output or maximize output for a given level of input. Aside from the internal resource management in the firm investment value creation nexus, Naeman and Li (2019) posits that financial development influences corporate investment efficiency, adding that a positive relationship exists between financial development and corporate investment efficiency.

Some studies have made the case that financial factors and firm-specific factors matter in firm investment. The evidence from non-financial Nigerian firms is that firm-specific factors (specifically firm cash flow) are significant and positively related to corporate investment (Aijide, 2017). According to Love and Zicchino (2006), in countries with less developed financial systems, the impact of financial constraint on firm investment is significant. Ahiodorme et al. (2018) contends that in a dynamic market condition, listed firms in Ghana possess an advantage as they have lower financing constraints resulting in lower investment cash flow sensitivities whereas firms with high debt holdings have positive sensitivity of investment with internal funds.

Although the extant literature has investigated firm investment decisions, empirical evidence on technical efficiency on firm investment is in dearth particularly from a frontier market perspective. The literature review study by Gao and Yu (2020) focuses on the measurement of investment particularly from a frontier market perspective. The literature presents the results and discussion, while the conclusion and recommendations are presented in Section 5.

2. Related literature

2.1. Theoretical review

The neoclassical view of firm investment is that firms exist to maximize value from investment projects subject to some constraints; hence, the firm pursues positive net present value projects. The theoretical works on firm investment in the literature can be traced to the works of Keynes (1936) on private and public investment within an economy. According to Keynes, firm investment is determined by the marginal efficiency of capital. Firms rank and select projects with the highest marginal efficiency of capital above interest rate. This theory of firm investment does not make room for adjustment cost. The neoclassical theory of optimal capital accumulation view of investment by Jorgensen (1963) maintains that the main constraint of firms in undertaking investment activities is the cost of capital. In a lower cost of capital environment, firms undertake large capital investment compared to a higher cost of capital environment. The Tobin’s average q developed by James Tobin in 1970 defines the market value of a company as the ratio of the market value to the capital of the firm, implying that the value of a company can be estimated by its replacement cost, which is its investment in a physical asset. In the Tobin’s q framework, the firm investment is optimal when the marginal rate of adjustment cost of investment equals the marginal rate of installed capital, that is the ‘marginal q’. Empirically, Dong et al. (2007) sought to provide answers to whether and why misvaluation affects firm investment by comparing tangible and intangible investments; they opined that capital and especially R&D expenditures increase with overpricing in overvalued firms. The misvaluation of firms, from their work, affects investment directly and through equity issuance.

The cash flow model by Fazzari et al. (1988) is that the cash flows of a firm have significant influence on firm investment. The availability of cash flow for investment is what Jensen (1986) captioned the free cash flow problem, where managers pursue firm expansion through empire building which creates little value for shareholders. Using Tobin’s q as firm investment, Fazzari et al. (1988) indicated that cash flow and internally generated funds tend to have a bigger effect on the investment of firms more likely to face financial constraints due to information asymmetry in the capital market. The pecking order theory by Myers (1984) postulated that firms have a preferred order in financing firm investment. In using the pecking order theory firms rank financing choices, retained earnings is the first option because it costs less for the firm. The next option is debt, which has a tax shield advantage but comes with bankruptcy exposures. Equity financing is the least preferred because of the offering cost, the information signaling effect, and the dilution of ownership effect.

Another dominant firm investment theory is the accelerator theory of investment by Chenery (1952) which opined that firm investment is dependent on the level of demand that the firm must satisfy. This view is from the fact that as income increases in an economy, the demand for goods and services produced by the firm also increases. Hence, the firm must increase its capital investment to increase output that will satisfy the increase in demand for its goods. There are two variants of the accelerator theory of firm investment: the simple accelerator and the flexible accelerator theory of firm investment. On how money, that is cost of funds at the macro level, influences firm investment, the financial accelerator model in Bernanke et al. (1999) shows that changes in credit market conditions cause swings in the financial position of small firms, which then affects their ability to undertake capital investment.

In the market structure context, Modigliani and Miller (1958) proffered the perfect-capital-market hypothesis, holding that in frictionless markets, the funding structure of a firm’s investment, be it from internal or external sources, does not affect the value of the firm. The financial performance of the firm and the cost of capital are what influence the size of firm investment. The empirical evidence on capital investment in Danao et al. (2019) is that financial market condition drives corporate investment decisions. They contend that financial flexibility induces managers to overinvest. In addition, the expectation of future profitability leads firms to underinvest during high market sentiment periods. Martinez-Carrascal and Ferrando (2008) averred that for non-financial corporations in Belgium, Germany, France, Italy, the Netherlands and Spain, capital structure is crucial in explaining firm investments. They further reported that financial pressures emanating from firm cash flow, indebtedness, and debt burden determine firm investment dynamics.
The agency theory on firm investment decision holds that managers, who are agents of shareholders, will rationalize the investment making process and pursue capital investment options that maximize their utility (Simon 1955; Shapiro 2005). The shareholder value maximization drive coupled with the agency problem blurs the efficiency in the deployment of the firm’s financial resources. This creates a fertile ground for suboptimal investment for firms, a position at variance with Hayashi (1982), who opined that firm investment must be a positive addition to firm value to warrant the commitment of firm resources. Other strands of literature on firm investment decision extend into the corporate governance literature. This is not too surprising as the huge capital outlays in firm investment are strategic decisions that heavily define a firm’s success. According to the Jensen (1986) free cash flow hypothesis, managers of firms that have internal funds prefer to invest regardless of the viability of the project. In doing so, they expose shareholders’ funds to negative returns for the sake of managerial compensation. When presented with free cash flow, managers are tempted to expand their firm by undertaking capital investment with the argument of creating more value for shareholders. This, from the free cash flow hypothesis, does not lead to value creation for owners of the firm, as managers undertake inefficient investment to the detriment of the owners. Empirically, Yeo (2018) revealed that free cash flow is a determinant of firm investment and dividend decision, to the extent that greater free cash flow leads firms to increase investment and reduce dividends for shareholders. In Dogru et al. (2020), firms with high free cash flow reported lower return compared to firms with low free cash flows in the restaurant industry. They conclude that external growth through acquisition exposes firms to overinvestment problems, hence less value for shareholders as results of inefficiency in firm investment. With the evidence from these studies, free cash flow usage aside from dividend payment can be a conduit for firm resource wastage by managers; hence, how it relates to the size of capital investment of firms deserves research inquiry.

Due to the dynamic nature of firm environment, the static neo-classical models of firm investment create restrictive sets of assumptions that do not provide real world firm investment behavior. The Euler equation model of firm investment attempts to resolve the restrictive, static, one period assumption, and considers firm investment in an intertemporal dynamic framework. In the Euler firm investment framework, managers must consider the current investment needs of the firm and that of the future, in addition to timing the financial market for capital to undertake investments. In this model, firm investment is optimal when the marginal cost of investing today equal the marginal cost of waiting to invest tomorrow. For firms operating in countries with low financial development, the changes in the cost of capital are double in magnitude compared to firms operating in countries with average level financial development. Črnić and Verbić (2014) deployed an error-correction model and the Euler-equation specification, and provide evidence that firm investment is determined by financial constraints during a financial crisis. They note that the financial constraints of the 2008 global financial crisis were severe for both financially constrained and financially unconstrained firms, with the capital investment of financially constrained firms in Slovenia severely affected during the crisis.

The real option theory of firm investment posits that firms can access the embedded conditions that surround an investment decision. This theory is another dynamic model compared to the static neoclassical model. In the real option theory of firm investment, managers can assess the value of an investment by considering the timing, that is, the benefit to delay the investment. The timing benefits help the firm to measure the riskiness of the investment and secure the investment from the premium paid to secure the project. A fair assessment of these factors then influences the firms’ decision to invest or not.

Clearly, the financial commitment to capital investment is enormous, and with the premise of maintaining the going concern, managers are motivated to undertake these investments. What is noticeable is that firm investment behavior is not too different from individual investor behavior. The expected utility theory, which describes the expected behavior of individuals in maximizing their benefits in the presence of risk and preferences, is the same behavior that comes into play when managers consider firm investment decisions. This behavior is in sharp contrast with the narrow profit maximization stance, which claims that firms underinvest because they desire to increase profit. For Kahneman and Tversky (1979), firm investment fits perfectly into the prospect theory, in that in a sure gain investment situation, firm managers are risk-averse; however, when facing losses managers exhibit risk-seeking investment behavior with the expectation of reducing firm losses. In an experiment on finance professionals, Pikulina et al. (2017) found that managers who exhibit strong overconfidence engage in excess investment. Those who portray underconfidence underinvest, whereas moderate overconfidence leads to accurate investments.

Concerning firm investment and efficiency, Naem and Li (2019) provided evidence on non-financial firms in 35 OECD member countries that point to the fact that financial development has a direct impact on corporate investment. Specifically, they mentioned that a one-standard-deviation increase in financial development leads to investment efficiency by 0.423 percent for underinvesting firms. They also posited that for firms that are overinvesting, a reduction of 0.902 percent of corporate investment can lead to a reduction of agency problems to achieve efficiency. Comparing how the nature of financial development affects firm investment efficiency, Love (2003) posited that financial development affects growth by reducing financing constraints that would otherwise distort the efficient allocation of investment. For market power and corporate investment, Chortareas et al. (2021) used data from listed firms in South Africa to examine the role of firms’ market power in affecting the link between firm-specific uncertainty and corporate investment decisions. They found that corporate investment of firms with low market power and market share responds positively to idiosyncratic uncertainty. On the other hand, they contend that a high degree of market power, however, moderates this positive relationship, allowing for delayed investment under conditions of uncertainty in order to avoid wasting firm investable funds.

From the theoretical and empirical perspectives, firm investment, if properly executed, helps the firm achieve its goal. Figure 1 is the conceptual framework developed from the theoretical and empirical works on firm investment. In this framework, managers of a firm would purchase inputs to generate output. The process of turning these inputs into outputs is the technical efficiency. The method to measure this efficiency is the DEA technique.

The efficiency level, from this framework, affects the level of firm investment and annual capital consumption captured in depreciation and amortization. In addition, firm investment is influenced by some internal and external factors as well as prior year profit. Firm profitability is important in the investment efficiency nexus because these investments are expected to improve profits, and efficiency is also expected to impact profitability. The level of previous year profit is expected to influence firm investment.

The plethora of theoretical postulations and empirical evidence on corporate investment provides different conclusions on how efficiency relates to firm investment. Despite these mixed evidence on capital investment, firms continue to undertake these investments to maintain their operational capacity and their going concern. This paper is based on the agency theory and the free cash flow hypothesis. The free cash flow hypothesis considers the role of free cash flow in determining the firm’s decision to invest. However, the presence of free cash flow also provides a fertile ground for managers to undertake valueless investment by pursuing projects that benefit managers but at the expense of shareholders. The knowledge set to turn inputs into outputs is critical if the firm is to avoid wastage, hence technical efficiency. How to manage the firm investment-efficiency nexus is indeed a challenging area for shareholders and managers alike in the presence of firm goal-incongruence. The gap that this research seeks to fill is how...
technical efficiency and free cash flow associate with firm investment for listed banking and manufacturing firms in Ghana.

3. Methodology

3.1. Data and sample

For firms to generate revenue, be profitable and increase shareholder value, managers undertake investment through which they deploy their managerial skills. This paper makes use of listed firms on the GSE with data spanning from 2012 to 2019. We agree in general that firms both listed and unlisted engage in investment decisions. However, subject to data availability, listed firms were preferred to the unlisted ones. The decision to use listed firms is supported by French et al. (2021) that listed firms tend to engage more in capital investment than unlisted firms. Data was collected from the published annual reports of sampled firms on the GSE. The GSE was officially launched in 1991, although trading had started in 1990. As of the end of the year 2019, there were 40 listed firms on the GSE; the sectoral distribution was Finance 11 of which 8 are banks and 3 are insurance companies, Distribution 4, Food and Beverage 5, ICT 2, Insurance 2, Manufacturing 8, Mining 4, Agriculture 1, Education 1, Exchange Trade Fund 1, and Advertisement and Production 1. The few number of banks and manufacturing firms listed on the GSE sampled for this paper limits the extent of robust estimations; nonetheless, the test on the data conducted meets the standard minimum procedure for the results generated. We therefore treat our results as associations and not causality to deal with plausible endogeneity that may exist between the predictor variables and the error term in the models. The GSE market summary statistics as at the end of the year 2019 revealed that the GSE Composite Index was 2,257.15 and that the GSE Financial Stock Index was 2,019.65. The market capitalization was Ghs 56,791.28 million ($11,587.69 million) with a domestic market capitalization of Ghs 22,681.98 million ($4628.03 million).

In measuring firm efficiency, the extant literature posits two major strands, the parametric application technique such as the stochastic frontier analysis and the non-parametric Data Envelopment Analysis (DEA) estimation technique. The DEA is a non-parametric mathematical linear programming technique that measures efficiency levels of homogenous production units called Decision Making Units (DMUs). In the DEA programming the same set of inputs and outputs are specified for the DMUs. One advantage of the DEA technique is that it does not require the specification of the production frontiers compared to the parametric efficiency models. According to Svitalkova (2014), the DEA technique permits the estimation of efficiency using inputs and outputs measured at different measurement scales. Furthermore, the DEA technique identifies efficient firms, which become performance benchmarks for inefficient firms (Aggelopoulos and Georgopoulos, 2017).

The approach adopted in this paper follows a two-stage method. First, the paper estimates technical efficiency for all sampled firms using the DEA technique. Secondly, these efficiency scores are used as the variables of interest to predict firm investment. The variables include firm-specific variables from the annual reports published by the sampled firms. The variables are firm investment, total assets, dividend payout, free cash flow to the firm, capital investment, return on equity, firm investment consumed captured as depreciation and amortization, intermediation, technical efficiency, equity to assets, and external variables, mainly the macroeconomic variables such as inflation, lending rates, exchange rate, and Gross Domestic Product (GDP) growth.

3.2. Model specification and estimation strategy

3.2.1. Measuring technical and cost efficiencies: the DEA approach

To achieve the stated objective, first the technical efficiency was estimated using the DEA technique. The input-oriented DEA with variable returns to scale (VRS) suggested by Banker, Charnes, and Cooper (1984) was used to measure technical efficiency (TE). TE reveals how well managers deploy resources to produce a certain level of output. In the TE estimation, to achieve efficiency, the input is minimized subject to a given level of output. The input-oriented DEA technique is a linear programming model, which presents TE as:

$$
\begin{align*}
\text{Min} & \quad \theta' = \theta \\
\text{s.t.} & \quad \theta X_{it} \geq \sum_{j=1}^{m} a_j Y_{jt} \quad (i = 1, \ldots, n) \\
& \quad Y_{it} \leq \sum_{j=1}^{m} a_j Y_{jt} \quad (s = 1, \ldots, r) \\
& \quad \sum_{j=1}^{m} a_j = 1, \\
& \quad a_j \geq 0
\end{align*}
$$

Eq. (1) is the generic specification for TE. In this paper, $a$ is a $N \times 1$ vector of weights that sums up to 1; $X$ and $Y$ are the $n \times m$ input and $r \times m$ output matrices, respectively; $j = 1, \ldots, m$ denotes the number of decision-making units (DMU) in each industry classification; $\theta$ is a scalar which represents the technical efficiency score for each DMU $j$ and ranges from 0 to 1, with a score of 1 implying full efficiency; $i = 1, \ldots, n$ denotes the number of inputs; and $s = 1, \ldots, r$ denotes the number of outputs. Due to data availability, 8 banks on the GSE are represented in the sample while 5 out of the 8 manufacturing companies are used for this study. In the DEA estimation, the DMU must be homogenous, and to this end the study use the industry classification adopted by the GSE for the classification of...
banks and manufacturing companies. In the second stage, these efficiency estimates from Eq. (1) is used as an explanatory variable to determine firm investment size. The following panel regression model was estimated,

\[
FIRM \text{ INVEST}_{it} = \beta_1 \theta_{i} + \beta_2 \sum_{t=1}^{n} \text{Firm Factors}_{it} + \beta_3 \sum_{t=1}^{n} \text{Macro}_{it} + \epsilon_{it}
\]  
(2)

\[
FIRM \text{ INVEST}_{it} = \beta_1 \theta_{i} + \beta_2 \text{ROE}_{t-1,i} + \beta_3 \sum_{t=1}^{n} \text{Firm Factors}_{it} + \beta_4 \sum_{t=1}^{n} \text{Macro}_{it} + \epsilon_{it}
\]  
(3)

From the empirical model, Eq. (2), \(FIRM \text{ INVEST}_{it}\), is firm investment size, where \(\theta_{i}\) is the estimated TE derived from the input-oriented VRS DEA. \(\text{Firm Factors}\) is a vector of firm-specific characteristic or internal variables under the control of management, and \(\text{Macro}\) is a set of macroeconomics variables, which are external to the firm. \(\epsilon_{it}\) is the error term, and the subscripts \(i\) and \(t\) represent the individual firm and time, respectively. The details of the firm-specific and macroeconomic variables are presented in Table 1. Eq. (3) is the lagged independent model as we posit that current period profit should influence next period capital investment. In this study, lagged Return on Equity (ROE) is used to measure the profitability of the firm. The econometric reason is that there exists a long run (one period) impact of prior period profitability (ROE) on firm investment.

This study adopts two measures of \(FIRM \text{ INVEST}_{it}\). The first measure is firm investment as captured in the cash flow from the investment section of the statement of cash flow which includes plant, property, and equipment as well as intangible assets purchased for the year to measure of firm investment. Secondly, the sum of depreciation and amortization in the statement of profit or loss is used as a proxy for the replacement of the non-current asset. The use of these two measures of firm investment adds to the robustness of our model. Further, the use of natural logs was to capture the size of firm investment, size of depreciation and amortization because of the wide variation and outliers to normalize the variable.

We measure free cash flow for the firm to all providers of capital is estimated as,

\[
\text{FCF}_{it} = \sum_{t} EBIT_{it}(1 - \text{Tax})((1 - \text{Tax})_{it} + \text{DEP}_{it} + \text{AMORT}_{it}) - \text{NET CAPEX}_{it} - \text{INWC}_{it}
\]  
(4)

In Eq. (4), \(\text{FCF}_{it}\) is free cash flow to the firm for all capital providers, \(\text{EBIT}\) is earnings before interest and Tax, \(\text{Tax}\) is corporate Tax, \(\text{DEP}\) is depreciation, \(\text{AMORT}\) is amortization, \(\text{NET CAPEX}\) is net firm investment, and \(\text{INWC}\) is the increase in working capital in the case of manufacturing firms. To estimate free cash flow for banks, net interest income (NII) is used in place of \(\text{INWC}\) because banks by nature do not classify their assets and liabilities into current and non-current, hence any attempt to estimate bank working capital might be misleading for this study.

Table 1 is the description of the variables used in this paper; how the variables were measured, the expected sign for each variable and the source of the variables are also presented. \(\text{AFS}\) is annual financial statement.

This study specifically hypothesizes the following:

**H1.** Technical efficiency has a negative and a statistically significant association with firm investment.

**H2.** Free cash flow has a positive effect on firm investment.

4. Results

Panel A of Table 2 is the descriptive statistics for Banks. The size of firm investment range between 6.379 and 8.332 with a variation of 0.444 and a mean of 7.318. The size of depreciation and amortization was from a low of 6.43 to a high of 8.15 with a variation of 0.414 and a mean of 7.24. The mean value of technical efficiency was 0.987 with a variation of 0.053, and the range of efficiency was 0.675–1. Table 6 provides additional details of the technical efficiency scores for the period 2012 to 2019. Free cash flow to assets had a mean of 12.582, with minimum and maximum values of 2.387 and 30.876, respectively.

In Panel B of Table 2, the descriptive statistics for manufacturing companies have the variation in size of firm investment to be 0.791, with a range of values of 4.929 minimum and a maximum of 7.785 with a mean value of 6.207. In the case of the size of depreciation and amortization, the variation is 0.49, with a mean of 5.93. The lowest
The highest correlation value is between technical efficiency and free cash flow to assets 0.657. The VIF Test score of 1.62 in Table 5 indicates that multicollinearity is not high among the independent variables.

The regressions results presented in Table 4 show that the prescribed model is the Random Effect (RE); this was inferred from the Hausman’s test value of 0.9542, 0.4002 and 0.5305 for column 2, 4 and 5, respectively. Furthermore, our justification for the RE is in line with Torres-Reyna (2007) that differences across firms have some influence on firm investment hence the RE model. The R-Square overall of the model explains the variation in the size of firm investment undertaken by banks to be 0.5682, 0.5893 and 0.4663 for RE models. The choice for the fixed effect (FE) model, column 3, is due to the Hausman’s test value of 0.0000. The R-square within is 0.5053, and this shows the variation in firm investment accounted for by the independent variables in the model. These values of R-square are attributable to data availability, a constraint beyond the authors of this paper since there are 8 banks listed on the GSE. This few number of banks also limits the extent of robust estimations. We therefore treat our results as associations and not causality to deal with plausible endogeneity that may exist between the predictor variables and the error term in the models. The Wald $\chi^2$ value of 86.87, 226.46 and 24.84 has an associated probability $W_2$ value of 0.0000 for the RE models. These probability $W_2$ imply that the overall models are significant in explaining firm investment and depreciation and amortization.

The results in Table 4 show that intermediation has a positive association with the capital investment of banks, and that a unit increase in bank ability to create loans out of deposit results in a 0.0046 percentage increase in firm investment of the sampled banks. Furthermore, bank size has a positive coefficient and is a statistically significant association with firm investment, and a unit increase in bank size results in a 1.3823 percent increase in the size of firm investment, holding all the other independent variables constant. With respect to intermediation, the inference is that banks that create more loans out of deposit engage in high size firm investment. Specially, a one percent increase in bank intermediation associates with a marginal 0.0046 percent increase in firm investment, holding all the other independent variables constant. Technical efficiency is statistically significant and has a negative coefficient with the size of firm investment. This implies that an improvement in bank’s ability to use the least amount of input to generate outputs associates with a reduction in the size of firm investment by 1.4688 percent, holding all the other predictor variables constant.

From the macroeconomic variables, a one percent increase in inflation, implies a statistically significant and direct influence on the size of firm investment by 0.0345 percent. This confirms the economic reasoning that, as general prices increase, firm investment is mostly likely to increase hence the positive relation. The free cash flow to assets has a negative and statistically insignificant relation in determining the size of firm investment in column 2. In column 2 of Table 4 the only addition to the variables that is statistically significant is free cash flow to assets. The inference is that a one unit increase in free cash flow to asset associates with a reduction in capital investment by 0.06 percentage. Furthermore, in column 2, the results show that the change in the next period’s firm investment has a direct relation with current period profit, albeit insignificant. A unit change in the current period profit measured by Lag Return of Equity associates with a 0.0032 percent increase firm investment for the next period in the sampled banks.

In column 4 of Table 4, where depreciation and amortization is the dependent variable, dividend payout has a negative and statistically significant relation with size of depreciation and amortization. This is because a one percent increase in dividend paid out to shareholders results in a 0.0015 and 0.0014 percent decline of funds to be set aside for depreciation and amortization in the year, holding all the other independent variables constant. The cash flow reason is that banks that pay a high dividend to shareholders have fewer funds available to undertake firm investment through the non-movement of cash item such as depreciation and amortization. It is plausible that the funds saved from

depreciation and amortization in a year was 5.092 with the highest value of 7.11 percent. The variation in technical efficiency over the sample period is 0.144 with a mean of 0.93, and the efficiency score ranged from 0.305 to 1. Table 7 provides details of the technical efficiency scores over the period 2012 to 2019. The free cash flow to asset was -382.296 on average and hovered between a low of –2,730.52 and 191.261 maximum.

4.1. Correlation

From the correlation Table 3 Panel A, the variables in the regression model estimated for banks show no evidence of multicollinearity. The highest correlation value of 0.796 is observed between GDP growth and inflation. To test for evidence of multicollinearity, the Variance Inflation Factor (VIF) test was conducted. The mean VIF of 2.71 in Table 4 provides no evidence of multicollinearity in that the VIF value is not high among the independent variables.

In Panel B of Table 3, the correlation values of variables in the manufacturing company model, there is a very low level of correlation.

Table 2. Descriptive statistics.

| Variable                  | Obs | Mean  | Std. Dev. | Min  | Max  |
|---------------------------|-----|-------|-----------|------|------|
| **Panel A: Bank**         |     |       |           |      |      |
| Size Firm Investment      | 64  | 7.378 | .444      | 6.379| 8.332|
| Size Dep and Amort        | 64  | 7.24  | .414      | 6.43 | 8.153|
| Return of Equity          | 64  | 20.099| 15.931    | 27.351| 47.734|
| Dividend Payout           | 64  | 19.475| 25.333    | 45.47 | 77.58 |
| Bank Size                 | 64  | 9.524 | .315      | 8.766 | 10.265|
| Intermediation            | 64  | 63.823| 22.586    | 31.819| 124.693|
| Free Cash Flow to Assets  | 64  | 12.582| 6.75      | 2.387 | 30.876|
| Capital Expenditure       | 64  | 39107813| 42658401| 2400000 | 2.100e+08|
| Total Assets              | 64  | 6.207 | .791      | 4.929 | 7.785 |
| Free Cash Flow to Assets  | 64  | 4.713e+08| 3.704e+08| 6500000 | 1.500e+09|
| Technical Efficiency      | 64  | .987  | .053      | .675  | 1    |
| **Panel B: Manufacturing Companies** |     |       |           |      |      |
| Size Firm Investment      | 40  | 6.207 | .791      | 4.929 | 7.785 |
| Size Dep and Amort        | 40  | 5.93  | .49       | 5.092 | 7.11  |
| Dividend Payout           | 40  | 26.752| 68.568    | 42.29 | 327.889|
| Equity to Assets          | 40  | 28.433| 15.183    | 23.186| 52.541|
| Free Cashflow             | 40  | -78709914| 95172104| -3.700e+08| 7200000 |
| Free Cashflow to Assets   | 40  | -382.296| 790.374 | -2730.52| 191.261|
| Company Size              | 40  | 7.61  | .802      | 6.422 | 8.861 |
| Return on Equity          | 40  | -9.549| 93.941    | -412.319| 81.215|
| Technical Efficiency      | 40  | .93   | .144      | .305  | 1    |
| Capital Expenditure       | 40  | 6957405| 12228039| 84934 | 61000000|
| Total Assets              | 40  | 1.273e+08| 1.567e+08| 2600000 | 7.300e+08|
| Lending Rate              | 40  | 26.381| 1.659     | 23.555| 28.623|
| Inflation                 | 64  | 12.03 | 4.114     | 7.126 | 17.455|
| Exchange Rate             | 40  | 3.56  | 1.161     | 1.825 | 5.217 |
| GDP Growth                | 40  | 5.751 | 2.471     | 2.18  | 9.29  |
Table 3. Correlation matrix for the variables.

| Variables       | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Panel A: Bank   |     |     |     |     |     |     |     |     |     |
| (1) Dividend Payout | 1.000 |     |     |     |     |     |     |     |     |
| (2) Bank Size   | 0.145 | 1.000 |     |     |     |     |     |     |     |
| (3) Intermediation | 0.061 | -0.501 | 1.000 |     |     |     |     |     |     |
| (4) Free Cash flow to Assets | 0.401 | 0.373 | 0.128 | 1.000 |     |     |     |     |     |
| (5) Return on Equity | 0.429 | 0.150 | 0.055 | 0.615 | 1.000 |     |     |     |     |
| (6) Technical Efficiency | -0.163 | 0.278 | -0.048 | 0.047 | -0.036 | 1.000 |     |     |     |
| (7) Exchange Rate | -0.179 | 0.699 | -0.464 | -0.125 | -0.312 | 0.331 | 1.000 |     |     |
| (8) Inflation | 0.124 | -0.108 | 0.164 | 0.102 | 0.053 | 0.147 | -0.070 | 1.000 |     |
| (9) GDP Growth | 0.004 | -0.102 | -0.127 | -0.065 | 0.048 | -0.227 | -0.199 | -0.796 | 1.000 |
| Panel B: Manufacturing |     |     |     |     |     |     |     |     |     |
| (1) Dividend Payout | 1.000 |     |     |     |     |     |     |     |     |
| (2) Equity to Total Assets | -0.044 | 1.000 |     |     |     |     |     |     |     |
| (3) Free Cash flow to Assets | 0.186 | -0.163 | 1.000 |     |     |     |     |     |     |
| (4) Company Size | -0.189 | 0.071 | -0.396 | 1.000 |     |     |     |     |     |
| (5) Return on Equity | 0.189 | 0.447 | -0.011 | 0.051 | 1.000 |     |     |     |     |
| (6) Technical Efficiency | 0.179 | -0.097 | 0.657 | -0.253 | 0.064 | 1.000 |     |     |     |
| (7) Exchange Rate | -0.284 | -0.171 | -0.031 | 0.138 | -0.376 | 0.080 | 1.000 |     |     |
| (8) GDP | 0.237 | 0.007 | 0.031 | -0.044 | -0.084 | -0.113 | -0.199 | 1.000 |     |
| (9) Lending Rate | -0.070 | 0.221 | -0.081 | -0.020 | 0.393 | 0.045 | -0.291 | -0.556 | 1.000 |

Regression: Banks.

Table 4. Bank Regression estimates.

| Variables       | RE Firm Investment | RE Firm Investment | Dep and Amort | Dep and Amort |
|-----------------|-------------------|-------------------|---------------|---------------|
| Free Cash flow to Assets | -.0048 | -.006* | .0012 | .0002 |
| Dividend Payout | -.021 | -.0025 | -.015* | -.0014* |
| Intermediation | .0046* | .0042 | .001 | .0002** |
| Bank Size | 1.3823*** | 1.8833*** | 1.0277*** | 0.8926*** |
| Technical Efficiency | -1.4688** | -2.0113*** | -.294 | .4488 |
| Exchange Rate | -.0185 | -.0685 | .0072 | .0449 |
| Inflation | .0345*** | .0468* | -.0002 | -.0007 |
| GDP Growth | .0222 | .0298 | .0126 | .0164 |
| Lag Return on Equity | .0032 | .0014 |
| Constant | -5.0043* | -9.2953* | -2.9849* | -2.0968 |
| Hausman | 0.9542 | 0.0000 | 0.4002 | 0.5305 |
| R-Square within | 0.5035 | 0.5035 |
| R-Square overall | 0.5682 | 0.5983 | 0.4165 |
| Wald χ² | 86.87 | 262.46 | 24.84 |
| Prob > χ² | 0.0000 | 0.0000 | 0.0000 |
| Mean VIF | 2.73 | 2.73 | 2.73 | 2.73 |
| Observations | 64 | 56 | 64 | 56 |
| R-squared | .5035 | .5035 | .8514 |

Standard errors are in parentheses: **p < .01, *p < .05, p < .1. RE is Random Effect Model, FE is Fixed Effect Model.

Table 5. Manufacturing Companies Regression estimates.

| Variables       | FE Firm Investment | FE Firm Investment | Dep and Amort | Dep and Amort |
|-----------------|-------------------|-------------------|---------------|---------------|
| Free Cash flow to Assets | .0001 | -.0001 | -.0002** | -.0001 |
| Equity to Assets | .0095 | .009 | -.0062** | -.0071** |
| Dividend Payout | -.0007 | -.0008 | .0003 | .0006 |
| Company Size | 1.5258*** | 1.6451*** | .3388*** | .3699*** |
| Technical Efficiency | -.9134** | 1.5811** | -.9542** | -.1652** |
| Lending Rate | -.0959 | -.1002 | .0177 | .0157 |
| Exchange Rate | -.3116** | -.298* | -.0152 | -.0124 |
| GDP Growth | -.0505 | -.0562 | -.0068 | -.0051 |
| Lag Return on Equity | .0002 | .0007 |
| Constant | -.8498 | -4.0745 | 3.9659*** | 4.4774*** |
| Hausman | 0.0863 | 0.0000 | 0.9998 | 0.9878 |
| R-Square within | 0.4095 | 0.4644 |
| R-Square overall | 0.5682 | 0.4644 |
| Wald χ² | 97.97 | 97.54 |
| Prob > χ² | 0.0000 | 0.0000 |
| Mean VIF | 1.66 | 1.66 | 1.66 | 1.66 |
| Observations | 40 | 35 | 40 | 35 |

Standard errors are in parentheses: **p < .01, *p < .05, p < .1. FE is Fixed Effect Model, RE is Random Effect Model.

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depreciation and amortization in the cash flow from operations used to pay dividends, hence it has no effect on depreciation and amortization. Bank size has a statistically significant and positive relation with depreciation and amortization; bigger banks tend to have higher depreciation and amortization values. This is not surprising as big size operations demand large size firm investment which leads to high depreciation and amortization charge. The result on bank size is that a unit increase in big size results in a 1.0277 and 0.8926 percent increase in depreciation and amortization, holding all the other independent variables constant. In column 4 and 5 of Table 4, the coefficient of technical efficiency is positive and statistically insignificant in influencing the size of depreciation and amortization. This is the opposite in the case of firm investment model; perhaps the long-term nature of capital investment and the short-term operational nature of depreciation and amortization may be contributing to this reversal in the coefficient of technical efficiency in the bank regression model. A detailed investigation as to why this is so is beyond the scope of this paper. In the case of profits, the prior period's return on equity has a negative and statistically insignificant effect on the next period's depreciation and amortization. The free cash flow to assets has a positive coefficient with depreciation and amortization; however, this is statistically insignificant in both columns 4 and 5 of Table 4. From the results there is evidence in Table 4 to support hypothesis 1 that there exists a negative and significant association between technical efficiency and the size of firm investment in columns 2 and 3; however there is no such evidence in the case of columns 4 and 5. Furthermore, there is evidence in support of hypothesis 2 that free cash flow has a positive effect on firm investment, in columns 4 and 5.

5. Regression: manufacturing companies

The Hausman's test value of 0.0063 and 0.0000 implies that a Fixed Effect (FE) model is preferred in estimating the firm investment in columns 2 and 3 of Table 5. The FE model as predicted by Torres-Reyna (2007) helps to assess the net effect of the independent variables on firm investment, by removing the time-invariant characteristics in the model. To correct for the heteroskedasticity problem, the fixed effect robust that was estimated is employed. The R-square within which captures the variation within the dependent variables is 0.4095 and 0.4644. In columns 4 and 5 the random effect is estimated because of the Hausman's test values of 0.9998 and 0.9878; the Wald χ2 values are 97.97 and 97.54, respectively. The R-square overall among the variables used in columns 4 and 5 in Table 5 is 0.7596 and 0.7960, respectively, whiles the overall R-square average is 0.5904.

From the regression results in Table 5, in reference to column 2, the factors that influence firm investment include company size, the evidence being that a percentage increase in the size of sampled manufacturing companies results in a 1.528 percent increase in the size of firm investment, holding all independent variables constant. Technical efficiency has an inverse relation with firm investment; this implies that the more technically efficient a manufacturing company is, the smaller the size of its firm investment. A unit increase in technical efficiency associates with a 0.9134 percentage decline in the size of firm investment, holding other predictor variables constant. Free cash flow to assets is positive but statistically insignificant in influencing the size of firm investment for manufacturing firms. The exchange rate between the local currency Ghana Cedi and the US Dollars exhibits negative relations, and a unit decrease in the value of the domestic currency against the US dollar associates with a 0.3116 percent decline in firm investment, holding all explanatory variables constant. The fact that most of the inputs of these investments are imported best explains this relation. In column 3 of Table 5, company size and exchange rate are statistically significant and have the same nature of coefficient in explaining the size of firm investment. However, when the current period return on equity is considered, the coefficient between technical efficiency and the size of firm investment becomes positive, implying that technically efficient manufacturing companies tend to pursue increase firm investment. Free cash flow to assets has a negative coefficient and is statistically insignificant in column 3 of Table 5.

From the RE model in Column 4 of Table 5, manufacturing companies with high free cash flow to asset record a marginal decrease in firm investment by 0.0002 percent. The higher free cash flow available to managers in manufacturing companies, the lower the firm's investment. The extent to which a company relies on debt to finance its operations, that is equity to assets, has a negative and statistically significant coefficient with the size of depreciation and amortization. A unit increase in shareholders' contribution to the firm associates with a marginal decline of 0.0062 percent in the size of depreciation and amortization. The size of the manufacturing firms has a statistically significant and positive relation with depreciation and amortization: this is significant at 1 percent. The effect of the size of the company is that a unit increase in the size of the manufacturing firm results in a 0.3388 percent increase in the size of depreciation and amortization, holding all the other independent variables constant. There is also evidence that holding all the other independent variables constant, a unit improvement in technical efficiency leads to a decline in the size of depreciation and amortization by 0.9542 percent. In column 5 of Table 5, the lagged independent variable model, free cash flow to assets has no significant influence on the size of depreciation and amortization. On the other hand, equity to assets, company size and technical efficiency are statistically significant with similar relations as in column 4 of Table 5. The lag profitability indicator, return on equity, has a positive but statistically insignificant effect on the size of firm investment and the size of depreciation and amortization. There is evidence in Table 5 to support hypothesis 1 that there exists a negative and significant association between technical efficiency and the size of firm investment in all but FE model column 3 estimates. However, there is no such evidence in the case of columns 4 and 5. Furthermore, we have evidence in support of hypothesis 2 that free cash flow has a positive effect on firm investment only in FE model presented in column 2.

6. Discussion

There is evidence in this paper which shows that technical efficiency is higher in listed banks than in manufacturing companies. This study provides evidence that firms that are technically efficient report a lower level of firm investment. This evidence makes practical sense because if the technology deployed in turning inputs into outputs turns out more output for a given level of input, then such firms would have to cut down on their investment as they benefit from the high efficiency. This evidence on technical efficiency is comparable to Ben-David et al. (2013); Graham et al. (2013); Pikulina et al. (2017); and Pikulina et al. (2017) on managerial disposition towards capital investment, in that technically efficient firms do not overly invest in capital investment. These results imply that managers who produce high output from a given level of input avoid wasting shareholders' funds by undertaking small size capital investments compared to firms with lower technical efficiency. Hence, the agency problem in firm investment is reduced when technical efficiency increases.

The case for free cash flow is inconclusive as the sign and the statistical significance of the coefficients are not consistent with the empirical results, across the banking and manufacturing firms. Free cash flow only influences the size of depreciation and amortization in manufacturing firms. This evidence on free cash flow agrees with Fazzari et al. (1988) that the cash flows of a firm have a powerful influence on firm investment albeit the other models did not present a statistically significant coefficient in favor of free cash flow. The other factor that determines depreciation and amortization is dividend payout, comparable to Fazzari et al. (1988). For manufacturing firms, debt usage captured as equity to asset is statistically significant. In respect to Danso et al.’s 2019 position that expected future profits motivates manager to underinvest in capital investment, our results for the sample manufacturing firms is contrary, as prior period profit has a positive coefficient with firm investment and depreciation and amortization.
The results further show that the size of the firm matters in the size of firm investment. Big size firms tend to spend more on firm investment, and this is not surprising as big size firms would need to keep up a higher level of operation and hence must invest more funds into firm investment. This is so for both listed banks and manufacturing companies sampled in this study. Big size firms have a strong statement of financial position to support huge financial needs, hence they can undertake large-scale capital investment compared to small size firms. This finding is similar to the inference made by Fazzari et al. (1988), Bernanke et al. (1999), and Black et al. (2000) that small size firms have difficulty in undertaking large capital investment. In the case of manufacturing firms, in particular, our conclusion that company size influences firm investment collates the findings of Martinez-Carrascal and Ferrando (2008) which aver that for non-financial firms financial positions is crucial in explaining firm investment.

The macroeconomic variables that matter in firm investment are inflation and exchange rate. In this study, there is evidence from the regression estimates that a weak macroeconomic environment characterized by inflation and depreciation of the local currency does not support firm investment. This finding is similar to Farooq et al., (2021) that a weak macroeconomic environment with inflation and high interest rates deters firms from investment.

Increasing lending rates also negatively associates with the size of investment undertaken by manufacturing firms. The neoclassical theory of optimal capital accumulation on investment by Jorgenson (1963) and the financial accelerator model in Bernanke et al. (1999) hold in our work, as increasing inflation increases the cost of capital for firms, which then inhibits the firm’s ability to undertake capital investment. Our results on lending rates on firm investment in manufacturing firms collaborate Bhardwaj and Kumar’s (2020) findings on Indian manufacturing firms that low interest rates and availability of credit propel firm investment. This is no different position from Gandelman and Rasteletti (2017) on Uruguayan firms.

For depreciation and amortization, the size of the firm is important: big size firms tend to consume more capital. Although this might come as wasteful for measuring profitability, from the cash flow perspective, this implies an improvement in cash flow generated from operations. The evidence on technical efficiency is rather mixed, in the depreciation and amortization models across the banking and manufacturing industry.

7. Conclusion and recommendation

This paper measures technical efficiency using the DEA, input VRS estimation technique to answer how technical efficiency associates with the firm investment of listed firms on GSE. Secondly, we provide evidence about how free cash flow links firm investment for the sampled listed banks and manufacturing companies in Ghana. The results point to the fact that technical efficiency is high among banks compared to manufacturing companies. Furthermore, technical efficiency has a negative association and is statistically significant in determining the size of firm investment in banks but not in the case of depreciation and amortization where a positive but statistically insignificant relation exists. For manufacturing firms, technical efficiency has a negative coefficient and is statistically significant in determining the size of firm investment, depreciation and amortization.

The evidence on free cash flow to the firm and how it relates to firm investment is inconclusive from this paper as the signs of the coefficients are opposite for banks compared to the manufacturing companies, and statistically not significant in all empirical models but for depreciation amortization in manufacturing firms. Other variables such as firm size, dividend payout, debt usage, inflation, and exchange rate are identified as determinants of firm investment. The evidence of free cash flow to assets is mixed. In the first case, free cash flow to assets has no significant effect on firm investment but it firm investment or depreciation and amortization. In the second case, there is inconsistency in the coefficient of free cash flow to assets in explaining firm investment for listed banks and manufacturing firms on the GSE.

We recommend that firms with low technical efficiency should reduce their input mix to match their current level of output as efficiency has been predicted to influence the size of the firm investment. If these firms employ technologies that maximize output from a given input, then the possibility of wasting funds under the guise of pursing capital investment would be greatly reduced. Hence, some cost savings for shareholders. Our empirical evidence provides some policy implications for monetary authorities, as a weak macroeconomic environment characterized by increasing inflation and exchange rate depreciation does not support firm investment. Managers of the Ghanaian economy must pursue policies that would stabilize inflation and strengthen the local currency. Further studies on how free cash flow and free cash flow scaled by assets relates to efficiency deserve detailed research attention in the corporate investment-agency problem empirical research.

Declarations

Author contribution statement

Benjamin Amoah, Ph.D: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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Appendix

Table 6. Technical efficiency scores.

| Bank      | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|
| ACCESS    | 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| ADB       | 1.0000| 0.9304| 1.0000| 0.9428| 1.0000| 1.0000| 1.0000| 1.0000|
| CAL       | 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| GCB       | 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| REPUBLIC  | 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| SCB       | 0.8533| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| SG        | 0.6751| 0.7660| 1.0000| 0.9812| 1.0000| 1.0000| 1.0000| 1.0000|
| ECOBANK   | 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| Average   | 0.9410| 0.9620| 1.0000| 0.9905| 1.0000| 1.0000| 1.0000| 1.0000|

Table 7. Technical efficiency scores of manufacturing companies.

| DMU | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| ALW | 0.3054| 0.7632| 0.8403| 0.7449| 0.7806| 0.7047| 0.6296| 0.5858|
| CMLT| 1.0000| 1.0000| 1.0000| 0.8247| 0.9853| 1.0000| 1.0000| 1.0000|
| PZ  | 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 0.9216| 1.0000| 1.0000|
| SAMWOOD | 0.9564| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| UNIL GH | 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000| 1.0000|
| Average  | 0.8524| 0.9526| 0.9681| 0.9139| 0.9532| 0.9409| 0.9102| 0.9517|

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