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IMPACT OF INVESTORS SENTIMENT ON IPO PERFORMANCE: EVIDENCE FROM NASDAQ AND NYSE

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Fatouma Ahmed Ibrahim¹, Vahit Ferhan Benli²

¹Istanbul Commerce University, Graduate School of Finance, Istanbul, Turkey.

fatouma.ibrahiim@gmail.com, ORCID: 0000-0002-6380-8539

²Istanbul Commerce University, Banking and Finance Department, Istanbul, Turkey.

vfbenli@ticaret.edu.tr, ORCID: 0000-0002-0510-7662

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ABSTRACT

Purpose- The paper explores the correlation between investors' sentiment, underpricing and performance over a period of 36 months of newly issued American stocks with a sample of 199 newly listed firms on NASDAQ and NYSE within the period of January 2015 to April 2021. IPOs listed on US stock exchanges have received little attention even though anomalies related to new stock issues are well documented. We aim to fill the existing academic gap.

Methodology- We have hypothesized investor sentiment as the potential explaining variable inducing the anomalies observed and we extract this variable from the American Association of Individual Investors¹ survey results per the nearest date of each IPO issue. We compute the returns in two separate timeframes. The Market Adjusted Initial Returns (MAIRs) are computed as the price change observed during the offer day, adjusted to the S&P500 index. We investigate long-term performance by calculating the Buy-and-Hold Abnormal Return (BHARs) of each IPO for a period of 36months. The company characteristics, which are age, proceeds, number of issued shares, venture capital backing status and economic sector, are retrieved from Thomson Reuter's screens to control on IPO pricing. Then we use a regression model to see whether the predictor variable has an effect on the outcome variable.

Findings- We found that the correlation between the bullish ratio and the MAIRs confirms results found in previous literature and no relationship between investor sentiment and long run performance have been observed.

Conclusion- We conclude that on American stock markets, the existing underpricing can be explained by investors overreacting to new issues while findings relative to the long run performance contradict earlier research, as there is no evidence of underperformance among companies that went public between January 2015 and April 2021. Further research can be oriented toward understand why the documented poor performance related to IPOs no longer exists, as well as the particular characteristics of US markets which are favorable to the profitability of the new issues in the long-term.

Keywords: Investor sentiment, behavioral finance, long-term performance, underpricing, initial public offering, IPO.

JEL Codes: D91, G10, G41

1. INTRODUCTION

In traditional finance theory, investor sentiment has no place. Investors are assumed rational; therefore, they diversify their portfolios to improve the performance parameters of their investments. Price levels match the rationally discounted value of predicted cash flows, and expected returns depends on systematic risks because of competition among them (Baker and Wurgler, 2003). In other words, traditional finance theory implies that individuals make decisions by obtaining all relevant information and have the abilities to analyze this information rationally and unemotionally in order to make the best decisions. It is based on the concept of an idealized perfectly rational individual who has infinite access to knowledge, is capable of accurately interpreting all signals, and makes the best decisions based on impartial perspective and prediction of future events (Szyszka, 2013).

Contradicting the common sense of traditional finance, this paper explores the correlation between investors' sentiment, underpricing and performance over a period of 36 months of newly issued American stocks with a sample of 199 newly listed

¹ AAI Investor Sentiment Survey: <https://www.aaii.com>

firms on NASDAQ and NYSE within the period of January 2015 to April 2021. In fact, scholars have demonstrated interest in exploring the underlying factors inducing IPOs to be underpriced and present poor returns in the long term. Authors discovered that the anomalies are observed worldwide extending to global financial markets. Studies tend to focus on emerging markets while developed economies such as the United States received little attention. This justifies the focus of our paper, instigating the well-known anomalies related to IPOs restricting to American stock markets.

Traditional finance failed to explain this recurring phenomenon, and it is for this reason that researchers turned toward behavioral finance. In this paper, the stock market for newly listed companies has been chosen, as it is a good place to look at the impact of sentiment investors on company prices. By definition, issuing companies are young, immature and fail at providing historical price performance. Consequently, it is unsurprising that they are difficult to value and market participant often have a wide variety of priors when it comes to their valuation. They are more likely to be affected by market sentiment as individuals are relying on their personal valuation biases.

The literature analysis in part two highlights the theories developed by previous scholars building the foundation of IPO underpricing and long-term underperformance, along with several theories for why stock prices rise dramatically on the offer day while providing lower long-term profits. The following sections include, first the previous literature found on IPOs underpricing and long run underperformance. Next is presented the dataset and methodology employed to further make our analysis, followed by the findings and discussion. A concluding section is presented at the end of the paper.

2. REVIEW OF LITERATURE

2.1. IPO Underpricing

Initial Public Offering (IPO) underpricing occurs when listed shares are priced at a value inferior to their market value. The phenomenon has attracted the attention of many researchers since 1836. It has been continuously explored since then empirically and theoretically. IPOs tend to be underpriced all over the world and the anomaly is not associated with a particular time of issue or geographical location of the company. Asymmetry of information and behavioral theories have been linked to the above-mentioned phenomenon.

Before diving into the background of the study and further theories behind common characteristics related to IPO, it is interesting to mention reasons why companies go public in the first place. Kim and Weisbach (2005), based on a study of 16,958 IPOs from 38 countries, argue that capital raising is the most important motive for companies to issue an IPO. They also point out that the amount of money raised is mainly spent on inventory, research and development, plant and equipment and net property, suggesting that companies use raised capital for investment purposes. Furthermore, Pagano, Panetta and Zingales (1995) note that, in addition to lowering the cost of debt, going public has a value-maximizing incentive by facilitating firms to be sold at a higher price. In fact, the high notoriety and media coverage of companies going public for the first time tend to attract executives with recognition and provide them with a higher bargaining power over their vendors, credit institutions and distributors. However, as earlier researchers have noted, issued shares are generally priced at a discount, and issuing firms frequently give up on some amount of profit to the benefit of initial investors who receive positive first-day returns. The phenomenon is extensively studied and known as IPO underpricing. Now, exploring the reasons for it to occur we mention asymmetry of information, specifically winner's curse and theories based on quality signals between the players involved in an IPO transaction.

2.1.1. Theory of Winner's Curse

Scholars defined winners' curse by the act of overbidding an item in the aim of winning it, but with the risk of exceeding its intrinsic value (Lahti, 2021). Rock (1986) has produced the most quoted paper based on Akerlof's (1970) lemons dilemma, claiming that the underwriting institution and issuing firm dispose of a wider range of information compared to other parties involved. The asymmetry of information even extends to the potential investors themselves. Therefore, better-informed investors tend to only bid for attractively priced IPOs while avoiding unattractive ones. As for the uninformed investors, they bid indiscriminately. The fact that uninformed investors are unable to absorb all the shares issued forces companies to resort to underpricing to incite informed investors to bid for the offered shares even though they find them unattractive. It is also useful for uninformed investors since they will not end up with negative return. Hens and Schenk-Hoppe (2009) mention the fact that firms might exploit the herding behavior of traders by inducing a positive cascade of information, which might lead to winner's curse phenomenon. In fact, "the low prices (of IPOs) induces early adoptions" causing a herding behavior among other traders who will buy the IPO afterwards. The winner's curse model of Rock (1986) basically, turns on information asymmetry and According to Michaely and Shaw (1994), as the heterogeneity of information approaches zero, the winner's curse fades and underpricing is no longer necessary.

2.1.2. Signaling Firm's Quality through Underpricing

Previous studies have also documented theories going against previously mentioned scenario and assuming that companies underprice their IPO to convey the firm's "real" high value (Ljungqvist, 2007). The strategy will allow companies to return to the market later on to sell equities at a higher price. As Ibbotson (1975) said, "leave a good taste in investors' mouths", underpriced shares will allow companies to demonstrate their high potential.

2.1.3. Behavioral Theories

Previous hypotheses have been inconsistent in describing market peaks and large amounts of money given up on throughout history. According to Ljungqvist (2007), issuing firms left \$62 billion on the table in a one-year period (1999-2000), leading several experts to question whether asymmetry of information-related theories could explain such a large scale of underpricing. To find relevant theories shedding light on the observed phenomenon studies on behavioral finance debuted to expand. "Behavioral finance studies the psychological factors that influence financial behavior both on the level of the individual as well as on the level of the market" (Hens & Bachmann, 2011). Turning to the behavioral hypotheses, it is assumed that there are irrational traders willing to bid for overly higher prices that go beyond the intrinsic value of the stock, or that issuers are biased in evaluating the true value of their offerings (Ljungqvist, 2007). In this paper, irrational investors called sentiment investors will be our focus in explaining underpricing and long-term underperformance observed. Investor sentiment is defined as the financial market traders' general attitude with regard to the value and potential future returns of a financial instrument founded on their emotional and cognitive biases (Cathy, 2008). Wang, Rieger, & Hens (2017) investigated the effect that culture has on loss aversion. Moreover, while culture is deemed to shape the emotions of investors, the authors, after analyzing results from 53 countries, found that cultural differences influence investment decision-making of market participants.

Market timing is another theory explored and defined as the strategy of selling or buying financial instruments in the attempt of outperforming the market. In other words, market timing is considered as the investor's ability to profit from price reversals using technical or/and fundamental analysis to predict price movements. This can induce higher number of deals and returns on the market (Montier, 2003). Lowry (2003) suggests that, after studying a sample of 5349 IPOs that high IPO volumes are triggered by high investor optimism. She notes that firms that go public during high-volume periods do not appear to be mispriced compared to other similar companies; it appears that these firms successfully go public when their entire sector is overvalued. Schill (2000) finds similar results. Hens and Benli (2021) report that in times of crises and high uncertainties, investors tend to exhibit adaptive behaviors, panic selling and guilt. They observe higher activities of investment and disinvestment making market timing possible for investors that are more rational. Market sentiment plays an important role when companies are making the decision of going public.

2.2. Long-term Performance

In addition to be characterized as underpriced following the offer, IPOs present long-term poor performance as a familiar pattern. Theories behind the phenomenon are not as elaborate as for the underpricing and results from previous research are controversial (Tomadakis et al. 2012). According to Ritter (1991), exceptionally high prices shortly after the company issues its first stock are accompanied with disproportionately poor long-run returns. The described pattern, as per Ritter and Welch (2002), is especially prominent during "hot market" conditions. They argue that individual traders' overconfidence may account for the well-documented price rises that occur when dealing with newly issued stocks, as well as the dismal returns that follow in the first few years of trade. According to Ritter (1991), some of the underpricing can be attributed to markets participants overreacting to upcoming Initial public offerings. Companies, on the other hand, are more likely issue their first stock when market sentiment tends toward higher growth and profit expectations and are willing to pay excessive larger amounts based on unrealistic estimates.

2.3. Related Studies

Cornelli et al. (2004) investigated the role of grey market investors (representing the investor sentiment) on the price of IPO by using over-the-counter market price data of a wide range of European new stock issues from 1995 to 2002 shedding light on the issue of underpricing. The authors observe that when investors are overconfident, aftermarket prices are high because they are ready to pay a premium over the IPO's underlying worth. In addition to that, they observe that long-term returns and grey market prices are negatively correlated. They also discover that rational investors perceive investor sentiment and benefit from it by selling the shares to them when they are optimistic in the aftermarket. In accordance with the previously cited authors, Xian (2021) found similar results, concluding that optimistic sentiment leads to a higher post-IPO turnover, implying the sale of overpriced IPO shares to exuberantly optimistic investors.

Similarly, Derrien (2005) investigated the relationship between investor sentiment and IPO pricing from 1999 to 2001. The author created a model and tested it on a sample of 62 initial public offerings (IPOs) registered on the French stock exchange.

He concluded that the demand of individual investors is strongly correlated with the market condition and that they have an impact on IPO price. IPO shares are overpriced when investor sentiment is more favorable. Moreover, he noted a positive correlation between their demand and initial returns and turnover, as well as a negative correlation with the long run IPO performance.

Bajo and Raimondo (2017) contributed to the literature on the relationship between finance and media. They gathered information from 2814 initial public offerings (IPOs) and 27,309 published works in US periodicals. They employed textual analysis to formulate a mathematical equation describing the sentiment tone of the publications. They discovered that a positive tone influences considerably the degree to which IPOs are underpriced. According to the study, an increase in the standard deviation in tone by one accounts for a 2.5% increase in the level of underpricing.

In the same spirit, DN Rathnayake et al. (2019) used a dataset comprising 148 CSE Initial public offerings from 1991 to 2017 and collected data from companies' annual financial statements and the official website of CSE to find that IPOs had a level of underpricing of 47% and 32 of the them were overpriced by 17–18%. The correlations between initial returns and several independent factors were investigated using the Ordinary least square method and a cross-sectional study. The size of the issue, time lag factor, market sentiment, risk level, volatility of the market, as well as hot market conditions all have a major impact on offerings' profits, according to the researchers. According to the authors, average overpricing is also a problem.

3. DATA AND METHODOLOGY

This section sheds light on the data used and the methodology we aim to employ in order to conduct our analysis.

3.1. Hypothesis Definition

This empirical study, investigating the impact of investor sentiment on US IPOs listed on NASDAQ and NYSE underpricing and long run performance tests, two hypotheses;

H₁⁰: Investor sentiment ratio does not have an impact on IPOs' market adjusted initial returns.

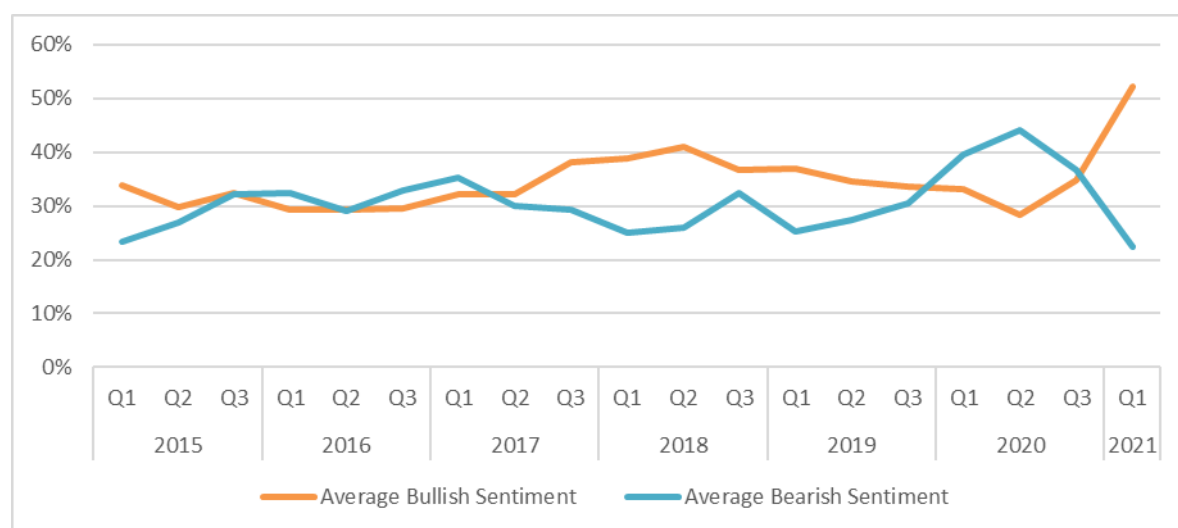
H₂⁰: Investor sentiment ratio does not have an impact on IPOs' long-term performance.

3.2. Data and Variables Definition

3.2.1. Investor Sentiment

Investor sentiment ratios have been extracted from the AAll website administering direct surveys and conducting monthly publications. Investors' bullishness and bearishness levels on the week within which the IPOs have been issued are added to the IPOs' information. Below we present, in Figure 1, the evolution of the market sentiment throughout our study period, which is 2015 to the first quarter of 2021. The market sentiment remains bullish from the second quarter of 2017 to the end of 2019 while the bearish sentiment prevails from the second quarter of 2015 to the end of the first quarter of 2017. We note a more bearish sentiment during the year of 2020 and an overtaking bullish sentiment at the beginning of 2021.

Figure 1: Average Bullish and Bearish Sentiment



3.2.2. IPO Data and Control Variables

Following the selection criteria documented by previous studies: DN Rathnayake et al. (2019), Lowry (2003), Derrien (2005), Bajo, Raimondo (2017), IPO data have been extracted from Thomson Reuters' database. We select US IPOs and exclude REITS, unit IPOs, utility and financial firms, IPOs backed by private equity through LBOs, IPOs with offer price lower than 5\$, in-progress, postponed, canceled and foreign IPOs are excluded. We further filter out by security type, including only common and ordinary shares. A number of 378 US IPO listed on NASDAQ and NYSE for the period of January 2015 to April 2021. We, then, unselect shares that have been unlisted before the end of our period. The final sample contains 199 IPOs. For each IPO we have collected the name, foundation date, ticker symbol, industry and the stock exchange on which it has been listed. Furthermore, offer characteristics for each IPO have been collected in order to compute the Market Adjusted Initial Returns (MAIR) and the Buy-and-Hold Abnormal Returns (BHARs).

Focusing on isolating the effect of investor sentiment on the performance on newly issued stocks, other factors have to be controlled. First we have the proceeds generated, representing the size of the company. Second, the age of the firms have been collected following the remarks of Chambers and Dimson (2009) about older companies having lower underpricing levels compared to the younger ones that present higher levels of risk. Next, we have the number of outstanding shares, which represent the supply of the Initial Public Offering, and is a pricing factor as well. Furthermore, we create dummy variable to identify venture capital backed and belonging to high-tech industry firms. Lee and Wahal (2004) demonstrate in their paper that VC backing and IPOs level of underpricing are related. In their paper, the authors demonstrate that characteristics of the venture capitalists involved tend to reduce the degree to which IPOs are underpriced by reducing uncertainty with higher quality of monitoring. The same conclusions are made by Jahidur Rahman et al. (2021). Finally, we have IPOs belonging to a high tech industry, which are characterized by higher levels of risks and uncertainties, thus, higher underpricing levels (Loughran and Ritter, 2004). As noted more recently by Gregory et al. (2020), the documented impact of previously cited factors on IPO pricing should be controlled to isolate the effect of investor sentiment.

Table 1: Summary Variables

Dependent Variables	
MAIR	Market Adjusted Initial Return
BHAR	Buy and Hold Abnormal Return
Independent Variable	
Bullish	Bullish Ratio
Bearish	Bearish Ratio
Control Variables	
Age	Age of the firm
Ln_PROCEED	Ln of the total proceeds generated in all markets
LnNBShares	Ln of the number of shares offered
ECO SECTOR	Dummy Variable equals to 1 if the IPO belongs to a technology industry and 0 otherwise
VC_BACKED	Dummy Variable equals to 1 if the IPO is backed by Venture Capital 0 otherwise

3.3. Methodology

In the aim of investigating the first day price run-ups and long-term performance of IPOs, we compute the returns in two separate timeframes. The MAIRs are computed as the price change observed during the first day of trading taking the price at the end of the day and the price of the offering, we then adjust the proceed to the S&P500 index. We measure the performance over the long term by calculating the BHARs of each offering for a period of 36months. We also extract the market sentiment from the AAll survey results per the nearest date of each IPO issue. The company characteristics, which are age, proceeds, number of issued shares, venture capital backing status and economic sector, are retrieved from Thomson Reuter's screens to control their effect on IPO pricing. Then we use a regression model to see whether the predictor variable has an effect on the outcome variable.

3.3.1. Market Adjusted Initial Returns and Buy-and-Hold Abnormal Returns Calculations

Underpricing of IPOs is measured as the return made on the first day of trading. The formula below is used to obtain the initial raw returns of each IPO on the first trading day:

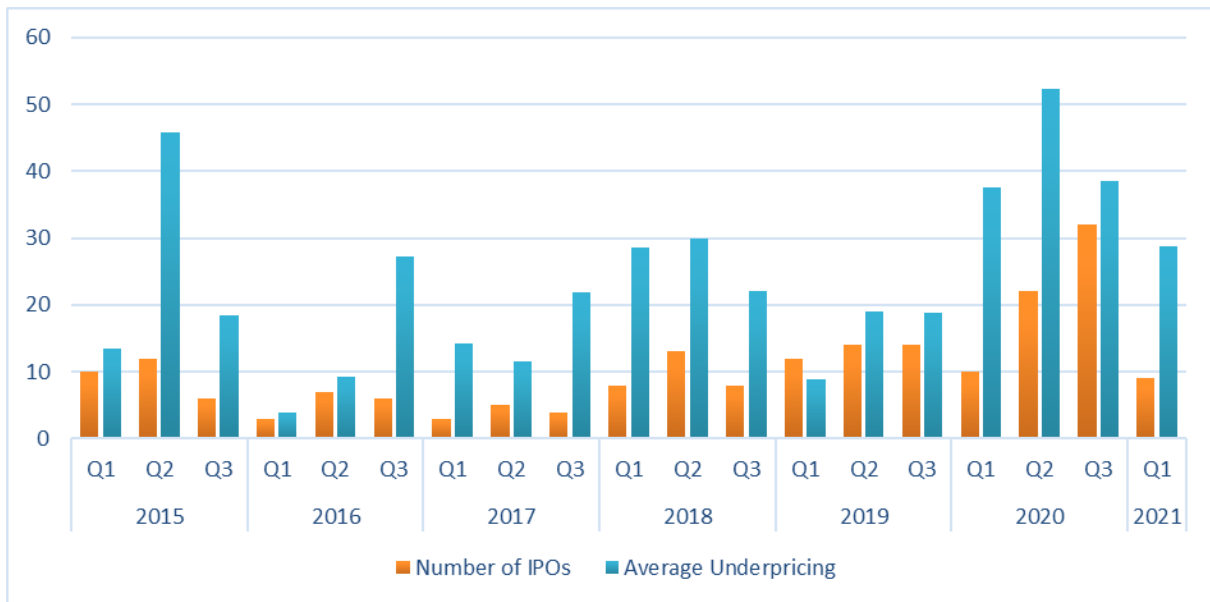
$$RIR_{i,t} = \frac{P_{i,1} - P_{i,0}}{P_{i,0}} \tag{1}$$

$P_{i,t}$ represents the price at the end of the first trading day, while $P_{i,0}$ represents the offer price. However, because the raw first returns do not account for general market movements, the prices must be modified using a benchmark index. The Market Adjusted Initial Returns are thus computed as follow:

$$MAIR_{i,t} = \frac{P_{i,1} - P_{i,0}}{P_{i,0}} - \frac{M_{i,1} - M_{i,0}}{M_{i,0}} \tag{2}$$

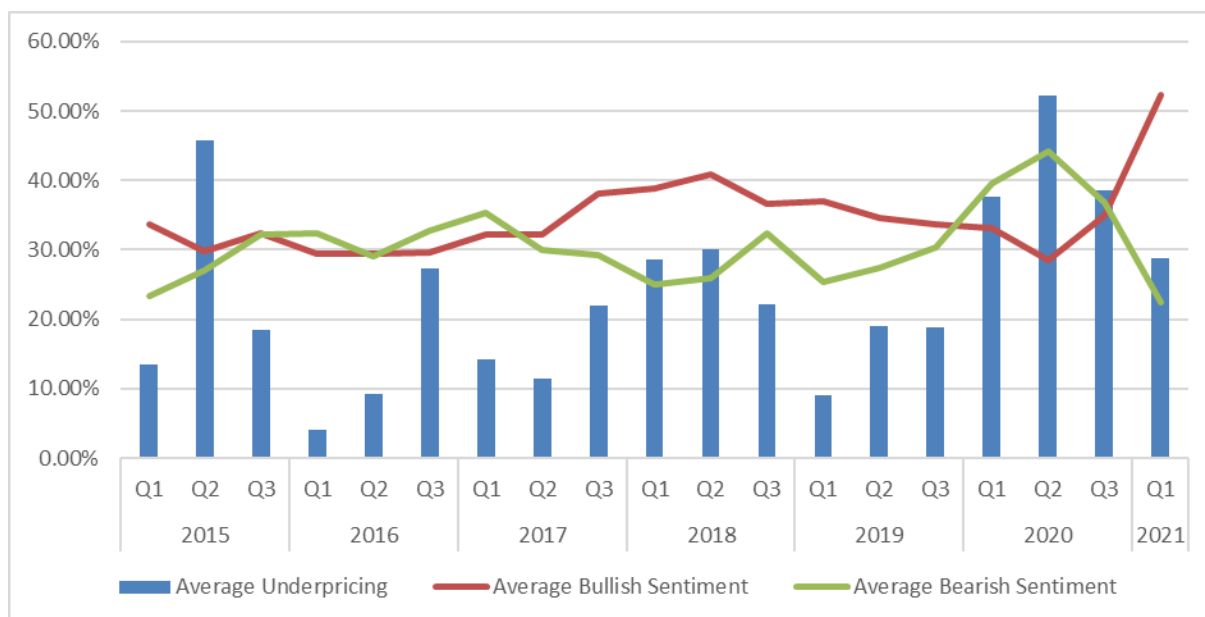
In the above equation, $M_{i,1}$ represents the equity index price at the conclusion of the offer day and $M_{i,0}$ is the index's most recent value prior to the first trading day. Because the data set in this research is heterogeneous, and the only common criteria that apply to the complete data sample are that the firms are US-based, and the IPOs were done on either the NASDAQ or NYSE stock market, I picked the S&P 500 index as a benchmark. The S&P 500 stock index is a capitalization-weighted index that contains the 500 largest and most powerful organizations in the United States, properly reflecting the common market movements in which the IPO sample companies operate (Lahti, 2021). The level of underpricing detected in our sample during the study period is depicted on the graph in Figure 2. The biggest number of initial public offerings (IPOs) were issued in the second quarter of 2020, when a record number of companies went public. In addition, the year 2020 was marked by a significant level of underpricing. The level of underpricing has remained below 30 since the peak in 2015.

Figure 2: Number of Quarterly Issues and Level of Underpricing



Combining the market sentiment and the level of underpricing we can observe on Figure 3 that during the period of 2015 to the beginning of quarter 2 of 2017, the bearish sentiment was mainly above the bullish sentiment ratios. The market was, on average, pessimistic with the expectations of failing prices. The level of underpricing beside the peak of 2015 Q2 remained low. From the end of quarter 2 2017 to 2019, the bullish sentiment is taking over and prevailing on the market. Higher level of underpricing is observed compared to the previous timeframe. Lastly, during 2020, we observe higher ratios of bearish sentiment. This corresponds to the Covid19 outbreak period. Fear, pessimism, panic and uncertainties related to global health crisis might explain the prevailing sentiment. The level of underpricing, however, is at its highest level. It starts to get lower as a more bullish sentiment is felt on the market at the beginning of 2021.

Figure 3: Level of Underpricing and Market Sentiment Data



Next, long-term performance is measured by the average BHAR. The BHAR, according to Barber and Lyon (1997), is a better measure of IPO stock long-term success than the Cumulative Abnormal Return (CAR), which is also used by early researchers. In addition to that, Lyon et al. (1999) suggest that the BHAR technique measures true experience of buying and holding the asset of individuals and is thus more essential in gauging IPO stock experience. However, BHARs tend to be positively skewed inducing a skewness bias to the long-term returns. A bootstrapped skewness adjusted regression test might allow us to reduce the risk of skewness bias and a more relevant analysis. The BHR of the IPO is calculated using the following formula:

$$BHR_{i,T} = \prod_{t=1}^T (1 + r_{i,t}) - 1 \tag{3}$$

T is the number of months, and $r_{i,t}$ is the stock's raw return for month t.

The market index return is determined in the same way. The BHARs, are calculated as follows, according to Kooli and Suret (2004):

$$BHAR_{i,T} = \left[\prod_{t=1}^T (1 + r_{i,t}) - 1 \right] - \left[\prod_{t=1}^T (1 + r_{m,t}) - 1 \right] \tag{4}$$

The return of the market index for the same period is $r_{m,t}$.

We illustrate the computed returns in Figure 4 presented below. Abnormal returns have been realized during the quarter 3 of the four years representing our study period as well as the quarter 2 of 2016 and quarter 1 of 2018. Negative returns and low performance compared to the market returns can also be observed on the graph. The overall performance of our IPO sample is slightly above the overall market returns with a holding period of 36 months.

Figure 4: Buy-and-Hold Returns of the IPO Sample, the Market Return and the Abnormal Return

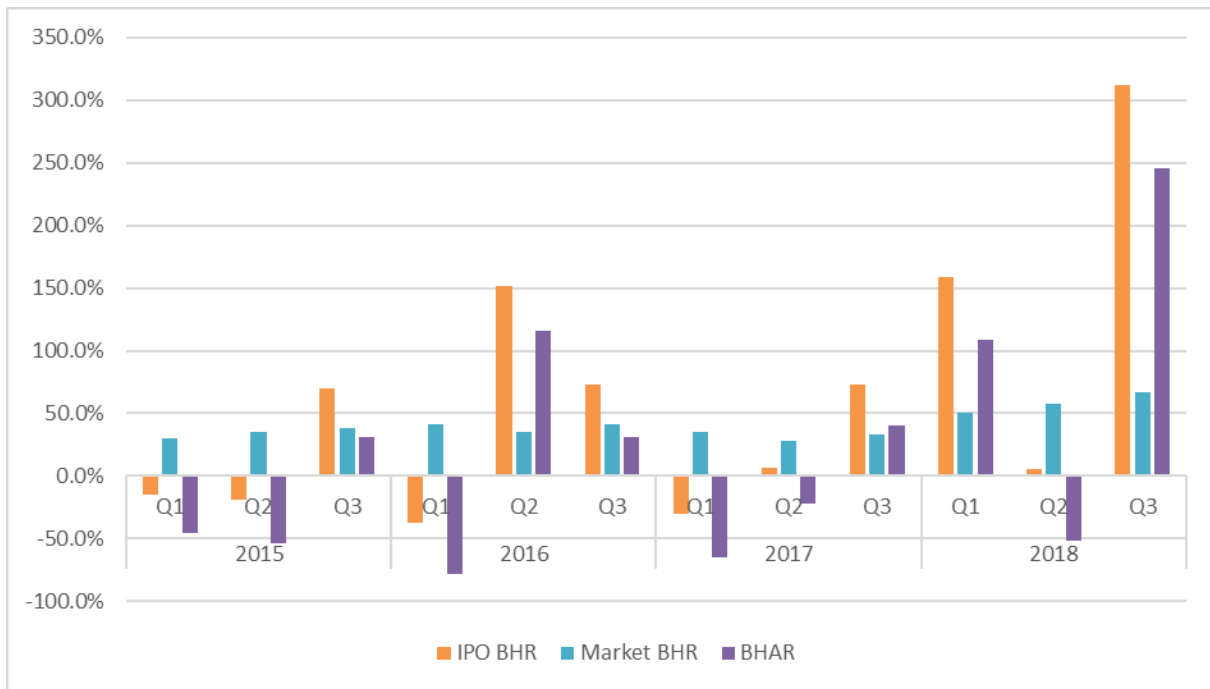
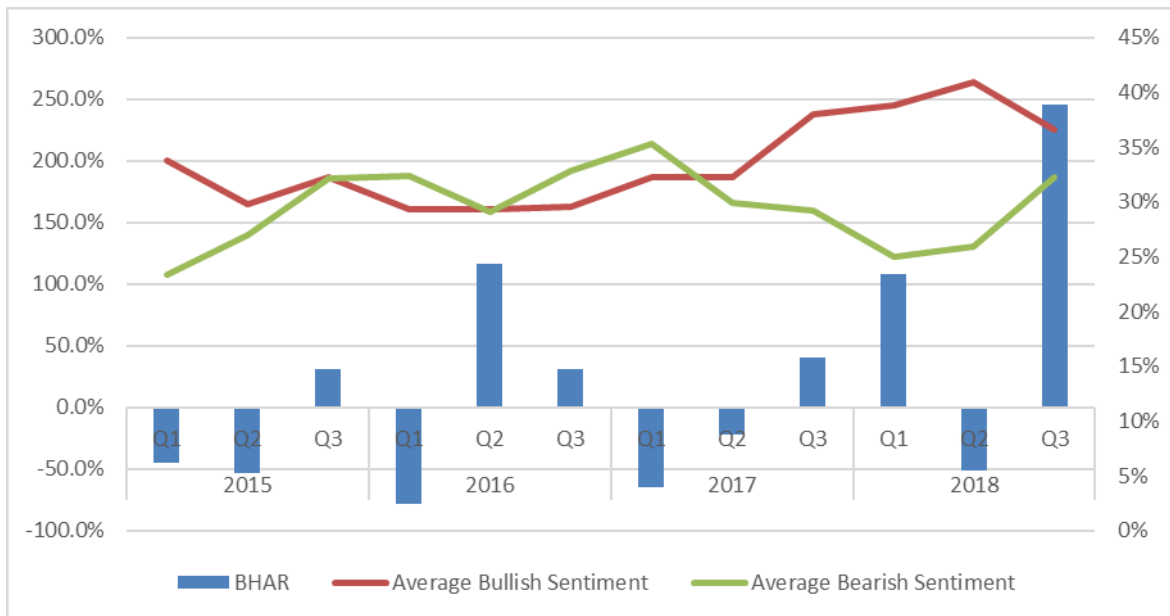


Figure 5 illustrates the quarterly values of Buy-and-Hold returns and the market sentiment for the period of 2015 to 2018. A clear pattern is not observed on the graph as to how the long-term performance of IPOs in the study sample correlate to the market sentiment.

Figure 5: Quarterly Buy-and-Hold Abnormal Returns and Market Sentiment



3.3.2. Regression Equation

Studies from previous scholars investigating IPO performance and behavioral explanations employ regression models to test the underlying hypotheses (see Liu, Zhang & Lyu, 2021; Hoechle, Karthaus & Schmid, 2020; Beck, 2017). After data collection, regression analysis is made through the Statistical Package for Social Sciences (SPSS). Prior to the regression analysis, multi-collinearity diagnostic has been made. Results tabulated in the following section are retrieved from SPSS. Descriptive statistics of our variables are also displayed on the system. The following formula presents the regression model used in this study:

$$Y_i = \beta_0 + \beta_1(\text{bullish}_{ratio}) + \beta_2(\text{bearish}_{ratio}) + X_i + \varepsilon_i \quad (5)$$

Where Y_i is defined as the predicted variable, which is the MAIR and will next be used to examine the behavior of the BHARs, X_i represents the control variables: Age, log of proceeds, log of the number of shares offered, high tech dummy, exchange dummy and VC backed dummy and ε_i is the error term.

4. RESULTS OF THE STUDY

Following data collection, the findings are presented in this section.

4.1. Univariate Analysis

4.1.1. Descriptive Statistics: Whole Sample

The table below displays the descriptive statistics of the studied variables. The mean Market Adjusted Initial return (MAIR) of our selected sample of 189 IPOs was 28.677%, the median value was 17.082%, and we noted a maximum value of 197.84% and a minimum of -30.838%. The standard deviation was 39.721. The average bullish ratio was 35.10% while for the bearish ratio it was 30.29%. Firms included in the sample have a mean age of 11 years. The mean log of the number of share and the proceeds generated are of 15.751 and 4.670 respectively.

Table 2: Descriptive Statistics: Initial Returns

	MAIR	BULLISH	BEARISH	AGE	LN PROCEED	Ln NB Shares	VC BACKED	ECO SECTOR
N Valid	198	198	198	198	198	198	198	198
N Missing	0	0	0	0	0	0	0	0
Mean	28.677	35.10%	31.70%	10.83	4.670	15.751	.85	.10
Median	17.082	34.70%	30.29%	9.00	4.682	15.701	1.00	.00
Mode	-30.838 ^a	34.78%	21.70% ^a	6	4.317	15.424	1	0
Std. Deviation	39.721	8.47%	8.46%	9.263	.9157	.6589	.359	.295
Minimum	-30.838	20.21%	18.60%	1	1.609	13.815	0	0
Maximum	197.840	56.91%	52.66%	77	8.999	19.008	1	1

4.1.2. Venture Capital Backed IPOs

New stocks issued that are backed by venture capital are listed on Thomson Reuters' screens. We have flagged such IPOs in our dataset and presented below.

Table 3: IPOs Backed by Venture Capital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	30	15.2	15.2	15.2
	1	168	84.8	84.8	100.0
	Total	198	100.0	100.0	

The table presents the statistics following the criterion of venture capital backing. In our selection, 84.8% of the IPOs issued are backed by venture capital while 15.2% were not. Venture capital backed IPOs present lower level of underpricing depending on their quality of monitoring compared to the ones that are not (Jahidur Rahman et al. 2021), (Barry et al. 1990). The effect is controlled in this paper.

4.1.3. IPOs Belonging to a High-tech Industry

Furthermore, the table classifies IPOs following the economic sector they belong to. In the sample, 9.6% were from High-tech industry while the highest number of IPOs belonged to the healthcare industry with a percentage of 81.8. In fact, 63 IPOs have been issued by healthcare companies during the year of 2020 and the first quarter of 2021 following the COVID19 outbreak. The high sentiment during the crisis implies that companies issue stocks in hot markets when they are overvalued, and conditions are overall positive. The following industries have a cumulative percentage of 8.6.

Table 4: Descriptive Statics: 1 = High Tech Industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	High-tech	19	9.6	9.6	9.6
	Healthcare	162	81.8	81.8	91.4
	Consumer cyclical	6	3.0	3.0	94.4
	Industrials	7	3.5	3.5	98.0
	Consumer non-cyclical	2	1.0	1.0	99.0
	Energy	1	.5	.5	99.5
	Basic materials	1	.5	.5	100.0
	Total	198	100.0	100.0	

4.1.4. Descriptive Statistics: Sub-sample

A subsample of 85 IPOs is chosen, and their relative long-term returns defined as the profits generated over a 36-month period are computed, with the goal of examining the influence of market sentiment on the long-term performance of newly issued stocks. Because IPOs have a well-documented history of poor long-term performance, we will study if earlier hypotheses hold true on American stock markets.

Table 5: Descriptive Statistics: Long-term Performance

	BHAR 36	BEARISH	BULLISH	AGE	ECO_SECTOR	VC_BACKED	LN_PROCEED	Ln_NBShares
N Valid	85	85	85	85	85	85	85	85
Missing	0	0	0	0	0	0	0	0
Mean	.220296	28.42%	34.38%	13.35	.12	.80	4.479	15.640
Median	-.558700	28.74%	34.66%	13.00	.00	1.00	4.448	15.607
Mode	-1.4364 ^a	21.70%	44.78%	8	0	1	4.3174 ^a	15.4249
Std. Deviation	2.4980039	5.713%	7.704%	9.022	.324	.402	.7411	.5316
Minimum	-1.4364	18.60%	20.41%	3	0	0	2.7080	14.444
Maximum	17.9436	41.00%	54.11%	67	1	1	7.3195	17.957

The numbers related to the subsample selected are depicted in the table above in the aim of analyzing the long-term behavior of the IPOs' returns relative to investors' sentiment. The 85 IPOs presented an average BHAR of 0.220, a maximum of 17.94, a minimum of -1.436 and a standard deviation of 39. The average bullish ratio was 34.38% while for the bearish ratio it was 28.42%. Firms included in the sample are, on average 13 years of age. The mean log of the number of share and the proceeds generated are of 15.64 and 4.479 respectively.

4.1.5. IPOs Belonging to a High-Tech Industry

From the 85 IPOs, 11.8% belonged to a high tech industry while 88.2% were mainly from healthcare industry. The number of high-tech companies, presenting higher levels of risks and uncertainties, is low in our sample compared to the ones from other industries.

Table 6: Descriptive Statistics: High-Tech Industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	75	88.2	88.2	88.2
	1	10	11.8	11.8	100.0
Total		85	100.0	100.0	

4.1.6. Venture Capital Backed IPOs

The table above presents the number of IPOs backed by venture capital and it appears that 80% of them are while 20% are not backed by venture capital.

Table 7: IPOs Backed by Venture Capital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	17	20.0	20.0	20.0
	1	68	80.0	80.0	100.0
Total		85	100.0	100.0	

4.2. Bivariate Analysis

4.2.1. Regression Results (1)

The regression table depicts a significant correlation at 1% between the MAIRs and the bullish ratio variable. A collinearity diagnosis has been executed before the regression. The predictors are independent and the bullish ratio is significantly related to the MAIRs observed. Our findings confirm the results found in previous literature. When investors are highly optimistic, the aftermarket prices are high since they hold biased beliefs about the intrinsic value of the IPOs and rational investors who perceive investor sentiment benefit from it by selling the share to them when they are optimistic in the aftermarket. (Cornelli et al. 2004). This might explain the absence of correlation between the bearish ratio and the market adjusted initial returns.

Table 8: Correlation Initial Returns

Control Variables			MAIR	BULLISH	BEARISH
AGE & Ln_PROCEED & Ln_NBShares & VC_BACKED & ECO_SECTOR	MAIR	Correlation	1.000	.475**	.029
		Significance (2-tailed)	.	.000	.685
		df	0	191	191
	BULLISH	Correlation	.475**	1.000	-.402**
		Significance (2-tailed)	.000	.	.000
		df	191	0	191
	BEARISH	Correlation	.029	-.402**	1.000
		Significance (2-tailed)	.685	.000	.
		df	191	191	0

** . Correlation is significant at the 0.01 level (2-tailed).

Table 9: ANOVA*

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24017.726	5	4803.545	3.216	.008 ^a
	Residual	286805.362	192	1493.778		
	Total	310823.088	197			
2	Regression	105417.471	7	15059.639	13.930	.000 ^b
	Residual	205405.617	190	1081.082		
	Total	310823.088	197			

* Dependent Variable: MAIR

a. Predictors: (Constant), ECO_SECTOR, AGE, VC_BACKED, Ln_NBShares, LN_PROCEED

b. Predictors: (Constant), ECO_SECTOR, AGE, VC_BACKED, Ln_NBShares, LN_PROCEED, BEARISH, BULLISH

When we isolate investor sentiment in the second model to assess its impact on MAIRs, as shown in the above table, the ANOVA analysis yields a 1% significance level and an F value of 13.93, which further confirms the positive association between market sentiment and first day price run-ups.

4.2.2. Regression Results (2)

Surprisingly, there is no substantial correlation between sentiment ratios and 36-month BHARs. Our findings contradict prior research that found a negative correlation between the variables studied. We have not observed an underperformance; instead, the selected IPOs outperformed the market index S&P500. Researchers have largely admitted the theory of underperforming IPOs in the end, which is against results found in this study.

Table 10: Correlations: Long-term Performance

Control Variables			BHAR 36	BEARISH	BULLISH		
AGE & LN_PROCEED & Ln_NBShares & VC_BACKED & ECO_SECTOR	BHAR 36	Correlation	1.000	.089	-.235		
		Significance (2-tailed)	.	.431	.036		
		df	0	78	78		
	Bootstrap ^a	Bias	Std. Error	.000	.009	.028	
			BCa 95% Lower Confidence Interval	.	-.117	-.425	
		Upper	Confidence Interval	.	.295	.075	
		BEARISH	Correlation	.089	1.000	-.403	
			Significance (2-tailed)	.431	.	.000	
	df		78	0	78		
	Bootstrap ^a		Bias	Std. Error	.009	.000	-.005
				BCa 95% Lower Confidence Interval	-.117	.	-.573
	Upper		Confidence Interval	.295	.	-.252	
BULLISH	Correlation	-.235	-.403	1.000			
	Significance (2-tailed)	.036	.000	.			
	df	78	78	0			
	Bootstrap ^a	Bias	Std. Error	.028	-.005	.000	
			BCa 95% Lower Confidence Interval	-.425	-.573	.	
	Upper	Confidence Interval	.075	-.252	.		

5. CONCLUSION

The paper investigated the correlation between investor sentiment and Initial Public Offerings performance retrieving data from stocks listed on NASDAQ and NYSE. With a sample of 199 IPOs, we computed their first day returns, adjusted to market and with a subsample of 85 we computed the 36 months' abnormal returns using BHAR method. The regression analysis performed to evaluate the underlying relationship between underpriced IPOs and investor sentiment concluded in being positive. In fact, we note a positive significant correlation at a level of 1%. The result is in line with previous literature. However, findings relative to the long run performance contradict earlier research, as there is no evidence of underperformance among companies that went public between January 2015 and April 2021. Instead, over a three-year period, firms, which conducted an IPO, presented higher returns compared to the S&P 500 index and the IPO market's underperformance anomaly has at least temporarily vanished. Further research can be oriented toward understand why the documented poor performance related to IPOs no longer exists, as well as the particular characteristics of US markets which are favorable to the profitability of the new issues in the long run.

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THE RELATIONSHIP BETWEEN ECONOMIC GROWTH AND PUBLIC DEBT: A THRESHOLD REGRESSION APPROACH IN GHANA

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David Mensah Awadzie¹, David Kwashie Garr², Thomas Dodzi Tsoekeku³

¹Accra Institute of Technology, Department of Accounting and Finance, Accra, Ghana.

davidawadzie@gmail.com, ORCID: 0000-0001-5532-2152

²Presbyterian University College, Department of Economics and Finance, Accra, Ghana.

davidgarr2003@yahoo.com, ORCID: 0000-0003-1241-4422

³University of Ghana, Legon, Department of Finance, Accra, Ghana.

thomasdodzi@yahoo.com, ORCID: 0000-0002-5728-8581

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ABSTRACT

Purpose— Ghana's debt stock has been a subject of debate for a very long time. This study is to estimate the debt threshold level above which it will be detrimental to economic growth.

Methodology— The study used a threshold autoregressive model introduced by Tong (1978) and Hansen (1996). The study employed time-series data for thirty-one years from 1990 to 2020. Economic growth was measured by the Gross Domestic Product Per Capita (GDPPC). The study sought to answer the following question: What is Ghana's public debt threshold value?

Findings— The data reveal that Ghana has a single public debt threshold value (i.e., structural breakpoint), implying that public debt and growth are not linear. The derived threshold regression model indicates a public debt threshold of 57.09 per cent, above which the growth rate of GDPPC is considerably retarded. In addition, below the threshold level, there is a statistically significant positive association between public debt and growth.

Conclusion— This article concludes that low public debt is growth-enhancing, whereas public debt above the threshold value is detrimental to economic growth. Therefore, policymakers should focus on monetary policies that aid in maintaining public debt at a low level. However, this study makes the following recommendations to help sustain Ghana's expanding state debt:

To begin with, the government should halt the accumulation of external debt, which incurs additional costs during periods of currency depreciation. Second, policymakers with decision-making authority should exert severe restraint on the growing cedi. Thirdly, the government should eliminate all wasteful spending. Finally, the government of Ghana should allocate its external debt appropriately for economic investment and maintain a strong debt management policy.

Keywords: Ghana's debt stock, threshold, economic growth, policymakers.

JEL codes: F34, H63

1. INTRODUCTION

Borrowing allows governments, institutions, and individuals to meet their financial obligations. The government may be required to engage in public sector investments on occasion, for instance, constructing schools, hospitals, and enhancing roads. This investment later generates a return on investment, which contributes to the expansion of productive capacity and the acceleration of economic growth. However, most developing countries lack the financial resources to pursue this investment, forcing them to borrow. The national debt, often known as public sector debt, refers to the total amount of money borrowed by the government. Public debt, in the real sense, is not bad, but how sustainable can it be? Elmendorf and Mankiw (1999) argued that state debt is significant because of its effects on a country's economy, whether they are direct or indirect. Taking on public debt is a good way for governments to raise additional funds to invest in their economic growth in the short term.

First and foremost, state debt may have an impact on the conduct of monetary policy. Higher interest rates are more likely to occur in a country with a high level of government debt, and the monetary authorities may be under pressure to lower interest rates due to monetary policy. This strategy may have a short-term impact on interest rates, but the long-term impact will be an increase in nominal interest rates, inflation, and actual interest rates that remain unchanged. As a result of the rise

in these two indicators (i.e., interest rates and inflation), private investment will decline, resulting in a decline in Gross Domestic Product (GDP) and economic growth. Second, the state's debt may impact the political process by determining fiscal policy in the first instance. Some economists say that the possibility that the government will borrow money during the budgeting process weakens the budgetary discipline that is needed.

The latter is predicated on the assumption that if a government incurs additional costs unrelated to income tax, policymakers and the general public will be less concerned about whether or not these costs are justified. To add to the list of problems, when a country's economy is burdened with public debt, it becomes more vulnerable to a worldwide crisis of confidence. Due to its high level, increased state debt places pressure on the bank's balance sheet through various channels. For example, after financial institutions have increased their risk assets to a certain level, the cost of financing for the institutions in question rises. Suppose financial institutions hold a significant portion of the government debt of countries experiencing "economic stress," which is perceived to be risky. In that case, they may be required to pay higher interest rates and may have difficulty raising funds in all market circumstances. It's not certain that they will be forced to increase their capital and liquidity reserves, but it's possible.

In addition, all of these factors contribute to an increase in the cost of debt service, which is detrimental to economic growth. To summarize, financial institutions may experience capital outflows as well as asset replacements; according to Guraziu et al. (2012), as a result of all of the factors listed above, a high level of public debt has a negative impact on the country's international reputation, harms the business climate, and has a negative effect on investment and economic growth. In the context of Ghana's rising public debt, one of the most pressing issues in the country's capacity to comply with its obligations in the short and long term. When Ghana agreed to a three-year IMF Extended Credit Facility worth \$918 million in 2015, the Fund's debt sustainability analysis determined that the country faced a "high risk of debt distress" due to its high level of government debt. For four years, the country's debt situation remained unchanged in any significant way. Following their latest debt sustainability analysis, which concluded that Ghana's external and overall debt distress risks remain elevated, the World Bank and the International Monetary Fund (IMF) have maintained Ghana's status as a high-risk debt distress country. However, the country's public debt level has exceeded the sustainability threshold.

Following the Fund's debt sustainability analysis, completed in October 2019, the country's medium-term debt path was high due to lower GDP growth, a higher fiscal deficit (primarily due to costs associated with the energy sector), and debt service over the medium term. Despite a significant improvement in solvency ratios due to the adjustment to current prices, the debt service ratios continue to fall short of their respective benchmarks, demonstrating the country's deep-seated financial vulnerabilities. Currently, Ghana is the only country in Sub-Saharan Africa classified as high risk of debt distress. The government is accruing a significant amount of debt that it may not be able to pay back.

According to the Bank of Ghana, Ghana's public debt is unsustainable. Analysis by the Central Bank indicates that the high proportion of foreign investors makes the country vulnerable to external shocks. Interestingly, the Economic Commission for Africa (ECA) came to the same conclusion as the International Monetary Fund and the World Bank when it included Ghana among 11 countries in the sub-region at high risk of debt distress, which was a surprising turn of events. As a high-debt troubled country, Ghana's ability to meet its debt obligations is the international community's grave concern, as evidenced by its designation as such. Currently, the country's total public debt stock has increased from GH336 billion in 2021 to GH344.8 billion as of January 2022. The government has allocated more than GH37.44 billion in the 2022 Budget to cover interest payments, while GH32 billion was used to pay interest in 2021.

Concerns have been raised that any further deterioration in the country's fiscal situation will have a negative impact on the country's debt dynamics, which will have profound implications for investors' confidence in the country's economic prospects. Apart from that, Ghana continues to be burdened by high financing costs in both the domestic and international markets due to interest rates in the global financial market remaining extremely sensitive to actions taken by the Bank of the United States (the Federal Reserve). It has had a significant impact on Ghana's fiscal management because the cost of servicing the country's rising public debt (amortization and interest payments) has increased significantly. As a result, over the 11 years ending in 2019, the cost of servicing the debt (amortization and interest payments) increased significantly, making Ghana one of the African countries with the highest debt service obligations and posing a severe challenge to fiscal management. Total debt servicing increased from GH1.1 billion (3.6 per cent of GDP) to GH107.6 billion (31.1 per cent of GDP) between 2008 and 2012, reaching a level equal to the country's total external debt at the time.

The majority of the amortization, amounting to GH13.5 billion (53.6 per cent), was completed during the 2017-2019 period. Interest payments on the government debt increased from GH6.5 billion in 2009-2012 to GH36 billion in 2013-2016, and then to GH39.9 billion in 2017-2019, representing a significant increase from previous years. Over eleven years ending in 2019, the Ghanaian government paid a total of GH82.5 billion in interest on the public debt (76.7 per cent of total debt servicing costs). Total debt servicing costs averaged 42.3 per cent of total tax revenue from 2009 to 2019. During this time, interest payments as a percentage of total tax revenue averaged 40.2 per cent. Thus, according to the World Bank, for every one cedi collected as tax revenue since 2009, 40.2 pesewas have been used to pay interest on the nation's debt. A further point to mention is that for every one cedi collected as to total revenue, 42.3 pesewas were used to service the national debt. According to

official figures, total interest payments on public debt exceeded total government capital expenditure for the sixth consecutive year in 2019. Suppose the government does not slow down the rate of borrowing. In that case, interest payments will almost certainly have to be financed by additional public debt or at the expense of other critical government expenditures.

The 2022 budget allocates over GH37.44 billion to pay interest on government debt, making it one of the essential items on the government's expenditure bill, even outspending the allocation for capital expenditure. Interest on government debt is one of the critical items on the government's expenditure bill, accounting for one-third of the total expenditure bill. There's also the issue of rising energy sector debts, for which the government declared a "state of emergency" in July 2019. Ghana's public debt profile and its associated servicing costs rise further as the country prepares for the crucial 2020 election cycle, marked by increased demand for improvements in living circumstances. The Minister of Finance stated that the 2019 Budget includes a provision for interest payments on loans and borrowings of GH18.6 billion. As projected in the 2020 Budget, interest payments totalled GH21.7 billion. According to the Minister, if the economy does not improve or grow to accommodate rising debt servicing costs, the debt-to-GDP ratio, which stood at 62.1 per cent in 2019, may suffer.

Another cause for concern is that foreigners hold a more significant portion of Ghana's public debt is another cause for concern. It poses severe risks to the country's balance of payments and external vulnerability. At the end of 2018, foreign investors held a total of 30 per cent of the country's domestic bonds, and they held a total of 64.9 per cent of the country's total public debt, according to the IMF. By March 2019, the situation had deteriorated to 67.2 per cent, making Ghana the country with the highest external holding of public debt in Africa, according to the World Bank. With more foreign investors, the government has had to deal with more market sentiment changes and currency exchange rate risks.

Ghana's freshly contracted state debt is also mainly non-concessional external foreign-currency debt, a significant source of concern. In this context, there is the possibility of capital flight if non-resident holders of the country's debt find other economies more attractive for investment than the one in which they are currently located. Furthermore, as foreigners hold a more significant proportion of Ghana's local bonds, the country has become more susceptible to investor confidence shifts and foreign exchange risks. As a result, the Ghanaian economy has become more vulnerable to the sentiments of foreign investors. If a panic situation arises that causes a capital flight, non-resident investors will sell off their holdings in the country.

Public debt is one of the most important macroeconomic indicators determining how a country is perceived in international markets. It is one of the factors that influence the flow of inward foreign direct investment. Furthermore, given that governments borrow primarily through the issuance of securities, the duration, interest rates, and overall cost of debt financing have significant implications for the economy, the future of businesses, and the provision of social services to current and future generations of citizens. According to Karazijien and Sabonien (2009), public borrowing is an unavoidable and morally reprehensible economic development. For economic growth, money from foreign investors (external debt) is injected into the economy, and assets (internal debt) are distributed among those who have more support than they can use and those who lack assets for developing economic initiatives and other needs. Numerous empirical studies have been conducted to determine the relationship between public debt and economic growth in developed and developing countries. However, the findings of these researchers are inconclusive on the relationship between public debt and economic development. (Pattillo et al., 2002; Pattillo et al., 2004, Kumar and Woo, 2010; Lici and Dika, 2016; and Irfan Alan, 2019) are a few examples.

Furthermore, the focus of these studies is on the relationship between public debt and economic growth in developing countries. In contrast, studies on determining the debt threshold level on economic growth are scarce in the region, as previously mentioned. The current debate over Ghana's public debt and its long-term viability served as the impetus for this paper. The study's goal is to figure out how much debt Ghana can handle and how that affects its economy.

2. LITERATURE REVIEW

2.1. Theoretical Review

There are several schools of thought on public debt: the Classical school views it as a burden on society; the Neoclassical school views it as detrimental to investment and growth; the Ricardian school views the state as a future tax debt (Barro, 1974); modern economists view public debt as a driver of economic growth if the funds are used productively, and the Conventional school believes in a frugal society. Because they thought that balancing the government's annual budget was a good thing on its own, classical economists came up with the idea that a budget deficit was a sign that the state couldn't keep its finances in order.

In the event of a recession, Keynes advocated increased government borrowing. Keynes observed that during a recession, firms cut back on investment while households cut back on spending. This results in an increase in private sector savings as well as an increase in unused resources. In this situation, government borrowing will not crowd out but instead inject money into the economy's circular flow and serve to "kickstart" economic activity. Government borrowing will aid in the recovery of the economy as well as provide an increase in tax revenues. Monetarists are harsher on government borrowing, claiming it is frequently due to political pressures rather than economic necessity. According to Milton Friedman, "There is nothing so

permanent as a temporary government program." Friedman said that government borrowing happens because of political interests that make governments spend more on programs like social security, farm subsidies, and healthcare.

2.2. Empirical Review

There are several studies on the impact of public debt on economic growth. These studies are inconclusive on the direction of the impact of public debt on economic growth. A few of these studies that are on the impact of debt threshold levels are (Chudik et al., 2017; Alam, 2019; and Awadzie, 2020).

Egbe and Aganyi (2014) analysed the impact of external debt on economic growth in Nigeria. The study used the Vector Auto-Regression (VAR) model to test whether or not external debt, the ratio of external debt to exports, and other economic control variables such as inflation, real exchange rate, and public investment stimulate economic growth proxied by gross domestic product (GDP) growth rate. The result indicates that there is a causation between external debt and economic growth in the Nigerian contest. External debt could not be used to forecast improvement or slowdown in economic growth in Nigeria. Mohanty (2017) evaluates the impact of external debt on economic growth in Ethiopia for the period 1981 to 2014. The study employed time-series data, and the result suggests the existence of a long-run relationship between external debt and economic growth in Ethiopia. The results show that Ethiopia's economy grows better when it has more money from outside sources.

Mumba and Hong Li (2020) examined the association between external debt and economic growth in nine Southern African nations from 2000 to 2018. They utilized a panel model to examine the relationship between external debt and economic growth. The empirical evidence shows that short-term external debt has a negative effect on economic growth over the long run, just like it does in the short run. Long-term external debt has a negative effect on economic growth in the short run and a negative significant effect on growth over the long run, which means that the funds gained from external sources are not used for economic activities like investment, capital formation, or technology.

Getinet and Erumo (2020) use the ARDL approach to examine the effects of public foreign debt on economic growth in Ethiopia, utilizing annual data from 1983 to 2018. The yearly GDP growth rate is a dependent variable in the model. Other macroeconomic variables such as trade openness (TRD), rate of inflation (INFL), and public expenditure to GDP ratio (NEXPGD) are explanatory variables, as are debt variables such as public external debt stock to GDP (PEDSGD), debt service stock to GDP (DSSGD), and debt service stock to export (DSSEXP). For long-run co-integration, bound testing was used, and ECM was used for short-run dynamics. The findings of this study revealed that the debt variables PEDSGD and DSSGD are major debt factors that have a negative long-term and short-term influence on Ethiopia's economic growth. Economic growth is hurt by another debt variable, DSSEXP. This one is only looked at in the short term.

On the other hand, Alam (2019) investigates the relationship between the debt threshold and GDP per capita growth by using Panel Threshold Regression. The study used G7 (advanced countries) from the period of 1995 to 2015. The results suggest that the scale of the debt threshold is ambiguous in this study because the debt threshold has no significant effect on GDP per capita growth at the threshold level of 62.47%. The magnitude of the debt effect is not the same below and above the threshold level. Awadzie (2020) investigates the relationship between debt and financial performance. The study employed the Panel Threshold Regression model introduced by Hansen (1999). The study used panel data covering a period of fifteen years from 2005 to 2019 for twenty-five listed companies on the Ghana Stock Exchange. Financial performance was measured by the return on assets. The study finds the threshold level of debt at 43.85%. The result of the study, however, indicates that the debt threshold level is positive in both low and high debt regimes, but the degree of debt impact on both regimes is not comparable. It has also been indicated that debt has a significant potential impact on financial performance in low debt regimes and a slightly lower impact in high debt regimes. The findings further suggest that more debts have been contracted by companies in low debt regimes than in high debt regimes.

3. DATA AND METHODOLOGY

This study's methodology is based on the threshold autoregressive (TAR) approach proposed by Tong (1983) and Hansen (1996). In this model, the dependent variable is a function of its lag. In the self-exciting threshold model, the lag dependent variable is used as the threshold variable. This model specifies that individual observations can fall into discrete classes based on the value of an observed (threshold) variable. In growth theory, the primary sources of growth power lie in accumulating production and promoting marginal and total factor productivity. The threshold level of inflation is based on the following equation:

$$Y_t = \beta'_1 \times_t h(qt \geq y) + \beta'_2 \times_t h(y < qt < y) + \varepsilon_t \quad (1)$$

Where γ_t is the dependent variable, \times_t is a vector of covariates with dimensions $1 \times k$ possibly containing lagged values of γ_t , β'_1 is a $k \times 1$ vector of regime-invariant parameters, ε_t is an iid error with mean 0 and variance σ^2 , h is a vector of exogenous variables with regime-specific coefficient vectors β'_1 and β'_2 , and q_t is a threshold variable that may also be one of the variables in \times_t . Regime 1 is defined as the subset of observations in which the value of being q_t less than the threshold y . Similarly, Regime 2 is defined as the subset of observations in which the value of q_t is greater than y .

$$\gamma_t = \beta_1' \times_t h + \varepsilon_t \quad \text{if } q_t \leq \gamma \quad (2)$$

$$\gamma_t = \beta_2' \times_t h + \varepsilon_t \quad \text{if } q_t > \gamma \quad (3)$$

Where q_t signifies the threshold variable, dividing all the observed values into two groups or "regimes". Term γ_t signifies the variable to be explained, whereas ε_t is a matrix that denotes the explanatory variable. The error term ε_t is white-noise iid, and γ represents the threshold value, which is unknown but can be estimated. The model implies that when the threshold variable is smaller than the threshold parameter, the regression Equation (2) is applicable. Let $h_t(\gamma) = \{q_t \leq \gamma\}$, and $\{.\}$ as an indicator function with $h = 1$ if $q_t \leq \gamma$ occurs, or $h = 0$ otherwise. In addition, when $\times_t(\gamma) = \times_t h_t(\gamma)$, the equations (2) and (3) are revised as follows.

$$\gamma_t = \theta' x_t + \rho' x_t(\gamma) + e_t, e_t \sim iid(0, \sigma_e^2). \quad (4)$$

Therein, $\theta = \theta_2$, $\rho = \theta_1 - \theta_2$, $e_t = [e_{1t} \ e_{2t}]'$, θ , ρ , and γ are the parameters to be estimated. Equation (4) allows all the regression coefficients to differ between sample groups. The resulting sum of squared error as a result of estimating these parameters θ , ρ , and γ can be expressed as follows:

$$S_1(\gamma) = \hat{e}(\gamma)' \hat{e}(\gamma) \quad (5)$$

The least-squares method for estimating γ was introduced by Hansen (1996). This can be achieved by minimizing the sum of squared errors in (5). The estimated threshold value is given as:

$$\hat{\gamma} = \text{argmin } S_1(\gamma) \quad (6)$$

And the variance of the residual is expressed as:

$$\hat{\sigma}^2 = \frac{1}{n} \hat{e}_t(\gamma)' \hat{e}_t(\gamma) = \frac{1}{n} S_1(\hat{\gamma}) \quad (7)$$

Once $\hat{\gamma}$ is obtained, the vector of parameter estimates is $\hat{\theta} = \theta(\hat{\gamma})$ and $\hat{\rho} = \rho(\hat{\gamma})$. The regression equation for a two-regime TAR model can be expressed as:

$$GDPPC_t = \beta_{10} + \beta_{11} PDGDP_t + \beta_{12} INFRATE_t + \beta_{13} TIGDP_t + \beta_{14} GEGDP_t + \varepsilon_t \quad \text{if } \leq \gamma \quad (8)$$

$$GDPPC_t = \beta_{20} + \beta_{21} PDGDP_t + \beta_{22} INFRATE_t + \beta_{23} TIGDP_t + \beta_{24} GEGDP_t + \varepsilon_t \quad \text{if } > \gamma \quad (9)$$

In assessing the model above, the threshold value is determined by obtaining the threshold value that limits the entirety of the squared error given by Equation (5). Since this paper aims to examine the inflationary threshold impacts on the connection between valuation and capital market performance, the quarterly growth rate of inflation is utilized as the core threshold variable in the examination. We have to test for the threshold impacts before applying the two-regime Threshold Autoregression (TAR) model. In this situation, it is undifferentiated from testing the null hypothesis of the linear model against the alternative view of the two-regime model for the Equation. Standard techniques for theory testing can't be applied in light of the trouble with the threshold boundary γ being unidentified under the null hypothesis. For this situation, the necessary appropriation of a vast example isn't dispersed by Chi-square dissemination.

Hansen (2000) proposed an answer to this issue and recommended that necessary tests be led using a Lagrange Multiplier (LM) bootstrap technique. For γ isn't distinguished under the invalid speculation of the no-threshold impact, a fixed bootstrap technique registers the p-values. To analyze by testing whether the coefficients in the two regimes are equivalent or not, the null hypothesis of no threshold impact to Equation is.

$$H_0 = \beta_{1i} = \beta_{2i} \quad i = 0 \dots \dots \quad (10)$$

Let S_0 and S_1 be the residual sum of squares under the null hypothesis and alternative of (9). As such, the F -test is based on:

$$F_1 = \frac{S_0 - S_1(\gamma)}{\hat{\sigma}^2} \quad (11)$$

Once the threshold effect exists, the next question is whether or not the threshold value can be known. The null hypothesis of the threshold value is $H_0: \gamma = \gamma_0$ and the likelihood ratio statistics are:

$$LR_1(\gamma) = \frac{S_1(\gamma) - S_1(\gamma_0)}{\hat{\sigma}^2} \quad (12)$$

Where $S_1(\gamma)$ and $S_1(\gamma_0)$ are the residual sums of squares from Equation (7) given the actual and estimated value, respectively. The asymptotic distribution of $LR_1(\gamma_0)$ can be used to form a valid asymptotic confidence interval about the estimated threshold values. The statistics of $LR_1(\gamma_0)$ are generally not distributed, and Hansen (2000) computed their no-rejection region, $c(\alpha)$, α is a given asymptotic level. That is if $LR_1(\gamma_0) \leq c(\alpha)$, where $c(\alpha) = -2 \ln(1 - \sqrt{1 - \alpha})$, the null hypothesis of $H_0: \gamma = \gamma_0$ cannot be rejected. Aside from testing the existence of one threshold value, to further investigate whether there are two or more threshold values that exist, we first employ the F_1 test to assess the null hypothesis of no threshold. If this

null hypothesis is rejected, then at least one threshold value is ensured. We next proceed to test the null of one threshold against the two thresholds. We assume a known estimated $\hat{\gamma}_1$ and proceed to search the second threshold, γ_2 . In this case, we obtain the following:

$$S_2^r(\gamma_2) = S(\hat{\gamma}_1, \gamma_2) \text{ if } \hat{\gamma}_1 < \gamma_2 \quad (13)$$

$$S(\gamma_2, \hat{\gamma}_1) \text{ if } \gamma_2 < \hat{\gamma}_1$$

The threshold value, the null hypothesis, and the F -test is respectively stated as follows:

$$\hat{\gamma}_2^r = \text{argmin } S_2^r(\gamma_2), \quad (14)$$

$$H_0 = \text{only one threshold} \quad (15)$$

$$F_2 = \frac{S_1(\hat{\gamma}_1) - S_2^r(\hat{\gamma}_2^r)}{\hat{\sigma}_2^2} \quad (16)$$

Where $S_1(\hat{\gamma}_1)$ is referred to as the sum of squared errors acquired from the previous threshold estimation. The residual variance is given as follows:

$$\hat{\sigma}_2^2 = \frac{1}{T} S_2^r(\hat{\gamma}_2^r) \quad (17)$$

The significance F_2 implies the rejection of the null of one threshold and two thresholds is expected. If the two thresholds cannot be rejected, then the confidence interval for two points (γ_1, γ_2) can be constructed in the same way. The procedures are carried out until the null in (17) can no longer be rejected.

4. FINDINGS AND DISCUSSIONS

This section focuses on the empirical estimation, presentation and economic interpretation of the regression results carried out using the methodology highlighted in the previous section.

4.1. Empirical Results

Table 1 presents a summary of the statistics for the variables that were used in the research paper. From 1990 to 2020, Ghana's average inflation rate was approximately 6.42 per cent, whereas the country's maximum and minimum inflation rates were 9.73 per cent and -0.46 per cent, respectively, during the same period. Ghana's average GDP growth over the same period was approximately 1.74 per cent, with a maximum of 6.13 per cent and a minimum of -6.13 per cent at various points in history.

Table 1: Descriptive Statistics

	GDPPC	PDGDP	INFRATE	TIGDP	GCGDP
Mean	1.737178	-4.680262	6.417439	8.089632	3.925201
Median	2.576422	-4.730551	7.878682	8.286252	3.892840
Maximum	6.130813	-2.409566	9.730751	10.38559	5.348060
Minimum	-6.151633	-6.924473	-0.460449	4.850936	3.167161
Std. Dev.	2.885501	0.969509	3.071229	1.394657	0.509607
Observations	117	117	117	117	117

The correlation matrix between the variables is shown in Table 2. The correlation coefficients for all of the explanatory variables range from -0.134 to 0.396, which is acceptable in order to avoid multicollinearity in the base regression model.

Table 2: Correlation Matrix

	GDPPC	PDGDP	INFRATE	TIGDP	GCGPD
GDPPC	1.000000				
PDGDP	0.231616	1.000000			
INFRATE	-0.551122	0.052602	1.000000		
TIGDP	-0.134096	-0.364883	-0.072072	1.000000	
GCGPD	0.232894	0.396211	-0.081464	-0.285789	1.000000

4.2. Test Statistics for Existence of Threshold Effects

Table 3 shows the threshold effects test results using the yearly public debt to GDP as the threshold variable. To correct the standard errors of the estimates, 1,000 bootstrap replications are used to produce the findings of the threshold test and asymptotic p-values in the endogenous threshold analysis.

The study first determines whether or not a threshold effect exists. F_1 statistics have a value of 13.23 per cent and a bootstrap p-value of 0.023. As a result, the F1 test strongly rejects the null hypothesis that there is no threshold at the 5% significant level, implying that there is at least one threshold. According to this variable, the projected ideal threshold value is 57.09 per cent, which separates the study's sample into two regimes (low public debt and high public debt regimes).

Table 3: Summary of Test Results of Debt Threshold Effect

Hypothesis Test	F-Test	Bootstrap P-Value	Estimated Threshold (%)	95% Confidence Interval
Null of no Threshold	13.23**	0.033	57.09%	[55.76%, 57.09%]
Null of one Threshold	1.79	0.989		

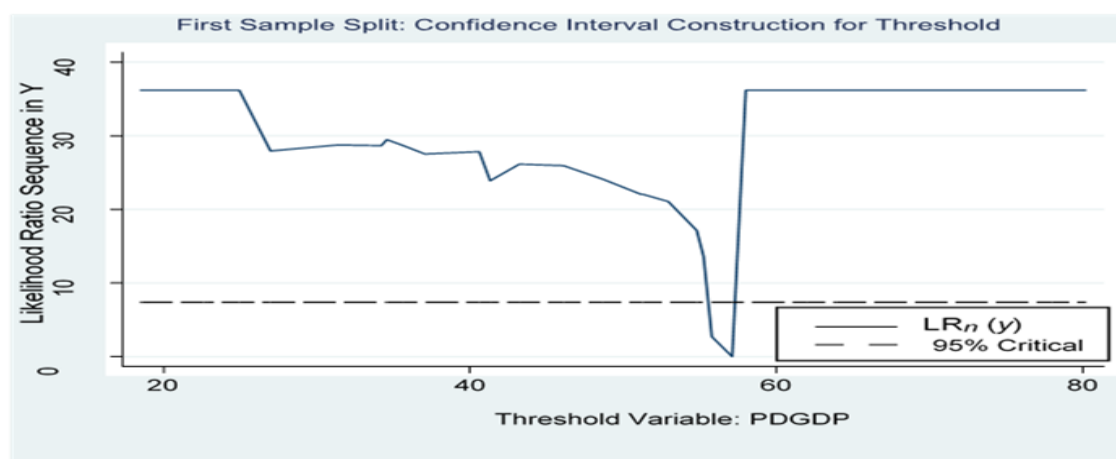
Notes: The estimation period is 1990 to 2020. The threshold variable is denoted as PDGDP. The thresholds are obtained by the minimum sum of the squared residual. The F test is calculated based on (15). "*" is significant for 5%.

The F test is also used in the study to see if there is the potential for more than one threshold. The split results in insignificant bootstrap p-values of 0.989 (i.e., the null hypothesis of one threshold cannot be rejected). As a result of the test technique, there is just one threshold, which is 57.09 per cent, and two public debt regimes in Ghana's debt-growth relationship. As a comparison, Alam's (2019) study shows that there is a structural break in the data.

The estimated threshold value is quite different from the panel data studies when using time series data and an endogenous TAR model. However, there is an underlying assumption in these panel studies that for all nations in the sample, there is a unique and single structural break in the link between inflation and economic growth beyond which inflation becomes deleterious to economic growth (Munir & Mansur, 2009). Sepehri and Moshiri (2004, p. 192) believe that imposing a single "inverted U" connection across countries at different stages of development and with distinct institutions and social norms is inappropriate. Once the paper finds the threshold, the next step is to figure out what exactly it is. The confidence interval around the threshold estimate is examined using the LR test. The asymptotic confidence interval of 95 per cent [55.76%, 57.09%].

The normalized likelihood ratio sequence $LR^*n(\gamma)$ statistics as a function of the PDGDP threshold are shown in Figure 1. The least-squares estimate of the threshold ($\hat{\gamma}$) is the number that minimizes the function $LR^*n(\gamma)$ and occurs at $(\hat{\gamma})=57.090$ per cent, as previously stated. The dotted line depicts the asymptotic 95 per cent critical value of 9.25 (which is significant at 5 per cent levels) and the confidence interval [55.76 per cent, 57.09 per cent] where it crosses $LR^*n(\gamma)$. This indicates that the threshold estimates are extremely accurate. As a result, there is substantial evidence to support one of the model's thresholds. These findings show that a two-regime specification is quite likely. As a result, the findings show that Ghana has a PDGDP threshold, which means that the data can be broken up into two different regimes.

Figure 1: First Sample Split: Confidence Interval Constructions for Threshold



4.3. The Relationship between Inflation and Economic Growth

Table 4 provides the estimation results of the relationship between public debt to GDP (PDGDP) and GDP per capita (i.e., GDP per capita growth) for Ghana from 1990 to 2020. For comparison purposes, the second column presents estimates for linear regression equation (2) that ignore the threshold effect. Columns (3) and (4) provide estimates of the two-regime TAR model. The empirical results obtained from the estimation of the linear model show that public debt to GDP (PDGDP) has no significant impact on GDP per capita growth. Under a low public debt regime, defined below 57.09 per cent, public debt has a significant positive impact on economic growth, where the significant coefficient is 0.674. Column (3) illustrates that, on average, a 1 per cent increase in public debt in Ghana leads to an increase in economic growth (GDPPC) by 0.67 per cent. However, in column (4), when public debt is higher than the threshold level of 57.09 per cent, public debt has a significant negative effect on economic growth, as the coefficient is -0.048 , suggesting that, on average, a 1 per cent increase in public debt leads to a decline in the economic growth of 0.048 per cent.

This study's findings on the nonlinear relationship between public debt to GDP (PDGDP) and economic growth are consistent with the empirical and theoretical conclusions reached in previous studies by Sarels (1996), Bose (2002), Lee and Wong (2005), and Munir et al. (2009); that is, inflation has a negative effect on economic growth in a high-inflation regime (i.e., when inflation is high). Furthermore, in this study, both the linear model and the TAR model demonstrate that the calculated coefficients of public debt have a negative and statistically significant association with GDPPC (GDP per capita growth). Total investment in GDP (TIGDP) has a positive and insignificant influence on economic growth in the linear model and low public debt regimes, but it has a negative and significant effect on economic growth in the high public debt regime. Finally, according to the findings, the ratio of government expenditure to GDP has a statistically significant negative and positive effect on economic growth in both low and high public debt regimes. While in a linear model, the ratio of government expenditure to GDP has a positive but insignificant effect on economic growth.

Table 4: Regression Results of Public Debt and GDPPC (1990–2020)

Variables	Linear Model	Threshold Model	
	(OLS without Threshold)	Regime 1 $\leq 57.090\%$	regime 2 $> 57.090\%$
Constant	4.389** (1.954)	5.079** (1.903)	17.422** (3.293)
PDGDP	0.069 (0.306)	0.674** (0.251)	-0.048** (1.074)
INFRATE	-0.534** (0.146)	-0.706** (0.167)	-0.181** (0.049)
TIGDP	0.185 (0.319)	0.384 (0.338)	-3.680** (0.623)
GEGDP	0.138 (0.495)	-1.463** (0.478)	0.571* (0.290)
Observation	31	19	7
R ²	0.332	0.535	0.929

NOTES: The dependent variable is gross domestic product per capita from 1990 to 2020. Standard errors in parentheses are White corrected for heteroscedasticity. The estimation results correspond to a trimming percentage of 15 per cent. ***, **, and * represent significant at 1 per cent and 5 per cent and 10 per cent levels, respectively.

5. CONCLUSION AND IMPLICATIONS

Using new econometric approaches that provide appropriate procedures for estimation and inference, this research re-examines the topic of the existence of threshold effects in the relationship between public debt and economic growth. Estimates were made using annual data for the thirty-one-year period between 1990 and 2020. Empirical findings strongly show that there is a point beyond which public debt has a detrimental impact on economic growth. This means that the relationship between public debt and economic growth in Ghana is non-linear. The estimated results suggest that when public debt is below 57.09 per cent, it can encourage economic growth. Again, when public debt exceeds the threshold level of 57.09 per cent, it is harmful to economic growth.

Finally, the policy implication gained from this analysis is that keeping public debt below the threshold level in Ghana is desirable, as it may aid in ensuring sustainable growth. The structural break technique is used in this study to illustrate that the influence of public debt on economic growth is not just negative in a high-public debt regime, but can also be positive and more significant in a low-public debt regime. As a result, by focusing monetary policy on keeping public debt at a low level, a

significant rise in growth can be accomplished. Ghana's economy may be able to rebound and take off more quickly if the country's public debt is kept low and stable. In addition, given the current state of the Ghanaian economy, the findings of this research are critical for policymakers and other stakeholders involved in economic decision-making. In this situation, as the study's findings indicate, public debt levels above 57.09 per cent may have a negative impact on economic growth. To sustain Ghana's debt, this paper strongly recommends the following:

The government of Ghana should stop compiling the external debt, which comes with an additional cost when there is a disparity in the currency.

The policymakers who matter in decision making should strongly check the escalating cedis.

The government should cut down on all unproductive expenditures.

The government should use its external debt wisely and maintain a proper and efficient debt management policy.

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EFFECT OF RISK AND MARKET COMPETITION ON EFFICIENCY OF COMMERCIAL BANKS: DOES OWNERSHIP MATTER?

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Anupam Das Gupta¹, Afsana Yesmin²

¹Department of Finance, University of Chittagong, Bangladesh.

anupam@cu.ac.bd, ORCID: 0000-0002-0094-4541

²Department of Business Administration, Premier University, Bangladesh.

afsanayesmin23@gmail.com, ORCID: 0000-0002-0332-8912

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ABSTRACT

Purpose– This study aims to investigate the impact of risk and market competition on the efficiency of Bangladeshi commercial banks, having a special effect of ownership.

Methodology– We select 43 commercial banks out of 61, adjusting outliers and missing data from 2000-2019. The two-step Generalized Methods of Moments (GMM) is used to investigate unbalanced dynamic panel data of 666 observations. Unit root, multicollinearity, and other pre-diagnostic tests support our selected method of investigation.

Findings– The two-step Generalized Methods of Moments (GMM) reveals that the impact of risk, stability, and market competition has a homogeneous effect on cost and human capital efficiency in Aggregate industry, Conventional, and Private banks' data. With the increase of risk (stability), the efficiency of banks increases (decreases); having an exception, the human capital efficiency of private banks decreases with risk-taking. However, market competition depicts the inverse association with the efficiency of Commercial banks, Conventional banks, and Private banks.

Conclusion– The nonlinear and quadratic effect of risk and market competition on different ownership of banks is also found valid in the Bangladeshi banking industry. Finally, the reaction of Islamic and Public banks asserts the opposite response to Conventional and Private banks, respectively.

Keywords: Efficiency, ownership, market competition, GMM estimators.

JEL Codes: D61, G21, C20

1. INTRODUCTION

The aftermath of the financial crisis through policy and regulatory change has shaken the global market also wave most institutions and markets. As a participant in the Global market, Bangladesh is not exceptional. The banking industry of Bangladesh is bank-based, and like most countries, the banking industry of Bangladesh is dominated by commercial banks. Moreover, the new entrance of commercial banks in regular intervals expands the market's total size and competition (Das Gupta, Sarker, & Rifat Rahman, 2021). The growing number of banks and increased competitive situations make the commercial banks shrink their profitability target and concentrate more on the customer base to hold on and grow. However, competition increases the diversity in banking and increases the risk-taking tendency of commercial banks (Zheng, Gupta, & Moudud-Ul-Huq, 2017). Regulatory changes and emphasis on its implementation pinpoint the concern of regulators and policymakers regarding risk-taking in the competitive market. As capital is the costly source of finance, so regulatory capital affects banks' cost efficiency. Thus regulatory changes raise the tension of banks in risk-taking and efficiency balance (Y. Altunbas, S. Carbo, E. P. Gardener, & P. Molyneux, 2007). Again shortage of capital and regulatory compliance failure threaten depositors' and other stakeholders' positions (Gupta, 2018).

In the efficiency concern, Cost and Human capital are increasingly crucial in the performance measure of banks. Cost efficiency is inversely proxied the profit efficiency; on the other hand, human capital efficiency becomes a sensation in the

banking industry due to bankers' rapid job switching tendency (Zheng, Gupta, & Moudud-Ul-Huq, 2018b). Therefore, concern regarding the profit portfolio and retention of efficient employees is increasingly recognized as a severe issue to delve into the impact of risk and market competition on the efficiency of banks.

The efficiency of banks addresses the cost and human capital efficiencies in this study. Unlike previous studies, we incorporate aggregate industry and different ownership concerns for in-depth evaluation of efficiency. The extended nonlinear and quadratic model of the empirical research also addresses how the efficiency pattern of different ownership commercial banks changes with risk-taking, stability, and competitive market situation. Moreover, the joint effect of risk and market competition examination reinforces nonlinear and quadratic prescription findings. Amidu and Wolfe (2013) point out six reasons behind the importance of competition as a worth considering factor of the financial market in a literature review survey. These reasons are, first, to have more access to households and organizations to financial services; second, to ensure activities of financial sectors; third stability; fourth, efficiency; fifth resilience market rate and sustainable monetary policy; and finally, playing a role in industrial development and economic growth. Therefore there is an apparent significant association between bank efficiency and competition (Gupta, Sultana, & Das, 2021).

This study addresses a few significant insights. Firstly, intense market competition significantly impacts cost-efficiency deterioration and enhancement of human capital efficiency(HCE). Secondly, the risk-taking of commercial banks of Bangladesh increases the cost and human capital efficiency and decreases with incremental stability. However, the impact risk and stability do not hold the same over time. Finally, the quadratic effect of risk and competition on different efficiency is observed heterogeneous across ownership changes. Thus, from the finding of the study and evaluation of literature, it is apparent that risk, stability, market competition, and other industry level and macroeconomic factors significantly affect the efficiency of different commercial banks of Bangladesh. Moreover, increased market competition and growth of financial institutions reduce the information cost that raises concern of efficiency evaluation of financial institutions (Hauswald & Marquez, 2006). Therefore, the investigation of factors affecting efficiency demands empirical examination.

Further organogram of the study is as follows. Section 2 illustrates the related literature. Methodology development presents in Section 3 and Section 4 shows the study's empirical findings. Finally, concluding remarks are presented in Section 5.

2. LITERATURE REVIEW

With the expansion of banks' scope and size, banks' efficiency has become a critical consideration in a competitive market. As banks share uniform funding sources, i.e., deposits, capital, etc., efficient use of scarce resources is necessary for sustaining in the competitive business environment. As efficiency affects and is affected by banks' risk, risk needs to be measured explicitly in efficiency measure and vice versa (Koetter, 2008). No conclusive finding is observed to attain a decision regarding the association of risk and efficiency. For the ease of readership and debate of past research, the literature review presents in the following subsections: (1) Literature depicting association of bank risk and efficiency, (2) Literature relating to competition and efficiency, (3) Literature examining the impact of ownership on risk and efficiency.

2.1. Literature Depicting the Relationship between Risk and Efficiency

A negative association between risk and efficiency is based on the phenomenon that efficiency gain reduces the risk. However, diversified findings are also evident in the literature opposing and supporting the inverse association. Gupta et al. (2021), Das Gupta et al. (2021), Zheng et al. (2018b), Nguyen and Nghiem (2015), Fiordelisi, Marques-Ibanez, and Molyneux (2011), among others, depict an inverse association between efficiency and risk. Nonperforming loan is one of the significant determinants of banks efficiency (Allen N. Berger & DeYoung, 1997). Finding also points out that monitoring and recovery management has a significant impact on bank efficiency. However, T Deelchand and C Padgett (2009) find the moral hazard hypothesis's relevance¹ in risk and efficiency association. Fiordelisi et al. (2011) pin point low cost and revenue efficiency to enhance banks' risk that supports 'bad management'² hypothesis. Technological advancement also affect in achieving cost efficiency of banks Nguyen and Nghiem (2015).

In contrast to the negative relationship, different studies show the positive relationship between risk and efficiency. The single country exposure of Tan and Floros (2013) on China illustrate a significant positive association between risk and efficiency. Similar findings also show Zangina Isshaq, Bokpin, and Amoah (2015) on Ghanaian banks.

The technical efficiency of banks increases the loan volume on the one hand and reduces screening and monitoring of investments that enhance bank risk on the contrary (Tan & Floros, 2013). However, Y. Altunbas, S. Carbo, E. P. M. Gardener, and P. Molyneux (2007) do not observe a meaningful association between risk and efficiency in commercial banks. Salim, Arjomandi, and Dakpo (2017) blame political interference as a critical reason for loan default. They opine that over time,

¹ Moral hazard hypothesis (MHH) postulates that undercapitalization leads banks to opt for riskier project that results incremental default risk subsequently.

² Bad management hypothesis (BMH) explains that deterioration of cost efficiency act behind incremental credit risk.

although the efficiency of banks increases, the quality of loans decreases because of political interference in loan proposal screening. From the literature between risk and efficiency hypothesis of the study is:

H₁: Risk has a significant positive effect in determining the efficiency of banks.

2.2. Literature Relating to Competition and Efficiency

Two dominant hypotheses say, 'competition-efficiency' and 'competition-inefficiency', are dominantly available in the literature. Adopting the efficient structure (Demsetz, 1973), the competition-efficiency hypothesis is presented by Schaeck and Čihák (2008). The authors explain that banks are forced to control their costs and offer low-cost services to cope with the competition to adjust to the exogenous shock. Managers are also forced to increase their profitability through the shifting of outputs. Again due to size benefit, large banks become more efficient in controlling cost and gaining profitability that in turn help efficient banks to have more market power. That means higher competition leads banks to be more efficient. A concentrated market creates the opportunity for managers to enjoy a 'quiet life'³, and banks become cost-inefficient due to ignorance of cost control.

Competition-inefficiency narrates the opposite concept of the competition-efficiency hypothesis. The hypothesis illustrates that market competition has a detrimental effect on banks' efficiency (Schaeck & Čihák, 2008). Schaeck and Čihák (2008) pinpoint several reasons for the apparent existence of competition-inefficiency. The competitive market creates diversified options for the customer to grasp the best alternative. As a result, the propensity to switch banks increases. Thus banks without robust and loyal customers fall into a liquidity crisis in deposit mobilization.

Moreover, banks do not incur many resources to gain more information to build a solid customer base in competitive markets. In a competitive environment, they are less intended to spend resources to care about relationship-building. Therefore, a competitive market increase cost of banks to retain and attract customers due to aggressive market effort and information asymmetry. Inverse association between efficiency and market competition is also addressed in empirical investigations. For example, Evanoff and Ors (2003), Kumbhakar, Lozano-Vivas, and Hasan (2001), Deyoung, Hasan, and Kirchoff (1998), among others, show that market competition negatively affects the efficiency of banks. Deyoung et al. (1998) depict the inverse association of the new entrant of banks and efficiency.

Zangina Isshaq et al. (2015) asserts that the cost efficiency of foreign banks moves along with their risk-taking. That means efficiency and risk of banks are positively associated. A similar finding is also observed in the literature. Alhassan and Ohene-Asare (2016) affirm the positive relationship and advocate that market competition significantly impacted banks' efficiency.

In contrast to these findings, the evidence of H. T. M. Phan, Daly, and Akhter (2016) depicts the inverse association of competition and efficiency of banks. Again Fungáčová and Poghosyan (2011) observe no meaningful association between competition and the efficiency of banks. However, contract finding is also evident. A. Kasman and Carvallo (2014) evidence a significant association and opine that enhancing efficiency increases banks' market power, which contributes to further efficiency gains.

H₂: Market competition has a significant negative effect on the efficiency of banks.

2.3. Literature Examining the Impact of Ownership on Risk and Efficiency

Empirical research also evidences the significant association of ownership in risk and efficiency of banks. Amor (2017) opines that concentrated and State ownership reduces Tunisian banks' risk-taking, whereas diversified ownership enhances the same. Similar observation also pinpoints by Liu, Brahma, and Boateng (2019) on Chinese banks. The author advocate government ownership in managing credit risk, whereas private banks exacerbate the default risk of banks. In contrast to these findings, Ehsan and Javid (2018) assert that Government and concentrated ownership have significant positive whereas foreign ownership has a significant negative impact on banks' risk-taking. The debate with contrasting findings also apparent in cross country examination. Hammami and Boubaker (2015) advocate the positive association of credit risk and concentrated ownership from the study of MENA countries. They also opine that foreign banks are taking more risk than domestic banks, where Government-owned banks are more stable than other counterparts. In another work on MENA countries, Haque (2019) evidence the inverse relationship between foreign ownership and risk-taking of banks. They also observe the negative association of concentrated ownership with the risk-taking of MENA banks.

Supporting the "concentration-stability" view, ElBannan (2015) evidence that concentration increases banks' stability. However, Government banks are more prone to credit risk than their counterparts. Pointing differently, Hu, Li, and Chiu (2004) argue that the impact of government ownership over risk-taking follows a nonlinear U-shape curve. With the increase of

³ Quiet Life hypothesis (QLH) explains insufficient monitoring of market creates market power which makes managers reluctant to take risk that results lower profit and higher cost.

Government ownership, risk-taking decreases at a certain point and then increase. Working on Bangladeshi commercial banks, Moudud-UI-Huq, Biswas, Chakraborty, and AMIN (2020) preach that ownership structure has a significant positive association in default risk management and stability. Another empirical finding of Sarker and Nahar (2017) on Bangladesh enforces the impact of ownership on the risk-taking of Bangladeshi commercial banks. The authors depict that private commercial banks take less risk than parallel Government commercial banks. Evidence of Srairi (2013) of MENA countries shows that ownership does not significantly impact the stability of banks; however, Islamic banks are more efficient in credit risk management than conventional banks. Shehzad, de Haan, and Scholtens (2010) opine that ownership concentrations significantly affect banks' credit risk; however, these effects depend on protecting shareholders' rights and supervisory control.

The empirical study of Haque and Shahid (2016) examining the impact of ownership on risk-taking and performance of banks depicts that Government ownership increases the stability and credit risk of banks and reduces the performance in the form of profitability. A similar finding is observed in the Iannotta et al. (2007) study. Iannotta et al. (2007) opine that although ownership concentration is not statistically significant in the profitability of banks, but has a meaningful impact on loan quality and stability of banks. They also opine that large shareholders' ownership concentration has no significant effect on banks' risk and stability measures.

In examining the causal effect of ownership on efficiency, Altunbas, Gardener, Molyneux, and Moore (2001) preach that private banks are more efficient than mutual and public German banks. However, public and mutual banks have cost and profit advantages over private banks. Djalilov and Ngoc Lam (2019) findings also acknowledge the impact of ownership on banks' efficiency. The author pinpointed that banks with no controlling shareholders are observing lower efficiency. However, higher risk-taking plays an inverse role in confirming efficiency. In contrast to this finding, Aymen (2014) follows no significant impact of ownership on the performance of Tunisian banks. Few studies on single countries and cross countries also address substantial insights regarding the effects of ownership on the efficiency of banks.

Allen N Berger, Hasan, and Zhou (2009) postulate minority foreign ownership significantly enhance the efficiency of Chinese banks. The authors add that State-owned banks are the least efficient, and multinational banks are most efficient in China. Mamonov and Vernikov (2017) assert that banks' cost-efficiency depends on ownership and lending ratios. They argue that as government banks are led to politically motivated unprofitable loans, they are cost-efficient with a low lending ratio. In contrast, foreign banks are more efficient when they lend more.

Examining 82 cross countries, Doan, Lin, and Doong (2018) opine that State-owned banks are less efficient than their counterparts. However, the efficiency of foreign banks is heterogeneous. The authors pinpoint the efficiency of foreign banks' influence through diversification, and they are less efficient in developed countries but more efficient in developing countries. In contrast to this finding, another work on 105 cross countries Lensink, Meesters, and Naaborg (2008) provide empirical evidence of a negative relationship between foreign ownership and the efficiency of banks. They argue that good governance can make the negative effect of ownership less pronounced.

From the study of existing literature, there is a vacuum of empirical examination of how risk and efficiency are related in different ownership setups. Again the impact of ownership is homogeneous or heterogeneous over time on efficiencies yet to examine from a developing country perspective. Moreover, most of the studies focus on cost and profit efficiency. There is a scarcity of literature observing the effect of risk-taking and competition on human capital efficiency.

H₃: There is a heterogeneous impact of ownership on the efficiency of banks.

3. METHODOLOGY OG THE STUDY

This section explains the data and variables used in the study and the empirical analysis methods. At first, the description of variables and the following econometric models are described in this section.

3.1. Collection of Data

We source macroeconomic and industry-level data from the World Banks dataset and derive from where required from industry data of Bangladesh Bank. There are 61 schedule banks now operating in Bangladesh's Banking industry, including two newly entered banks in 2020. However, after excluding nine foreign commercial banks and three specialized banks due to non-availability and inconsistent reporting nature, we have 43 commercial banks for the study. Banks without having five years' consecutive reports and extreme (ICB commercial bank) outlier effect were also excluded from the dataset. After excluding missing years' data over 2000-2019, we have 666 unbalanced panel observations.

The remaining part of this section explains the data and variable description of the study and empirical econometric model to address the impact of risk and market competition on the Efficiency of Bangladeshi commercial banks.

3.2. Definition of Variables

Efficiency (dependent variable)

Following A. Kasman and Carvallo (2014), Zheng, Gupta, and Moudud-UI-Huq (2018a), Gupta and Moudud-UI-Huq (2020), Gupta et al. (2021), among others, we also determine Cost efficiency and Human Capital efficiency through Stochastic Frontier Analysis (SFA). Software FRONTIER version 4.1 opt for measuring bank efficiency from banks level data.

Using the intermediation approach (Sealey & Lindley, 1977) and following recent studies of Moudud-UI-Huq (2020), Gupta et al. (2021), Zheng et al. (2017), T. Deelchand and C. Padgett (2009), the translog cost function with three inputs and two outputs against the total cost as a dependent variable as follows.

$$\ln TC = \alpha + \sum_i \alpha_i \ln Q_i + \sum_j \beta_j \ln P_j + \frac{1}{2} \sum_i \sum_k \gamma_{ik} \ln Q_i \ln Q_k + \frac{1}{2} \sum_j \sum_h \delta_{jh} \ln P_j \ln P_h + \sum_i \sum_j \lambda_{ij} \ln Q_i \ln P_j + \varepsilon \quad (1)$$

Changing the error term to $V_n - U_n$ from $V_n + U_n$ and using the equation as a production function following Coelli (1996), we determine the human capital efficiency with three inputs and two outputs. Detailed estimation presents in Appendix A. Summary description of variables with literature reference is given in **Table 3**.

Risk Measures

The study chooses two measures- credit and stability risk to address bank risk.

Credit Risk: Following the previous literature of Abedifar, Molyneux, and Tarazi (2013), Liang, Xu, and Jiraporn (2013), Liang et al. (2013), Zheng et al. (2018b), Gupta et al. (2021), credit risk is also addressed through the ratio of Nonperforming loan to total loans and advances (NPLTL). The ratio indicates the proportion of default to total investment. The higher the ratio NPLTL, the more credit risk exposure.

$$NPLTL = \frac{\text{Non - performing Loan}}{\text{Total Loan and Advances}}$$

Stability Risk (Z-score): Z-score is the inverse measure of credit risk and direct measure of stability. A large ratio of Z-score refers to more stability. We derive Z-score by adding CAR with ROA, where CAR refers to capital adequacy ratio, and ROA denotes return on assets—then divided the sum by standard deviation (SD) of ROA. We use three years of successive data of ROA to determine the SD of ROA.

$$Z\text{-score} = \frac{(CAR+ROA)}{\delta(ROA)}$$

Following the study of Craig and Dinger (2013), Zheng et al. (2017), Moudud-UI-Huq, Zheng, and Gupta (2018), Gupta and Moudud-UI-Huq (2020), among others, Z-score is used to denote the stability risk. A higher ratio of Z-score indicates more stability and lower insolvency risk of banks (Roy, 1952). Detailed measurements explain in Table 1.

Market Competition (Boone indicator)

Following the literature of Gupta (2018), S. Kasman and Kasman (2015), Gupta and Moudud-UI-Huq (2020), and Tabak, Fazio, and Cajueiro (2012), this study is also opted for Boone Indicator to examine the competition effect. Boone indicator is a better-fitted model and encounters the problems of theoretical measure of market concentration and inverse competition measure Lerner index and (Lerner, 1934) and Posner and Rosses H-statistic (Zheng et al., 2017). BI assumes efficiency gain at minimum cost with maximum profitability (S. Kasman & Kasman, 2015). The empirical model used by S. Kasman and Kasman (2015) to estimate BI is,

$$\ln(ms_{st}) = \alpha + \sum_{t=1}^{T-1} \beta_t D_t \times \ln(mc_{st}) + \sum_{t=1}^{T-1} \theta_t D_t + \varepsilon_{st} \quad (2)$$

'ms' and 'mc' of the above equation refer to market share and marginal cost. Time dummies (D) are also incorporated in the model to control the time effect. Boone indicator represented by the coefficient β stands for Boone indicator and ε_{st} is the error term. An intense competitive market denotes by the large negative value of BI. However, information on the Boone indicator is not available in the World Banks data set after 2017. Following Schaeck and Cihák (2014), we also determine the value of the Boone indicator empirically from the aggregate industry data of Bangladesh Banks. The model for estimating Boone indicator is,

$$\Pi_{it} = \alpha + \beta \ln(MC_{it}) \quad (3)$$

Where Π_{it} refers to measures of profit of bank 'i' at 't' time and is measured through ROA; β is the Boone indicator. To determine the marginal cost, we follow Schaeck and Cihák (2014) suggestions and Boone (2008) and use average variable

cost as a proxy of marginal cost. We regress the logarithmic value of ROA ($\ln ROA$) with the logarithmic value of average variable cost ($\ln MC$) and determine the value of the market competition measure.

Detail measures of other variables are given below.

Table 1: Summary of Variables Description of the Study

Classification	Variable	Description	Literature references/Source
Dependent Variable			
Efficiency	Eff_C	Cost efficiency determined through stochastic frontier analysis	Harimaya and Ozaki (2021), Gupta (2018), Zheng et al. (2018b).
	Eff_HC	Human Capital efficiency determined through stochastic frontier analysis	Zheng et al. (2018b), Gupta (2018).
Independent Variables:			
Dummy Variables			
	Own _C	Ownership dummy- Conventional banks. Conventional Banks = 1, Otherwise = 0 (Islamic Banks).	Authors' calculation.
	Own _P	Ownership dummy- Private banks. Private Banks = 1, Otherwise = 0 (Public Banks)	Authors' calculation.
Industry-level variables:			
	BSD	Banking sector development= Ratio of Industry assets to GDP	Gupta et al. (2021), Das Gupta et al. (2021). Source: World Bank data
	BI	Boone Indicator: Competition proxy (see 3.2.3) $\Pi_{it} = \alpha + \beta \ln(MC_{it})$ Where β is the Boone indicator.	Gupta et al. (2021), Zheng et al. (2017), Schaeck and Cihák (2014). BI Derived by the authors following literature reference.
Macroeconomic variables:			
	GGDP	The growth of real gross domestic product	Moudud-UI-Huq (2020), Anupam Das Gupta (2021). Source: World Bank data.
	Inflation	Inflation, GDP deflator (annual %)	Gupta and Moudud-UI-Huq (2020), Gupta et al. (2021). Source: World Bank data.
Bank-level control variables:			
Risk measures			
Credit risk	NPLTL	Nonperforming loan to total loan and advances (Nonperforming loan denotes the default loans)	Das Gupta et al. (2021), Fang, Lau, Lu, Tan, and Zhang (2019), (Zheng et al., 2018b)
Stability risk	Z-score	Z-score= $\frac{(CAR+ROA)}{\delta(ROA)}$, Where ROA= Return on assets, CAR = capital adequacy ratio, & $\delta(ROA)$ = standard deviation of ROA of three years overlapping periods.	Gupta and Moudud-UI-Huq (2020), Farruggio and Uhde (2015), Pan and Wang (2013), Craig and Dinger (2013), Beck, Demirgüç-Kunt, and Merrouche (2013).
Size of Bank	Size	The logarithm of total assets	Yesmin (2018), Bougateg and Mgadmi (2016), Goddard, Molyneux, and Wilson (2004).
Profitability	ROA	Return on assets	Davis and Mathew (2017), Javaid (2016), Tan (2016), Anarfi, Abakah, and Boateng (2016).
Off-balance sheet exposure	OBSTA	Ratio off-balance sheet exposure to total assets (TA)	Yesmin (2018), Gupta (2018), Mongid, Tahir, and Haron (2012).
Deposit ratio	DTA	The ratio of deposit to TA	Yesmin (2018), Gupta (2018), Zheng et al. (2017).

Source: Compilation of authors. Fourth column of the table refers to the literature followed in measurements.

3.3. Empirical Research Framework

To address the effect of risk and market competition on the efficiency banks, we opt for System GMM (Generalized Method of Moments). Ownership dummy is considered to pinpoint the diversified effect of ownership, say Conventional banks vs Islamic banks; Private banks vs Public banks, in risk-taking and competitive market situations. Unbalanced panel data opt for examination to increase the degrees of freedom and cover maximum observations. Unbalanced panel data allows maximum statistical approximation and observation through the multiplication of cross-section with periods (Gupta et al., 2021). For the unbalanced dynamic panel data of the study, we use system GMM following Arellano and Bover (1995) and Blundell and Bond (2000). System GMM addresses the model's endogeneity, heteroskedasticity, and autocorrelation problem (see Appendix B) (Baselga-Pascual, del Orden-Olasagasti, & Trujillo-Ponce, 2018; Gupta & Moudud-UI-Huq, 2020; Moudud-UI-Huq, Ashraf, Gupta, & Zheng, 2018; Zheng et al., 2018a).

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \sum_{j=3}^4 \beta_j X_{i,j,t} + \sum_{m=5}^6 \beta_m X_{i,m,t} + \sum_{p=7}^{11} \beta_p X_{i,p,t} + \varepsilon_{i,t} \quad (4)$$

In the above empirical model. ' $Y_{i,t}$ ' represents the dependent variable-efficiency. Cross-sectional dimension denotes by the subscript 'i', and the subscript m,n,p denotes macro-economic (ME), industry-level(IL), and bank-level(BL) control variables, respectively. 't' refers to the time dimension and is expressed in the year. One year lagged dependent variable denotes by $Y_{i,t-1}$. The study covers data from the year 2000 to 2019.

The macroeconomic variables Inflation and GDP growth (GGDP) denotes by $X_{i,j,t}$. The ' $X_{i,m,t}$ ' depicts IL control variables: Competition Boone Indicator (BI) and Banking Sector Development (BSD) at t period. The $X_{i,p,t}$ refers to the banks level control variables of bank i at t period. Bank-level control variables are risk (NPLTL, Z-score), deposit to total asset (DTA), Size (logarithm of TA), Profitability (ROA), and Off-balance sheet exposure (OBSTA).

The pre-diagnosis test results restrict the use of OLS as a regression method due to heteroskedasticity (Breusch-Pagan / Cook-Weisberg test for heteroskedasticity), autocorrelation (Breusch-Godfrey LM test for autocorrelation). The preliminary model test also advocates the fixed-effect model (Hausman specification test). The lagged dependent variable in equation (4) depicts the dynamic panel and reject the assumption of OLS.

Therefore, system GMM estimates opt for an unbiased and consistent result of the fixed-effect unbalanced dynamic panel data model. System GMM addresses the discrepancies in unobserved and bias estimation (Arellano & Bover, 1995; Blundell & Bond, 2000). Our second-order serial correlation test results cannot reject the null hypothesis 'no serial correlation' of Arellano-Bond hypothesis. Our test results of AR(1) and AR(2) are in line with Nguyen and Nghiem (2020), Gupta and Moudud-UI-Huq (2020), H. T. Phan, Anwar, Alexander, and Phan (2019), Zheng et al. (2018b), among others. To remove the time-dependent inconsistencies, AR (2) in residuals must be statistically insignificant, observed in all our applied models.

To address the impact of ownership, we redefine the baseline equations with ownership dummies. Two ownership dummies- Conventional banks and Private banks- are considered treatment variables considering counterparts as zero in the model to address Conventional vs Islamic, and Private vs Public banks, respectively. Models with ownership dummy as follows:

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} \times Own_{C/P} + \beta_4 BI_{i,t} \times Own_{C/P} + \beta_5 BSD_{i,t} + \sum_{j=6}^7 \beta_j X_{i,j,t} + \sum_{p=8}^{11} \beta_p X_{i,p,t} + \varepsilon_{i,t} \quad (5)$$

Equation (5) precise how risk-taking and market competition affect Conventional vs Islamic banks and Private vs Publics banks of Bangladesh.

However, we also extend our baseline models to address the nonlinear and joint effect of risk and competition on bank efficiency. Assuming heterogeneous behavior of different ownership banks and risk-taking of the competitive market situation, we extend our baseline models as:

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} + \beta_4 risk_{i,t}^2 + \beta_5 BI_{i,t} + \beta_6 BI_{i,t}^2 + \beta_7 BSD_{i,t} + \sum_{j=8}^9 \beta_j X_{i,j,t} + \sum_{p=10}^{13} \beta_p X_{i,p,t} + \varepsilon_{i,t} \quad (6)$$

Equations (6) & (7) express the nonlinear and joint effect of risk and competition on bank efficiency.

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} + \beta_4 risk_{i,t}^2 + \beta_5 BI_{i,t} + \beta_6 BI_{i,t}^2 + \beta_7 risk_{i,t} \times BI_{i,t} + \beta_8 risk_{i,t} \times BI_{i,t}^2 + \beta_9 BSD_{i,t} + \sum_{j=10}^{11} \beta_j X_{i,j,t} + \sum_{p=12}^{15} \beta_p X_{i,p,t} + \varepsilon_{i,t} \quad (7)$$

Equation (8) presents the extended model depicting the quadratic effect of risk and completion in different ownerships.

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} \times Own_{C/P} + \beta_4 risk_{i,t}^2 \times Own_{C/P} + \beta_5 BI_{i,t} \times Own_{C/P} + \beta_6 BI_{i,t}^2 \times Own_{C/P} + \beta_7 BSD_{i,t} + \sum_{j=8}^9 \beta_j X_{i,j,t} + \sum_{p=10}^{13} \beta_p X_{i,p,t} + \varepsilon_{i,t} \quad (8)$$

Where ' $BI_{i,t}^2$ ' and ' $risk_{i,t}^2$ ' refer to the squared term of competition and risk, respectively.

Product of risk and ownership dummy, Competition and ownership dummy address the impact of risk-taking and competition in different ownership concerns. The model efficiency of cost with credit risk and stability in empirical results is levelled as Model I and III. Again, Model II and Model IV denote the efficiency of human capital with credit risk and stability, respectively.

4. EMPIRICAL FINDINGS

This section at first presents the summary statistics (Table 2), Unit root test (Table 3), and multicollinearity test (Table 4-5), then presents the empirical finding of the study. The empirical results depict the impact of risk and market competition on the efficiency of banks presented in Table 6-10.

4.1.1. Descriptive Statistics

Summary statistics of Table 2 note that mean value of dependent variables efficiency of cost and efficiency of human capital are 1.4397 and 0.3596, respectively. The efficiency values are derived from the stochastic frontier analysis (SFA). The value of cost-efficiency is usually more than 1, whereas human capital efficiency is less than 1. Details estimation of efficiency against their dependent variables, inputs, and outputs is given in Appendix A. The average value of risk measures NPLTL and Z-score are 0.0797 and 87.90, respectively. That means the average nonperforming loan ratio to total loan is about 8%. However, there is no NPL (0) ratio and 100% NPL to total loan. Market competition measure Boone Indicator (BI) shows the mean value -3.5736. Boone Indicator usually shows the negative ratio. The higher the BI value, the more intense the competitive market. The mean of BI of the Bangladeshi banking industry depicts low competition than the Asian average ratio of -7.50 (Zheng et al., 2017).

Table 2: Summary Statistics of the Variables

Variable	Mean	Std.	Min	Max
Eff_C	1.4397	0.2527	1.0262	2.7661
Eff_HC	0.3596	0.1971	0.1059	0.9620
NPLTL	0.0797	0.1105	0.0000	1.0000
Z-score	87.9014	151.7654	-227.2060	1624.7390
DTA	0.7969	0.1002	0.1845	2.2597
ROA	1.1558	1.2871	-13.5200	6.0500
Size	11.3713	1.1692	8.3667	14.2031
OBSTA	0.2814	0.1314	0.0000	0.9251
GGDP	6.3381	1.0289	3.8331	8.1527
Inflation	6.0414	1.3036	3.2612	8.1646
BI	-3.5736	2.5085	-8.6020	-0.0952
BSD	50.7405	21.8676	18.3879	80.3359
Number of observations	666			

The mean inflation value is 6.04, which is lower than India, 9.16, and higher than the largest Asian country China 2.97 (Zheng et al., 2017). However, in economic progression (GGDP), Bangladesh 6.33 shows better than the Asian market (Gupta et al., 2021; Soedarmono & Tarazi, 2013). Industry-level variable BSD depicts the mean value of 50.74. Bank-level control variables Size, DTA, ROA, and OBSTA show the average value 11.37, 0.7969, 1.15, and 0.2814, respectively.

4.1.2. Unit Root Test

We run the Fisher Type Augmented Dickey-Fuller test to check the unit root for each variable and the data stationary. From Table 3 of the unit root test, no observation is significant against Fisher-type ADF test statistics at a 5% significance level. Thus the value finds no statistical evidence to accept the null hypothesis of "All panels contain unit roots."

Table 3: Unit Root Test (Fisher type ADF) at Level

Variable	Statistic	Probability
Eff_C	224.300	0.000
Eff_HC	217.738	0.000
NPLTL	6.171	0.000
Z-score	29.203	0.000
Size	36.976	0.000
DTA	30.872	0.000
ROA	13.580	0.000
OBSTA	4.446	0.000
BI	9.140	0.000
BSD	-3.378	0.001
Inflation	1.945	0.025
GGDP	7.302	0.000

It advocates that panel series data does not contain unit root or the data is stationary.

4.1.3. Multicollinearity Test

To check the multicollinearity problem between or among the variables, we run the variables' correlation analysis and VIF test. Table 4 of the correlation matrix does not show any correlation value between independent variables above 0.70, indicating that our models are free from significant multicollinearity problems.

Table 4: Correlation Matrix

	NPLTL	Eff_C	Eff_HC	DTA	ROA	Size	OBSTA	GGDP	Inflation	BI	BSD
NPLTL	1										
Eff_C	-0.1392	1									
Eff_HC	0.3066	-0.0858	1								
DTA	-0.0313	-0.1710	0.1212	1							
ROA	-0.3540	-0.0261	-0.2387	0.0566	1						
Size	0.1327	0.4374	0.3624	0.0226	-0.2832	1					
OBSTA	-0.0786	0.0641	-0.0966	0.1325	0.1973	0.0077	1				
GGDP	-0.0219	0.4590	-0.1604	-0.0607	-0.2362	0.5081	-0.0667	1			
Inflation	-0.1896	0.0913	-0.0464	-0.0538	0.0177	0.2867	-0.0821	0.1222	1		
BI	-0.0999	-0.1774	0.0844	0.0130	0.1438	-0.0935	-0.0063	-0.3673	0.2751	1	
BSD	-0.0210	0.5643	-0.2158	-0.1896	-0.2159	0.6570	-0.2178	0.6233	0.2488	-0.2821	1

Multicollinearity refers to the exact linear relationship between independent variables (Gujarati, 2009). If two or more variables exist in the same model, then the explanation of the independent variable may exaggerate. Gujarati and Porter (2009) state that if the pairwise correlation value is less than 0.80, the model is free from severe multicollinearity problems. Again, Kennedy (2008) refers to the value 0.70. As no pairwise correlation value is more than 0.70 so the models of the study are free from multicollinearity.

Further, we check the Variance Inflation Factor (VIF) test to reinforce the 'no multicollinearity' claim (see Table 5). VIF measures the relationship between one predictor with another in a model. The VIF test predictor value 1 refers to the variable that does not correlate with other variables, where value 10 depicts a high degree correlation (Thompson, Kim, Aloe, & Becker, 2017).

Table 5: Variance Inflation Factors

Variable	VIF
BSD	3.69
Size	2.67
GGDP	2.34
OWN _p	1.73
OWN _c	1.15
NPLTL	1.44
ROA	1.40
BI	1.36
Inflation	1.32
OBSTA	1.28
DTA	1.13

Since no correlation value is above 0.70 and VIF more than 5, we may conclude no multicollinearity problem between variables in the regression models.

4.2. Determinants of Efficiency and Examination Impact of Risk and Market Competition

Table 6 depicts the effect of risk and market competition on the efficiency of commercial banks. The results of Table 6 show that with the increase of credit risk (NPLTL), both cost and human capital efficiency enhances. However, with the growth of stability of banks, efficiencies are inversely affected. These findings align with Zangina Isshaq, Bokpin, and Amoah (2012). Proportionate reduction of loan monitoring cost is one of the possible reasons for increased efficiency with enhancing credit risk (Tan & Floros, 2013). Another explanatory variable, Boone Indicator (BI), shows the negative association with the efficiency of banks. BI usually shows the negative figure; a positive sign of coefficient refers to an inverse relationship with the dependent variable. It advocates that efficiency of cost and human capital decreases in a competitive market. These findings also support the previous results of H. T. M. Phan et al. (2016). The negative association of human capital efficiency may be the outcome of the increased credit risk of banks. Nonperforming loans are considered one of the inputs of measuring human capital efficiency. Thus, incremental nonperforming loans may decrease human capital efficiency in competitive market situations (Gupta et al., 2021).

Table 6: Effect of Risk and Market Competition on Efficiency of Banks

Variable	Model I	Model II	Model III	Model IV
Dep(-1)	1.084021***(4348.22)	1.005078***(4894.55)	1.083911***(5350.90)	1.00528***(6709.63)
NPLTL	0.001842***(7.98)	0.001343***(16.1)		
Z-score			-5.38E-06***(-19.34)	-1.16E-07***(-12.47)
BI	8.69E-06***(6.95)	1.02E-05***(25.84)	2.44E-05***(4.23)	7.41E-06***(13.91)
BSD	-3E-05***(-13.5)	0.000023***(17.08)	-2.7E-05***(-9.78)	2.38E-05***(15.85)
GGDP	0.000123***(17.69)	5.48E-05***(17.58)	0.000178***(7.23)	4.18E-05***(12.30)
Inflation	-0.00014***(-18.7)	2.76E-05***(23.39)	-0.00028***(-13.09)	8.42E-06***(5.03)
Size	-0.00012***(-2.90)	-0.00027***(-13.48)	9.21E-05(1.43)	-0.00027***(-11.25)
DTA	5.56E-05(0.54)	-0.00035***(-4.27)	0.000419*(1.82)	-0.00049***(-11.68)
ROA	-0.0000167*(1.91)	-2.5E-05***(-6.92)	-6.3E-05***(-5.75)	-5.3E-05***(-16.38)

OBSTA	-0.0023***(-12.37)	0.000823***(15.82)	-0.00278***(-13.15)	0.000805***(17.75)
Constant	-0.08689***(-129.44)	-0.00575***(-42.12)	-0.08814***(-140.21)	-0.00542***(-28.30)
Hansen Test (P-value)	0.827	0.947	0.712	0.981
AR(1) (P-value)	0.083	0.795	0.109	0.551
AR(2) (P-value)	0.134	0.379	0.372	0.803
Observations	623	623	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano–Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

The coefficient of BSD, Inflation, and OBSTA depict the negative (positive) association with the efficiency of cost (efficiency of human capital) model. With the passage of banking sector development, inflationary growth, and increased off-balance sheet exposures, the cost efficiency of banks decreases and human capital efficiency increases. Age or experience of operations in the banking industry playing a possible role in such a relationship. However, deposit mobilization (DTA) explores the opposite relationship, which means the proportionate increase of deposit over assets increases cost efficiency and decreases human capital efficiency. Small-sized banks with low profitability are more efficient than their other counterparts. These findings are aligned with Gupta (2018). The significant coefficient of GGDP depicts that economic progress enhances the efficiency of the commercial banks of Bangladesh.

4.3. Determinants of Efficiency and Examination of the Impact of Risk and Market Competition with Ownership Dummy

The study opts for two ownership dummies to examine the impact of risk and market competition on different ownership of banks. Dummy variables address the multiple groups in a single equation. The treatment group was considered 1 and the control group 0 (Wooldridge, 2016). We considered two dummy variables. Conventional banks and Private banks denote through treatment groups, and counterparts refer otherwise, i.e., Islamic and Public banks, respectively, as control groups of formers.

Table 7: Effect of Risk and Market Competition on Efficiency of Banks with Ownership Dummies

Variable	Segment A				Segment B			
	Model I	Model II	Model III	Model IV	Model I	Model II	Model III	Model IV
Dep(-1)	1.084484*** (5229.8)	1.005079*** (2992.16)	1.084371*** (4712.39)	1.005263*** (7653.13)	1.084186*** (5176.72)	1.005094*** (6418.12)	1.084128*** (4716.61)	1.005008*** (7421.95)
NPLTL × Own _c	0.001675*** (7.19)	0.001384*** (17.11)						
NPLTL × Own _p					0.000751** (2.66)	-0.00021** (-2.24)		
Z-score × Own _c			-2.68E-07*** (-10.57)	-1.18E-07*** (-11.88)				
Z-score × Own _p							-8.16E-07*** (-24.65)	-8.98E-07*** (-6.05)
BI × Own _c	8.46E-05*** (23.26)	1.16E-05*** (24.91)	8.22E-05*** (30.49)	5.33E-06*** (8.76)				
BI × Own _p					2.71E-05*** (19.39)	0.000038*** (23.91)	1.32E-05*** (9.53)	2.31E-05*** (12.71)
BSD	-3.1E-05*** (-22.7)	2.32E-05*** (23.87)	-3.2E-05*** (-20.79)	0.000024*** (22.66)	-3.3E-05*** (-24.37)	2.44E-05*** (28.26)	-3.1E-05*** (-17.30)	2.33E-05*** (11.88)
GGDP	0.000161*** (26.99)	5.44E-05*** (20.19)	0.000154*** (27.41)	4.05E-05*** (17.00)	0.000131*** (38.11)	5.62E-05*** (21.75)	0.000106*** (17.26)	3.56E-05*** (6.98)
Inflation	-0.00019*** (-22.02)	2.72E-05*** (28.74)	-0.00023*** (-45.02)	1.12E-05*** (6.70)	-0.00019*** (-26.10)	7.75E-06*** (5.46)	-0.00018*** (-25.17)	4.57E-06*** (3.71)
Size	-0.00011*** (-2.83)	-0.00027*** (-16.47)	-5.6E-05 (-1.64)	-0.00027*** (-15.53)	-3.9E-05 (-1.09)	-0.00029*** (-20.20)	-6E-05 (-1.48)	-0.00025*** (-7.52)
DTA	0.000239** (2.07)	-0.00035*** (-6.99)	0.000172 (1.39)	-0.00048*** (-8.84)	5.67E-05 (0.53)	-0.00047*** (-4.61)	0.000123 (1.14)	-0.00036*** (-3.05)

ROA	-1.9E-05** (-2.40)	-2.4E-05*** (-7.60)	-4.7E-05*** (-6.19)	-5.2E-05*** (-13.51)	-3.5E-05*** (-5.67)	-6.1E-05*** (-18.54)	-3.6E-05*** (-5.66)	-5.5E-05*** (-23.35)
OBSTA	-0.00229*** (-17.02)	0.000814*** (21.74)	-0.00246*** (-14.30)	0.000818*** (24.57)	-0.00254*** (-15.02)	0.000899*** (19.00)	-0.00257*** (-16.35)	0.000841*** (18.47)
Constant	-0.08734*** (-232.55)	-0.00569*** (-50.78)	-0.08721*** (-222.94)	-0.0054*** (-34.76)	-0.08736*** (-249.26)	-0.00502*** (-29.23)	-0.08697*** (-205.93)	-0.00548*** (-19.07)
Hansen Test (P-value)	0.494	0.955	0.357	0.970	0.546	0.990	0.815	0.954
AR(1) (P-value)	0.093	0.697	0.080	0.781	0.083	0.000	0.103	0.028
AR(2) (P-value)	0.123	0.328	0.181	0.931	0.100	0.166	0.148	0.213
Observations	623	623	623	623	623	623.000	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. Own_c & Own_p refer the ownership dummy of conventional and private banks and present in Segment A and Segment B. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano-Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

In Table 7, Conventional vs Islamic banks addressed through dummy presented in Segment A and Segment B explains dummy presentation of Private vs Public banks.

The empirical finding of equation 5 in Table 7 depicts that different ownership concentrations have a heterogeneous effect on the efficiency of commercial banks. The coefficient of credit risk with conventional banks dummy represents the positive association with cost and human capital efficiency. It refers that with the increase of risk, the efficiency of Conventional banks increases, whereas the efficiency of Islamic banks decreases. Theoretically, the coefficient of dummy variable of treatment group represents the Gap of coefficients of treatment and control groups. Thus, coefficients of the treatment group refer to the opposite impact of control groups (Wooldridge, 2016). Stability effects in the opposite manner of risk, with the incremental Z-score, i.e., stability, the efficiency of Conventional banks decreases, and Islamic banks increases. However, in segment B, we observe the heterogeneous effect of risk on different efficiency of banks. With the rise in risk, the cost efficiency of Private (Public) banks increases (decreases), and Human capital efficiency decreases (increases). On the contrary, stability inversely (positively) affects the efficiency of Private (Public) banks.

Competition proxy affects both Conventional and Private banks similarly. The efficiency of Conventional and Private (Islamic and Public) banks decreases (increases) with the incremental change of market competition. These findings align with H. T. M. Phan et al. (2016), depicting the inverse association of market competition and bank efficiency.

We extend our baseline results in three dimensions. Firstly, we present the nonlinear impact of risk and market competition on the efficiency of banks using equation 6. Secondly, we examine the effect of interim variable risk and market competition to explore the combined effect using equation 7. Finally, report the nonlinear impact of risk and market competition in different ownership addressed through ownership dummy using equation 8.

4.4. Nonlinear Effect of Risk and Market Competition on the Efficiency of Banks

Following Das Gupta et al. (2021), Kouki and Al-Nasser (2017), Tabak et al. (2012), among others, we also extend our model to examine the nonlinear impact of explanatory variables. From Table 8, we observe that risk and stability have a diversified effect on the efficiency of banks. With the increase of credit risk (NPLTL), initially, the cost efficiency (human capital) of banks increases (decreases), and in the long run, it decreases (increases). With the immediate rise of NPTL, banks do not necessarily respond to increased loan monitoring and other recovery costs. However, they proportionately increase the cost to manage risk in the long run. And with time, employees become more efficient in dealing with risk. Stability homogeneously affects the efficiency of the Banks. Stability enhancement deteriorates the efficiency concern in the short run and increases in the long run. These findings are in line with Gupta (2018) examining the impact of risk and competition on the efficiency of commercial banks.

Table 8: Nonlinear Effect of Risk and Market Competition over the Efficiency of Banks

Variable	Model I	Model II	Model III	Model IV
Dep(-1)	1.083953***(3471.03)	1.005347***(5129.73)	1.083895***(4154.08)	1.005208***(5919.69)
NPLTL	0.008808***(17.72)	-0.00228***(-7.50)		
NPLTL ²	-0.0103***(-12.86)	0.005012***(7.51)		

Z-score			-4.91E-07***(-15.13)	-8.34E-07***(-8.51)
Zscore ²			3.90E-11***(9.12)	8.33E-11***(7.73)
BI	4.83E-05***(5.92)	-0.00000569*(-1.73)	7.36E-05***(13.18)	-1.8E-05***(-5.60)
BI ²	3.51E-06***(4.55)	-1.06E-06***(-3.23)	8.46E-06***(13.61)	-2.15E-06***(-6.55)
BSD	-2.6E-05***(-11.67)	0.000021***(18.62)	-3.2E-05***(-14.44)	2.42E-05***(12.31)
GGDP	0.000172***(14.95)	2.13E-05***(8.00)	8.96E-05***(13.61)	3.34E-05***(6.77)
Inflation	-0.0001***(-14.94)	4.97E-06***(3.38)	-0.00019***(-19.79)	2.56E-05***(9.11)
Size	-0.00023***(-4.66)	-0.0002***(-9.55)	-4.2E-05(-0.97)	-0.00026***(-7.31)
DTA	-4E-05(-0.30)	-0.00029***(-2.81)	0.000141(1.04)	-0.00047***(-3.84)
ROA	-5.13E-05***(-3.36)	-0.00005***(-12.55)	-4.2E-05***(-4.49)	-6.3E-05***(-9.88)
OBSTA	-0.00199***(-16.81)	0.000659***(12.65)	-0.00254***(-15.14)	0.000815***(10.01)
Constant	-0.08664***(-126.32)	-0.00605***(-23.26)	-0.08665***(-154.07)	-0.00554***(17.48)
Hansen Test				
(P-value)	0.771	0.960	0.107	0.921
AR(1)				
(P-value)	0.076	0.994	0.100	0.038
AR(2)				
(P-value)	0.100	0.707	0.548	0.150
Observations	623	623	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano-Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

The market competition also has a heterogeneous effect on the efficiency of banks. With the growth of market competition, the cost efficiency (human capital efficiency) of banks initially decreases (increases) and then increases (decreases) in the long run. In a nutshell, cost efficiency follows an inverted U-shape curve with the increase of risk. And follow a U-shape curve concerning stability and market competition changes. However, human capital efficiency follows a U-shaped with increased risk and stability but responds in a pattern of inverted U-shaped curve in a shift of market competition.

4.5. Nonlinear and Joint Effect of Risk and Competition on the Efficiency of Banks

Table 9 extends the results of Table 8 to examine the joint and nonlinear effect of risk and market competition on the efficiency of banks. The interim variable of risk and market competition evidence that with the increase of risk, the efficiency of cost increases and then decreases in the long run in a competitive market situation. In contrast, stability affects in opposite manners of credit risk. That means, in a competitive market, initially, efficiency decreases and then increases. These findings align with Gupta et al. (2021), explaining the relationship between efficiency and market competition.

Table 9: Nonlinear and Joint Effect of Risk and Market Competition over the Efficiency of Banks

Variable	Model I	Model II	Model III	Model IV
Dep(-1)	1.083747***(3643.06)	1.005084***(6165.09)	1.08398***(3385.50)	1.005171***(5406.96)
NPLTL	0.002083***(4.2)	-0.000773***(4.96)		
NPLTL ²	-0.00289***(-3.02)	0.003561***(11.05)		
Z-score			-6.19E-06***(-4.13)	-3.18E-07***(-7.17)
Zscore ²			7.28E-10***(5.78)	4.52E-11***(10.53)
BI	0.000154***(11.41)	-4E-05***(-6.4)	1.25E-04***(-3.48)	-1.2E-05***(-2.87)

BI ²	0.000016***(11.97)	-3.77E-06***(-6.09)	2.06E-05***(-4.48)	-2.57E-06***(-5.08)
NPLTL×BI	-0.00105***(-12.90)	0.000882***(13.35)		
NPLTL×BI ²	-0.00011***(-13.36)	7.81E-05***(12.52)		
Z-score ×BI			4.31E-07*(0.92)	1.44E-07***(3.94)
Z-score ×BI ²			1.70E-07***(3.40)	2.32E-08***(5.44)
BSD	-2.7E-05***(-11.25)	2.09E-05***(20.99)	-2.89E-05***(-10.54)	0.000024***(13.99)
GGDP	0.000134***(14.25)	2.19E-05***(5.77)	2.74E-05*(1.56)	3.68E-05***(8.19)
Inflation	-0.00014***(-14.15)	1.02E-05***(7.90)	-8.5E-05***(-10.21)	1.51E-05***(6.93)
Size	-0.00017***(-3.09)	-0.00021***(-9.53)	-0.00011*(-1.77)	-0.00027***(-8.88)
DTA	-8.34E-06(-0.06)	-0.00022(-1.50)	0.000185(0.76)	-0.00047***(-4.71)
ROA	2.65E-05*(1.72)	-4.1E-05***(-8.49)	-5.92E-05***(-3.81)	-5.5E-05***(-13.74)
OBSTA	-0.00213***(-10.76)	0.000717***(10.92)	-0.0024***(-7.90)	0.000838***(11.13)
Constant	-0.0861***(-116.28)	-0.00608***(-20.44)	-0.08648***(-118.21)	-0.00545***(-19.43)
Hansen Test				
(P-value)	0.946	0.990	0.647	0.972
AR (1)				
(P-value)	0.100	0.647	0.263	0.152
AR (2)				
(P-value)	0.346	0.101	0.823	0.429
Observations	623	623	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano–Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

However, the effect of market competition is homogeneous across risk and stability on efficiency. In intense competitive market efficiency of human capital decreases then increases. Human capital efficiency follows a U-shaped curve in the competitive market situation.

4.6 The Nonlinear and Quadratic Effect of Risk & Market Competition with Ownership Dummies

Following S. Kasman and Kasman (2015), Jeon and Lim (2013), Kouki and Al-Nasser (2017), Gupta and Moudud-UI-Huq (2020), we include the squared term of Boone Indicator (BI) in equation (5) and derived equation (7) & (8). The extended models examine the nonlinear effect of risk and competition in different ownerships. This study spread the previous works by incorporating the nonlinear and quadratic terms of risk and segregating the impact based on ownership.

Table 10: Nonlinear Effect of Risk and Market Competition with Ownership Dummies

Variable	Segment A				Segment B			
	Model I	Model II	Model III	Model IV	Model I	Model II	Model III	Model IV
Dep(-1)	1.084637*** (54530.90)	1.005195*** (5024.13)	1.084247*** (3988.07)	1.005189*** (7212.1)	1.084422*** (5347.61)	1.004184*** (3701.63)	1.083828*** (3694.4)	1.00512*** (6178.65)
NPLTL × Own _C	0.003829*** (6.01)	-0.00061** (-2.38)						
NPLTL ² × Own _C	-0.00244* (-1.78)	0.002888*** (5.39)						
NPLTL × Own _P					-0.00449*** (-3.72)	-0.02096*** (-11.79)		
NPLTL ² × Own _P					0.006379*** (2.96)	0.02321*** (5.70)		
Z-score × Own _C			-7.15E-07*** (-6.91)	-4.57E-07*** (-19.54)				

Z-score ² × Own _C			-4.15E-11*** (-5.74)	-2.50E-11*** (-16.33)					
Z-score × Own _P							-1.63E-06*** (-6.83)	-5.99E-07*** (-7.51)	
Z-score ² × Own _P							8.52E-10*** (7.83)	1.62E-10*** (4.33)	
BI × Own _C	0.000537*** (13.58)	-3.8E-05*** (-12.83)	0.000415*** (13.61)	-4.9E-05*** (-12.62)					
BI ² × Own _C	0.000056*** (13.56)	-4.35E-06*** (-14.04)	4.54E-05*** (13.62)	-5.08E-06*** (-12.00)					
BI × Own _P					0.000394*** (19.04)	0.000037*** (2.99)	1.65E-07*** (4.89)	6.75E-08*** (10.52)	
BI ² × Own _P					4.37E-05*** (19.22)	6.87E-06*** (4.71)	2.44E-08*** (5.25)	1.12E-08*** (10.77)	
BSD	-2.7E-05*** (-16.71)	2.09E-05*** (19.62)	-2.9E-05*** (-15.58)	2.32E-5*** (15.57)	-3.2E-05*** (-15.97)	9.61E-06*** (4.02)	-3E-05*** (-12.95)	2.24E-05*** (11.93)	
GGDP	6.75E-05*** (17.70)	3.71E-05*** (17.39)	2.64E-05*** (4.33)	3.81E-05*** (11.94)	1.52E-05*** (2.02)	-0.00014*** (-14.25)	8.62E-05*** (9.16)	2.97E-05*** (6.79)	
Inflation	-0.00025*** (-20.56)	2.74E-05*** (25.54)	-0.00024*** (-13.52)	0.000029*** (15.57)	-0.0003*** (-21.70)	-0.00018*** (-16.10)	-0.00017*** (-17.45)	0.000013*** (6.09)	
Size	-0.00027*** (-7.52)	-0.00022*** (-10.77)	-0.00019*** (-3.52)	-0.00026*** (-8.44)	-0.00014*** (-2.64)	-4E-05 (-0.56)	-0.000084* (-1.85)	-0.00023*** (-6.42)	
DTA	-0.00023* (-1.97)	-0.00034*** (-3.23)	-0.00027 (-1.58)	-0.00044*** (-4.52)	-0.00028* (-1.93)	-0.00065** (-2.11)	1.71E-05 (0.11)	-0.00043*** (-3.22)	
ROA	-4.3E-05*** (-4.46)	-3.5E-05*** (-12.10)	-7.6E-05*** (-7.30)	-5.1E-05*** (-11.29)	-2.6E-05** (-2.19)	-8.2E-05*** (-9.31)	-4E-05*** (-3.90)	-5.2E-05*** (-10.65)	
OBSTA	-0.00167*** (-9.14)	0.000676*** (11.32)	-0.00197*** (-10.04)	0.000742*** (11.06)	-0.00264*** (-13.53)	-0.0004*** (-2.89)	-0.00234*** (-10.63)	0.000721*** (8.16)	
Constant	-0.08456*** (-245.66)	-0.00609*** (-24.37)	-0.08427*** (-145.56)	-0.00568*** (-20.41)	-0.08416*** (-158.34)	-0.00327*** (-4.11)	-0.08628*** (-132.02)	-0.00565*** (-16.96)	
Hansen Test (P-value)	0.919	0.990	0.996	0.992	0.348	0.481	0.997	0.992	
AR(1) (P-value)	0.363	0.324	0.313	0.861	0.211	0.867	0.115	0.112	
AR(2) (P-value)	0.102	0.454	0.870	0.272	0.133	0.177	0.100	0.546	
Observations	623	623	623	623	623	623	623	623	

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. Own_C & Own_P refer to the ownership dummy of conventional and private banks, presented in Segment A and Segment B, respectively. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano-Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

Table 10 reveals the nonlinear impact of risk and market competition on different ownership of banks of equation 8. Comparing the two results of the efficiency of cost and human capital reveals that market competition has a heterogeneous effect on the efficiency of different commercial banks. With the increase of market competition, initially cost efficiency of Conventional and Private (Islamic and Public) commercial banks decreases (increases) and then increases (decreases) in the long run. Human capital efficiency of Conventional and Public (Islamic and Private) commercial banks increases with the increase (decrease) of market competition, and after a certain period, it decreases (increases).

The nonlinear effect of risk and stability is not apparent in all commercial banks of Bangladesh. For example, the nonlinear effect of stability on the efficiency of Conventional and Islamic banks is not evident in the Bangladeshi banking industry. With the increase of stability of Conventional (Islamic) banks, efficiency decreases (increases), having no different nonlinear impact. That means conventional banks with more stability are less efficient. However, the nonlinear effect of stability is valid for private and public banks. Stable public banks are more efficient concerning cost and human capital efficiency, but the efficiency of private banks deteriorates with their enhancement of capital base and profitability (stability).

The impact of credit risk addressed through NPLTL is also found heterogeneous across different ownership of banks. Risk-taking of Conventional banks enhances the cost efficiency and decreases the human capital efficiency initially. Later on, incremental risk-taking improves human capital efficiency and inversely affects banks' cost efficiency. On the contrary, increasing the riskier investment of Islamic banks deteriorates (enhances) cost efficiency (human capital efficiency) initially, then increases (decreases) in the long run. The reaction of private and public banks in response to efficiency is uniform in

both cost and human capital. Risk-taking of Private (Public) banks decreases (increases) the efficiency in the linear relationship, and in quadratic terms, the efficiencies are increasing (decreasing).

Significant coefficients of lagged dependent variables depict the dynamic nature of the models and advocate that the variables are persistently following from year to year. Statistics of AR (1) and AR (2) validate the instrument of the lagged dependent variables. Hensen test validates the instrument of the model. Supporting test of GMM application also present in 'Appendix B' through examination of heteroskedasticity, autocorrelation test.

5. CONCLUDING REMARKS

The financial system of Bangladesh is bank-based and occupies almost two-thirds of the total financial market. Banks are the dominant matchmakers of the economic system and play an active role in circulating financial flows and economic progression. Therefore, it is worth considering how risk, growing market competition, and other factors affect the efficiency of the banking industry of Bangladesh. This study attempts to explain how risk-taking, market competition, and ownership affect the efficiency of Banks. Financial liberalization, reformation, regulatory capital changes, more inclusion of banks increase the market's competitiveness and change the organization's risk-taking paradigm. However, banks' philosophy and business tradition differ due to ownership differentiation. Therefore, it is time demand how banks manage their cost and human capital efficiency in stiff market competition and risk.

The study's findings depict the diversified effect of risk-taking and market competition on different ownership of banks. The risk and stability of banks have a significant impact on the efficiency of banks. The increase of banks' risk (stability) efficiency increases (decreases) in the aggregate model. The effect of risk and stability of Conventional and Private banks is in line with the findings of the aggregate industry model, except for human capital efficiency. The human capital efficiency of private banks decreases with the increase of risk, unlike aggregate and conventional banks models. Islamic and Public banks' efficiency react oppositely in response to the risk and stability of banks. Market competition (BI) and efficiency of banks are inversely associated in the Conventional, Private, aggregate industry model. It refers to increasing market competition deteriorating the efficiency of banks of Bangladesh.

The nonlinear and quadratic impact of risk and market competition over different ownership and aggregate models are heterogeneous. The joint effect of risk and competition depicts that increased risk-taking in a competitive market initially efficiency of cost increases then decreases in the long run. However, the efficiency of banks in the competitive market with stability and human capital efficiency with risk-taking decreases then increases after a certain point. The efficiency of banks follows a U-shape curve in association with risk, stability, and market competition in aggregate model, conventional and private banks' model. Only efficiency of cost in risk change and efficiency of human capital in competition follows an inverted U-shape curve in aggregate and conventional banks models. This study also observes the significant impact of economic, banks level factors and development indicators on the efficiency of banks. The country's economic progression significantly enhances the efficiency of banks, whereas inflationary pressure deteriorates the efficiency of cost and increases human capital efficiency.

The nonlinear impact of risk and market competition on the efficiency of banks is also evident in this study. The study suggests that risk-taking does not necessarily decrease, and stability increases the efficiency of banks. Again all efficiency is not moving in parallel to each other. Risk and market competition heterogeneously affect different efficiency and different ownership of banks. The future direction of the study can incorporate cross-country data and simultaneous examination of risk, efficiency, and banks' competition.

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APPENDIX A: Determination of Cost and Human Capital Efficiency Using Stochastic Frontier Analysis (SFA)

This study approach stochastic frontier analysis to calculate the efficiency of each Bank is based on the stochastic frontier production methodology originated by Aigner, Lovell, and Schmidt (1977). Due to inefficiency and error term, the observed cost of a bank is formulated to differ from the cost-efficient frontier (Deelchand and Padgett, 2009, Gupta et al., 2021, Zheng et al., 2018). The stochastic cost frontier model was developed using this production frontier. For details, see Zheng et al. (2018a); Kwan and Eisenbeis (1997); Schmidt and Knox (1979).

For the 'n'th Bank,

$$\ln TC_n = f(\ln Q_i, \ln P_j) + \varepsilon_n \quad (1)$$

TC_n is the total operating cost including financial costs, There are two inputs(Q_i), i.e., Q_1 =Loans and advances, Q_2 = Other earning assets, Inputs are denoted by P_j . There are three inputs that are: P_1 = Price of labor which is the personnel expenses, P_2 = Price of physical capital, which is non-interest expenses to fixed assets, P_3 = Price of fund, which is the ratio of total interest expenses to the total deposit. ε_n depicts the deviation between the actual total cost of a bank and the cost-efficient frontier, and it has two disturbance terms:

$$\varepsilon_n = V_n + U_n$$

Where V_n and U_n represent the random error term and cost inefficiency, respectively. We assume that the random error term is independent and identically distributed $N(0, \sigma_v^2)$ and cost inefficiency is to be distributed independently of V_n and a half-normal distribution, i.e., $N(0, \sigma_u^2)$.

By using the intermediation approach (Sealey & Lindley, 1977) and by following (T. Deelchand & C. Padgett, 2009), we develop translog cost function to specify the cost function:

$$\ln TC = \alpha + \sum_i \alpha_i \ln Q_i + \sum_j \beta_j \ln P_j + \frac{1}{2} \sum_i \sum_k \gamma_{ik} \ln Q_i \ln Q_k + \frac{1}{2} \sum_j \sum_h \delta_{jh} \ln P_j \ln P_h + \sum_i \sum_j \lambda_{ij} \ln Q_i \ln P_j + \varepsilon \quad (2)$$

According to Jondrow, Knox, Materov, and Schmidt (1982), the expected value of U_n , conditional ε_n , represents the cost-inefficiency of bank n (defined as C_n).

$$C_n = E U_n / \varepsilon_n = [\sigma \lambda / (1 + \lambda^2)] [\varphi(\varepsilon_n \lambda / \sigma) / \Phi(\varepsilon_n \lambda / \sigma) + \varepsilon_n \lambda / \sigma] \quad (3)$$

λ denotes the standard deviation of U_n to standard deviation of V_n , Φ is the cumulative standard normal density function, and φ is the standard normal density function. C_n can be estimated by using equation (3).

We also use the alternative Human Capital inefficiency specification, where the dependent variable is the HC_n = Human capital (no. of employees) of all banks in the sample. Q_i indicates two outputs, i.e., Q_1 = Other earning assets, Q_2 = Loan and Advances, P_j stands for three input prices, i.e., P_1 = Price of labor which is the personnel expenses, P_2 = Price of physical operations, which is total operating expenses, P_3 = Price of risk-taking, which is the amount of nonperforming loans. We alternate the error term to $V_n - U_n$ from $V_n + U_n$ to use the equation (3) as a production function (Coelli, 1996). In the converted model, U_n signifies human capital inefficiency and distributed independently of V_n and a half-normal distribution, i.e., $N(0, \sigma_u^2)$ (Zheng et al., 2018a). Computer software named Frontier Version 4.1 developed by, Coelli (1996) opt to estimate the SFA Production and Cost function projected by the maximum likelihood method.

APPENDIX B: Diagnostic Test- Supporting the Regression Models

Heteroskedasticity (Breusch-Pagan test for heteroskedasticity), autocorrelation (Breusch-Godfrey Serial Correlation LM Test) have been performed to support the regression models. Each table's results represent the corresponding Tables diagnostic tests. Summarized diagnostic test results are given below.

Table 13: Breusch-Pagan Test for Heteroskedasticity

	Dependent Variables	
	Efficiency of Cost	Efficiency of Human capital
Chi2 Value	210.29	66.54
Prob > chi2	0.000	0.000

Table 14: Breusch-Godfrey LM Test for Autocorrelation

Dependent variable	chi2	df	Prob > chi2
	527.120	1	0.000
Efficiency of Cost	528.614	2	0.000
	453.977	1	0.000
Efficiency of Human Capital	458.624	2	0.000

From the test statistics results, it is clear that there are heteroscedasticity and autocorrelation problems in the model.

SUSTAINABILITY REPORTING AND THE FINANCIAL PERFORMANCE OF BANKS IN AFRICA

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Edward Attah-Botchwey¹, Michael Gift Soku², David Mensah Awadzie³

¹University of Professional Studies Accra, Department of Banking and Finance, Accra, Ghana.

edward.attah-botchwey@upsamail.edu.gh, ORCID: 0000-0003-1140-5786

²University of Professional Studies Accra, Department of Accounting, Accra, Ghana.

Michael.g.soku@upsamail.com.edu.gh, ORCID: 0000-0002-8333-2662

³Accra Institute of Technology, ACCRA, Department of Accounting and Finance, Accra, Ghana.

davidawadzie@gmail.com, ORCID: 0000-0001-5532-2152

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ABSTRACT

Purpose— This study examined the relationship between sustainability reporting and bank performance in Africa. Unlike previous studies that solely dwelled on accounting measures of performance, this study adopted both accounting (i.e., return on assets) and market-based measures of firm performance (i.e., Tobin's Q).

Methodology— The study relied on secondary data gathered from the audited financial statements of listed banks in Africa over ten years from 2010 to 2020. Notably, the financial statements of 20 listed banks (drawn from Ghana, Nigeria, and South Africa) were subjected to quantitative content analysis to quantify the extent of sustainability content. It was guided by the sustainability reporting framework developed by the global reporting initiative. The content analysis aims to identify and classify the extent to which firms report on Economic, governance, social, and environmental dimensions of sustainability. Besides, the financial statement figures aided the computation of a performance measure (return on assets and Tobin's Q) for the banks. Concerning data analysis, the study utilized a panel fixed effect regression model to estimate the relationship between sustainability reporting and firm performance.

Findings— The results suggest that economic, social, and governance reporting of sustainability content (in the financial statement) has a significant positive association with Tobin's Q and Return on Assets (ROA). Furthermore, the study's findings suggest that banks' reportage of environmental sustainability content has a significant positive effect on ROA. However, it has no significant effect on Tobin's Q.

Conclusion— Generally, the study concludes that increased sustainability reporting enhances bank performance in the long term. Among others, the study recommends that policymakers develop a sustainability framework specific to the banking industry's needs.

Keywords: Sustainability, return on assets, bank performance, framework.

JEL Codes: E44, F40, F43

1. INTRODUCTION

The challenge of businesses is to maximize 'shareholders' wealth and consider the sustainability of operations in the long term. Bebbington and Unerman (2018) elaborate further, noting that stakeholders are also interested in the environmental, Social, and Governance (ESG) practices of organizations aside from the assets, liabilities, and equity. The 21st century has witnessed arguments supporting that shareholder wealth maximization alone is not a sustainable business objective since other stakeholders are also integral (Mahmood et al., 2018). The accounting and finance literature generally agrees that the impact of organizational activities on its external environment should be disclosed to its shareholders and the public members (Elkington, 1997; Jennifer-Ho & Taylor, 2007).

Therefore, sustainability reporting is the disclosure or reporting of organizational activities in furtherance of sustainable development. In 1987, the World Commission on Environment and Development (WCED) defined sustainability as development that meets current demands without compromising future generations' ability to meet their own. Although the definition by WCED (1987) is widely held in the literature, noteworthy is the fact that it mainly dwells on an organization's interaction with the natural environment (Gibson, 2006; Marshall & Brown, 2003).

The complexities of the 21st century, occasioned by technological innovations, corporate malfeasance, and community activism, among others, have widened the scope of sustainability beyond the natural environment. Presently, the definition of sustainability comprises factors bordering on the Environmental, Social, Governance, and Economic responsibilities/practices of a firm (Heikkurinen & Bonnedahl, 2013).

The World Business Council for Sustainable Development (WBCSD, 1999) defined sustainability as "the commitment of business to contribute to sustainable economic development, working with employees, their families, the local community and society at large to improve their quality of life." This definition resonates with Schwartz and Carroll (2008), who argues that firms should be evaluated on their financial success and other performances that benefit society. Large firms must disclose some minimum sustainability indicators in their annual reports (Fabrizzi et al., 2017). Disclosures provide a premise for examining their non-financial performance.

However, unlike in the European context, sustainability disclosure is voluntary in most countries, especially those in the developing world (Doni et al., 2019). The voluntary nature of sustainability disclosures often underpins the question of "what motivates firms to disclose sustainability information when such disclosures are non-mandatory." For Blaesing (2013), three main reasons explain why firms disclose sustainability information. First, sustainability disclosure by some firms is motivated by their need to portray a positive public posture/reputation and gain legitimacy over resources. Secondly, other 'firms' disclosure of sustainability information is driven by their need to increase public transparency of risks, reduce the cost of capital, and attain a favourable capital market orientation. Finally, sustainability reporting may be motivated by the need to improve internal planning and performance management processes.

An examination of the existing literature reveals that several studies have investigated the relationship between sustainability reporting and firm performance. Nonetheless, limitations in existing studies justify the conduct of this research. First, most of the existing studies on the subject matter used only accounting and non-market-based performance measures (e.g., profit margin, return on assets, return on equity, etc.) to assess the relationship between sustainability disclosures and firm performance. For example (Saeidi et al. 2015; Chen et al. 2018). Meanwhile, accounting measures of performance, like any other measure, have their limitations (Hirschey & Wichern, 1984). For instance, accounting profitability measures are influenced by firm-specific selection and application of accounting assumptions, estimates, and treatments (Poonawala & Nagar, 2019). Again, factors encompassing earnings management and recognition criteria may lead to creative accounting practices which distort reported profits (Susanto & Widayawati, 2019). They suggest that studies dwelling solely on accounting performance measures may yield misleading or inconclusive results; hence, the need to investigate the phenomena using market-based financial performance measures. Also, Hirschey and Wichern (1984) expressed serious concerns about researchers and practitioners solely relying on either accounting measures or market-value-based measures of financial performance.

Regarding accounting measures, Hirschey and Wichern (1984, P. 375) stated that "... Accounting income numbers to measure firm performance are typically justified because they are the best available data. There are measurement problems, however, caused by different accounting practices across industries, (possibly) inappropriate expensing of research and development (R & D) and advertising expenditures, a failure to reflect opportunity costs and risk, and replacement-cost accounting

Besides, the authors also indicated that accounting profitability measures are based on historical data or are rather backwards-looking when shareholders are more interested in the firm's future outlook. Thus, the argument by Hirschey and Wichern (1984) suggests the need for a more forward-looking or future-oriented measure of profitability, which falls within the realms of market-value-based profitability measures. However, concerning market value-based measures of profitability, Hirschey and Wichern (1984) indicated that "The prices that the markets place on the securities issued by firms and the changes in these values over time provide an ongoing assessment of the value of such firms" (p. 375). Thus far, it can be said that one approach to performance evaluation cannot be overarching since, at best, it is either forward-looking or backwards-looking. It then underscores the need to integrate both accounting and market-value-based performance evaluation approaches in assessing financial performance.

Regarding this, Hirschey and Wichern (1984) adopt the perspective that; "neither accounting nor market data provide an ideal or true measure of profitability. Instead, we argue that measures developed from both sources offer potentially unique but imperfect measures of profitability. We believe that a comparison of accounting and market data can prove highly beneficial" (p. 375). In essence, Hirschey and Wichern (1984) call on researchers to use both accounting and market-value-based profitability measures to enhance the reliability of research findings. This study uses the 'Tobin' q ratio as a market-based performance measure. It uses return on assets as an accounting profitability measure to assess the relationship between C.R. and firm performance. In addition, there is a relative paucity of sustainability studies as far as developing 'countries' context is concerned (Abernathy et al. 2017; Lichtenstein et al. 2013).

An extant review of the literature suggests that most studies on sustainability have emphasized mainly European and North American corporate entities, with little attention dedicated to developing countries (Abernathy et al., 2017; Lichtenstein et al., 2013). Besides, the few empirical inquiries generally discussed the sustainability practices of firms without due consideration of how the disclosure practices influence vital variables, such as financial performance, growth, etc. Increasing sustainability-related research in the context of emerging economies is underscored by the fact that research findings in the developed world (e.g., Europe and North America) may not necessarily apply to developing countries due to differences in culture, and infrastructure among others (Rogers, 2016).

Finally, the financial sector, especially the banking industry, has inadequate sustainability-related research. It stems from the fact that most existing studies have paid attention to environmentally sensitive firms like mining firms. Meanwhile, research findings from other sectors may not apply to the banking sector because of their unique nature, such as regulations and levels of environmental sensitivity. Investigating sustainability in the context of financial institutions in general and banks will enrich the sustainability literature. The study focuses on listed universal commercial banks in Africa. The study used only listed banks to enhance accessibility to data for purposes of analysis.

The general purpose of the study is to investigate the relationship between sustainability reporting and firm performance. The specific objectives include to investigate the influence of economic sustainability reporting on bank performance, assess the influence of governance sustainability reporting on bank performance, and examine the influence of social sustainability reporting on bank performance and investigate the influence of environmental sustainability reporting on bank performance.

In order to achieve the study's objectives, the following questions were asked. First, what is the influence of economic sustainability reporting on bank performance? Second, what is the influence of governance sustainability reporting on bank performance?, Thirdly, what is the influence of social sustainability reporting on bank performance? Finally, what is the influence of environmental sustainability reporting on bank performance?

2. LITERATURE REVIEW

This chapter presents a review of relevant empirical literature as far as sustainability reporting and disclosure is concerned. The chapter is organized into three main sections. The first section looks at basic concepts relating to sustainability, the second section presents the theoretical review, and the third section discusses empirical literature focusing on sustainability reporting.

2.1. Concepts of Sustainability

The United Nations (U.N.) is an inter-governmental organization formed in 1945 to address crucial global issues encompassing climate change, sustainable development, human rights, disarmament, terrorism, humanitarian and health emergencies, gender equality, governance, food, production, and more (U.N., 2019). The U.N. championed the modern view of sustainable development in a report produced by the World Commission on Environment and Development (WCED, 1983). In September 2000, members of the U.N., consisting of 99 heads of state, signed the Millennium Declaration. The signing of the declaration committed world leaders to fight "poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women," among others. Eight Millennium development goals (MDGs) emerged from the millennium declaration, expected to be accomplished by 2015. Having expired in 2015, the MDGs were replaced with 17 sustainable development goals (SDGs), scheduled to be achieved by 2030. The SDGs are summarized below:

Table 1: United Nations Sustainable Development Goals

Goal Number	Description
1: No poverty	By 2030, eradicate extreme poverty for all people everywhere
2: Zero hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3: Good Health and Well-Being:	Ensure healthy lives and promote well-being for all at all ages
4: Quality Education:	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5: Gender Equality:	Achieve gender equality and empower all women and girls
6: Clean water and sanitation:	Ensure availability and sustainable management of water and sanitation for all
7: Affordable clean energy	Affordable clean energy: Ensure access to affordable, reliable, sustainable, and modern energy for all
8: Decent work and economic growth	Decent work and economic growth: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

9: Industry, innovation, infrastructure:	Industry, innovation, infrastructure: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
10: Reduced inequality	Reduced inequality: Reduce inequality within and among countries
11: Sustainable cities and communities	Sustainable cities and communities: Make cities and human settlements inclusive, safe, resilient, and sustainable
12: Responsible consumption and production	Responsible consumption and production: Ensure sustainable consumption and production patterns
13: Climate action	Take urgent action to combat climate change and its impacts*
14: Life below water	Life below water: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development
15: Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16: Peace, justice, and strong institutions	Peace, justice, and strong institutions: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels
17: Partnerships	Partnerships: Strengthen the means of implementation and revitalize the global partnership for sustainable development

Source: quoted from <https://sustainabledevelopment.un.org/sdgs>

2.2. Theoretical Review

2.2.1. Stakeholder Theory and Sustainability Reporting

The stakeholder theory has a broader perspective on corporate governance. Generally, stakeholders consist of a broad range of individuals and groups that can affect or be affected by a corporate entity's actions and inactions. Solomon (2010, p.15) offers a theoretical perspective of the stakeholder theory, noting as follows: "companies are so large, and their impact on society so pervasive, that they should discharge accountability to many more sectors of society than solely their shareholders... Not only are stakeholders affected by companies, but they, in turn, affect companies in some way". Contrary to the agency theory's propositions, stakeholder theory holds that a firm should be accountable to all parties interested in the firm (Chen & Roberts, 2010). Different stakeholders have different interests in the affairs of a firm. For example, while shareholders are interested in getting a rewarding return, employees are concerned about job security and good income.

Besides, creditors are interested in the firms' creditworthiness, while environmentalists expect the firm to adopt sustainable environmental practices. The stakeholder theory makes several assumptions. Notably, the theory holds that businesses should seek not only the financial interest of owners but also the interest of the broader society (Chen & Roberts, 2010). Relatedly, the theory assumes that the directors of organizations are equally accountable to all stakeholders, including employees, government, local community, customers, and suppliers. In the literature, stakeholder theory has been criticized because it conflicts with shareholder wealth maximization's central objective (Sternberg, 1997). Additionally, the theory has also been criticized for conflict with the agent-principal relationship, which posits that managers should be accountable primarily to shareholders.

In 1994, Elkington contended that corporations should concentrate on making profits and generating returns for shareholders. However, for Elkington (1994), businesses should also focus on social and environmental concerns. This concept later became known as the triple bottom line, and it seeks to gauge an organization's commitment to corporate social responsibility and sustainable business practices. Today the concept of sustainability reporting has become widespread among practitioners and academics (Blaessing, 2013). In demonstrating their commitment to sustainability, businesses report their sustainability practices in annual reports and other special reports. Stakeholder theory has been associated chiefly with the notion of morality in the context of corporate social responsibility.

Consequently, many prior works of literature resorted to the stakeholder theory in discussing sustainability reporting (Bebbington & Unerman, 2018; Unerman & Chapman, 2014). Mostly, such studies argue that business organizations should adopt practices that benefit shareholders and the entire society. By implication, businesses must adopt practices that benefit the community, protect and maintain the environment, and ensure the firm's long-term economic sustainability.

2.2.2. Stakeholder-Oriented Sustainability and Firm Performance

Three prominent theories offer explanations of the effects of sustainability reporting on firm performance. They include: (a) consumer inference-making theory, (b) signalling theory, and (c) social identity theory. 'The consumer inference-making

theory posits that consumers are more likely to infer positively about a product if they perceive the manufacturer as a sustainability-conscious or environmentally responsible producer (Brown & Dacin, 1997). As an implication, such favourable inferences about company products induce consumer purchase intentions and actual purchase decisions (Mishra & Suar, 2010; Crolic et al., 2019; Brown & Dacin, 1997; Handelman & Arnold, 1999; Gildea, 1994; Owen & Scherer, 1993). For instance, a recent multinational study conducted by Crolic et al. (2019) revealed that positive brand image perceptions about Microsoft induce purchase intentions among potential customers. Therefore, it is believed that such favourable inferences about a product can increase sales and create customer loyalty in the long run. Contextually, firms that engage in sustainable practices and report such practices in their sustainability reports are likely to be perceived as socially and environmentally responsible. With such a positive public image, the society or consumers would make a favourable inference about their products and eventually prefer to consume them. Thus, it can increase revenues and profitability. Besides, information about such a positive company image can impact stock prices and overall business performance.

2.2.3. Sustainability Reporting Practices

In 2015, Bonsón and Bednárová conducted a study investigating the extent to which companies within the Eurozone report on their corporate sustainability practices. Within the study, a content analysis was conducted on the annual sustainability reports of 306 Eurozone companies listed in the STOXX Europe 600. The sample for the study included 19 subsectors and 12 countries encompassing Austria, Finland, Germany, Luxembourg, the Netherlands, Spain, Belgium, France, Greece, Ireland, Italy, and Portugal. The dependent variables analyzed within the study were environmental, social, and governance indicators of sustainability based on the 'AECA's (the Spanish Accounting and Business Association's- AECA) integrated sustainability framework/scorecard. In addition, independent variables that were analyzed as predictors of the level of CSR disclosures encompassed country of origin, industry, and listing in DJSI.

In contrast, profitability and the size of the company were treated as control variables. The study's findings were that most Eurozone companies report more information on their corporate Governance practices than on their environmental and social practices. Also, the study found that Eurozone companies make moderate disclosures on their environmental impacts, whereas there is a limited disclosure on social indicators of sustainability practices. The study, however, did not find any significant relationship between the size of the company and the level of CSR practices. This finding contradicts earlier findings by Tagesson et al. (2009); Haniffa and Cooke (2005); and Branco and Rodrigues (2006), who indicated that large companies are more likely to make extensive sustainability disclosures since they are more socially visible and exposed to public scrutiny.

In a related study, Roca and Searcy (2012, p. 105) investigated the question, "What indicators are currently disclosed in corporate sustainability reports?" Within the study, a content analysis of the annual reports of 94 Canadian firms was examined using the global reporting initiative index. The study's findings suggested that most Canadian firms make more extensive disclosures on their social practices (e.g., Funding, donations, sponsorship, and community investments) than on environmental and governance practices. This finding contradicts the recent finding by Bonsón and Bednárová (2015) on firms in the Eurozone. Bonsón and Bednárová (2015) found that Eurozone firms disclose more information on governance than environmental and social aspects of sustainability; contradictory findings may be explained from two perspectives, namely "the research context" and "the research framework."

Differences in the findings of the two experts could be explained by differences in the geographic setting in which the investigations were done, notably Europe vs. Canada. However, again, differences in the research framework adopted in both studies might have accounted for the variation in results. In contrast, Bonsón and Bednárová (2015) adopted the Spanish Accounting and Business Association's (AECA) sustainability index, and Roca and Searcy (2012, P. 105) adopted the GRI sustainability index. Such mixed results suggest that the question of the sustainability practices of corporate entities has not been adequately addressed, hence justifying further studies such as this.

There is an emerging trend in sustainability reporting literature whereby scholars attribute sustainability reporting to the nature of the industry within which firms find themselves and the extent of sustainability regulations that firms must comply with. For example, Lokuwaduge and Heenetigala (2017) investigated the ESG reporting practices of metal and mining sector companies listed on the Australian Securities Exchange. The study used a content analysis scoresheet in examining the annual reports of 30 of the top 100 mining companies listed on the ASX. In terms of environmental sustainability disclosures, the study found that " on average, 63% of the indicators of environmental sustainability were not reported by the firms considered. According to Lokuwaduge & Heenetigala (2017), greenhouse gas emissions were the highest reported indicator, reported by 23 out of 30 companies (76.7% of the sample). They report their emissions as tonnes, kilotonnes, or megatonnes.

Regarding disclosures on the social dimension of sustainability, the study found that almost all the firms studied reported the majority of the social indicators of sustainability as far as the GRI framework is concerned. However, according to Lokuwaduge and Heenetigala (2017), the study relied on secondary data. Therefore, it was unclear whether companies avoided reporting this information or whether incidents such as fatalities, discrimination, human rights grievances, corruption, and non-

monetary sanctions did not occur during the reporting period. Concerning corporate governance disclosures, the study found that all the 30 sampled firms disclosed all required governance information as far as the GRI framework is concerned.

Relatedly, Kühn, Stiglbauer, and Fifka (2018) examined the website reporting practices of CSR activities by firms in Sub-Saharan Africa, notably Kenya, Botswana, Ghana, Tanzania, Uganda, Nigeria, and Zambia. In the study, a content analysis was undertaken on the websites of the firms involved in the study using Chapple and Moon's (2005) dimensions of CSR reporting. These are the existence of a CSR section on the company website; extent of CSR reporting; implementation of CSR; types of CSR and dimensions and channels of CSR. Besides, the study added two dimensions to those of Chapple and Moon (2005), namely "implementation of CSR" and "types of CSR." The study found that although most of the firms studied (above 80%) have sections on their corporate website that report on their CSR activities, the information contained on such websites was not extensive as far as CSR reporting is concerned. The study found that only about 13-14% of the firms studied made extensive disclosures on their CSR activities, regardless of their origin. Accordingly, the study also found that "only 18% of all sample companies issue a standalone CSR report, and even less (14%) provide information on how they handle stakeholder relations".

Regarding the type of CSR activity, the study found that across the seven countries, 88% to 100% of the companies report their engagement within the community (corporate philanthropy) with a firm emphasis on reporting locally-oriented involvement activities. This finding is supported by the recent study of Abukari and Abdul-Hamid (2018), Nyarku and Hinson (2018), and the earliest work of Moon (2002), and Chapple and Moon (2005); thus, according to these scholars, community involvement is the dimension of CSR addressed mainly by companies. However, besides community engagement, Employee relations (addressed by 61% on average) and responsible production processes (57%) are given considerably less attention (Visser, 2006). In another study, Aboagye-Otchere et al. (2012) investigated Corporate governance and disclosure practices of Ghanaian listed companies using Standard and Poor's (S&P) transparency and disclosure (T&D) items in the construction disclosure index. The study found that the overall mean score of the companies in terms of disclosure of corporate governance indicators was 50.76%, thus showing a moderate level of disclosure. Notably, the study found that listed firms in Ghana make more disclosures on financial transparency (62.48%). In contrast, ownership and governance disclosures recorded an average score of 55.90% and 32.74%, respectively.

2.2.4. Economic Sustainability Reporting

Economic sustainability (series 200) in the context of GRI standards requires organizations to disclose/report on their impacts on the economic conditions of stakeholders as a whole and economic systems at the local, national and global levels. The economic sustainability reporting dimension of the GRI framework looks at the flow of capital among various stakeholders and the impact that organizations have on society as they work toward generating wealth and other economic benefits, and how such effects are managed. The Economic Standards, otherwise called "The 200," include topic-specific Standards made up of the following:

GRI 201: Economic Performance 2016 Effective From 01 Jul 2018

GRI 202: Market Presence 2016 Effective From 01 Jul 2018

GRI 203: Indirect Economic Impacts 2016 Effective From 01 Jul 2018

GRI 204: Procurement Practices 2016 Effective From 01 Jul 2018

GRI 205: Anti-corruption 2016 Effective From 01 Jul 2018

GRI 206: Anti-competitive Behavior 2016

2.2.5. Environmental Sustainability Standards

Environmental sustainability standards (The 300 series) of the GRI Standards include topic-specific Standards used to report information on an 'organization's material impacts related to environmental topics. This dimension is also known as series 300, and its sub-components include the following:

GRI 301: Materials 2016 Effective From 01 Jul 2018

GRI 302: Energy 2016 Effective From 01 Jul 2018

GRI 303: Water and Effluents 2018 Effective From 01 Jan 2021

GRI 304: Biodiversity 2016 Effective From 01 Jul 2018

GRI 305: Emissions 2016 Effective From 01 Jul 2018

- GRI 306: Effluents and Waste 2016 Effective From 01 Jul 2018
- GRI 307: Environmental Compliance 2016 Effective From 01 Jul 2018
- GRI 308: Supplier Environmental Assessment 2016 Effective From 01 Jul 2018

2.2.6. Social Sustainability Reporting

Social sustainability reporting Standards (series 400) include topic-specific Standards used to report information on an 'organization's material impacts on social topics. It has subcategories encompassing the following:

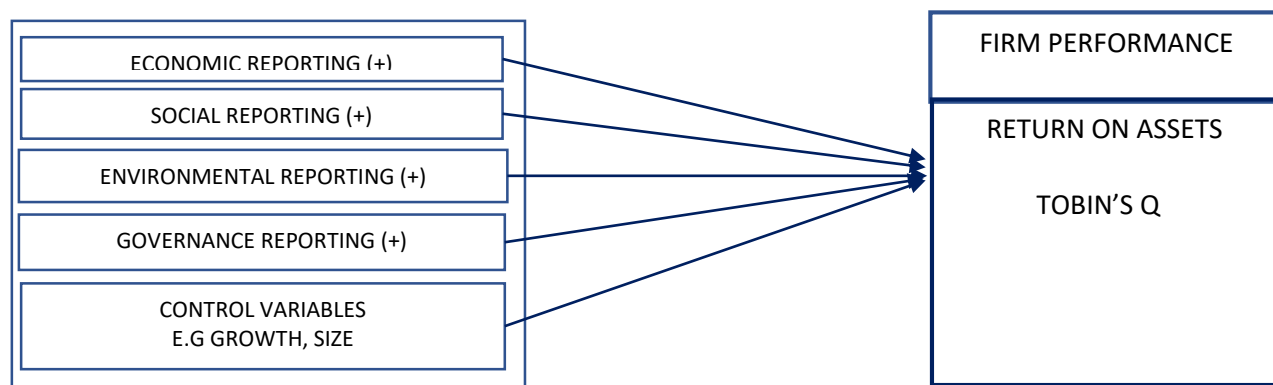
- GRI 401: Employment 2016 Effective from July 01, 2018
- GRI 402: Labor/Management Relations 2016 Effective From 01 Jul 2018
- GRI 403: Occupational Health and Safety 2018 Effective from January 01, 2021, GRI 404: Training and Education 2016 Effective from July 01, 2018
- GRI 405: Diversity and Equal Opportunity 2016 Effective from July 01, 2018, GRI 406: Non-discrimination 2016 Effective from July 01, 2018
- GRI 407: Freedom of Association and Collective Bargaining 2016 Effective from July 01, 2018
- GRI 408: Child Labor 2016 Effective from July 01, 2018
- GRI 409: Forced or Compulsory Labor 2016 Effective from July 01, 2018
- GRI 410: Security Practices 2016 Effective from July 01, 2018
- GRI 411: Rights of Indigenous Peoples 2016 Effective from July 01, 2018
- GRI 412: Human Rights Assessment 2016 Effective from July 01, 2018
- GRI 413: Local Communities 2016 Effective from July 01, 2018
- GRI 414: Supplier Social Assessment 2016 Effective from July 01, 2018
- GRI 415: Public Policy 2016 Effective from July 01, 2018
- GRI 416: Customer Health and Safety 2016 Effective from July 01, 2018
- GRI 417: Marketing and Labeling 2016 Effective from July 01, 2018
- GRI 418: Customer Privacy 2016 Effective from July 01, 2018
- GRI 419: Socioeconomic Compliance 2016

3. DATA AND METHODOLOGY

3.1. Model Specification

The causal research design was used in this analysis. Causal research looks at the interaction between variables, or the impact of one thing on another, and more precisely, the impact of one variable on another (Mugenda and Mugenda, 2003). The study's target population was listed banks operating in three African countries, including Ghana, Nigeria, and South Africa, which were emphasized in the study over ten years from 2010 to 2020. The utilized panel fixed effect regression model.

Figure 1: Conceptual Model



The conceptual framework is mathematically represented as follows:

$$\text{Tobin's } Q/\text{ROA}_{it} = \beta_0 + \sum_{i=1}^n \beta_1 X_{it} + \epsilon$$

Where, β_0 is the intercept of equation, β_1 is the coefficient of X_{it} variables, X_{it} is the different independent variables representing sustainability in bank one at Time t , t is time from 1, 2... years and ϵ =Error term, ROA is Return on Assets.

Finally, the above general least square model is converted into specified models as follows;

Research Model 1: Using Tobin's Q as Performance Measure

$$\text{Tobin's } Q_{it} = \beta_0 + \beta_1 \text{Econ_Sus}_{it} + \beta_2 \text{Gov_Sus}_{it} + \beta_3 \text{Soc_Sus}_{it} + \beta_4 \text{Env_Sus}_{it} + \beta_5 \text{Size}_{it} + \text{Growth}_{it} + \epsilon_{it}$$

Research model 2: Using Return on Assets as performance measure

$$\text{ROA}'_{it} = \beta_0 + \beta_1 \text{Econ_Sus}_{it} + \beta_2 \text{Gov_Sus}_{it} + \beta_3 \text{Soc_Sus}_{it} + \beta_4 \text{Env_Sus}_{it} + \beta_5 \text{Size}_{it} + \text{Growth}_{it} + \epsilon_{it}$$

Table 2: Variable Definitions

Name	Definition
Dependent variables	
ROA	"Return on Assets given as the Ratio of profits before interest and tax to total assets. "
Tobin's Q	"Ratio of the market value of a company's assets (as measured by the market value of its outstanding stock and debt) divided by the replacement cost of the company's assets (book value)."
Variables of Interest	
Econ_Sus	Economic disclosure score as per GRI standards
Gov_Sus	Governance disclosure score as per GRI standards
Soc_Sus	Social disclosure score as per GRI
Size (SIZE 1)	"The Log of total assets for the bank 1 in time t"
Growth (GRO)	"Year on Year change in interest income for Bank one in time t"
E	Error term

4. FINDINGS AND DISCUSSIONS

4.1. Descriptive statistics

Table 3 below contains the Descriptive statistics on the key variables measuring sustainability. On average, the results suggest that Economic disclosures have the highest mean score (mean=5.92; SD=2.17) across the firms studied. By implication, it indicates that banks disclose more information on sustainability's economic dimension compared to the other dimensions. Following financial disclosures, governance indicators were the second most disclosed dimension of sustainability by the banks under consideration (mean= 5.41). The financial sector is a sensitive one, and any governance anomaly can result in dire consequences to individual stakeholders and the macroeconomy. As a result of this, there are strict regulatory requirements concerning governance mechanisms and processes. In addition, the social dimension of sustainability was found to be the third most disclosed dimension of sustainability among the banks under consideration (mean=5.35). Finally, the environmental dimension of sustainability was the least disclosed sustainability dimension (Mean= 4.52).

4.2. Test for the Presence of Heteroskedasticity

From Table 4, a P-Value of 0.3340 at 5% significance suggests that we fail to reject the null hypothesis and accept that the underlying data (variables) for estimating the regression model does not suffer heteroskedasticity. Having established that the residuals of the variables are homoscedastic, we proceed to determine when the research models are best estimated using fixed-effects or random effects.

Table 3: Presence of Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance (Accept)
Variables: fitted values of TOBQ

chi2(1) = 0.93
 Prob > chi2 = 0.3340

4.3. Model 1 (Tobins Q) Specification Test

The results in Table 5 indicate that the Hausmann specification test selected the fixed effect specification. It suggests that the research model will be more efficient when estimated with fixed effects rather than random effects. Thus, with a P-value of 0.003 at a 5% significance level, we reject the null hypothesis that random effect is appropriate and accept that Fixed effects are somewhat appropriate.

Table 4: Model 1 Specification

	Coefficients			
	(b) initialFE	(B) initialRE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
ENVi	.0605308	.0629029	-.0023721	.
SIZEi	.0296286	.0384953	-.0088667	.
ECOi	.044726	.0642559	-.0195299	.
GOVi	.0727821	.0876994	-.0149173	.
SOCi	.0375393	.0429563	-.005417	.
GROWTH	.0635927	.0707377	-.007145	.

Prob>chi2 = 0.0000

H0: random effects are appropriate (reject)

Ha: Fixed effects is appropriate

4.4. Model 2 (ROA) specification test

As was the case in model 1, the Hausmann specification test result above indicates that the second research model can be better estimated using fixed effects. That is, against the null hypothesis that "random effect is appropriate," a probability value of 0.0000 suggests a rejection of the null hypothesis. Hence, the second model was also estimated using fixed effects.

Table 5: Hausmann Specification Test 2

	Coefficients			
	(b) fe3	(B) re3	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
ECOii	.0545596	.0677679	-.0132083	.0041047
GOVii	.0423894	.0355917	.0067977	.0021025
ENVii	.0381999	.0550752	-.0168753	.0055473
SOCii	-.0003282	.0098682	-.0101964	.0036498
SIZEii	.0180626	.0285133	-.0104508	.0018855
GROWTH	.0335101	.0388779	-.0053677	.0022932

Test: Ho: Random effect is appropriate (reject)

Ha: fixed Effects is appropriate (Accept)

Prob>chi2 = 0.0000

4.5. Model 1 - Final Estimate

The research model was re-estimated after correcting the problem of serial correlation. Compared to the previous model (where the serial correlation was present), the current model explains more of the variance in the dependent variable. In the final iteration, the co-efficient of determination increased from 63% to 67%. It suggests that the first estimate of the model was rendered less efficient by serial correlation. According to Chin (1998) and Moore (2013), r-squared values ranging from 50%-69% are considered moderate. It suggests that the exogenous variables in model one moderately explain the variations in the endogenous variable. Specifically, about 67% of the variance in bank performance can be jointly explained by

sustainability disclosures, including economic reporting, governance reporting, social reporting, environmental reporting, bank size, and growth. Bank size and bank growth were used as control variables. Additionally, it is noteworthy that all the variables were jointly significant at a 5% significance level (i.e., P-Value of F-statistics = 0.0000). Besides, the final model was examined for the second time to assess whether the introduction of the lagged dependent variable was successful in eliminating the problem of serial correlation.

Table 6: Final Estimation of Model 1

Fixed-effects (within) regression		Number of obs = 124				
Group variable: ID		Number of groups = 17				
R-sq: within = 0.6628		Obs per group: min= 4				
Between = 0.2308		avg = 7.3				
Overall = 0.2279		max = 8				
Corr (u _i , Xb) = 0.2109		F(7,100) = 28.08				
		Prob > F = 0.0000				
TOBQ	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lagdep	-.2232678	.0672354	-3.32	0.001	-.356661	-.0898746
ENV _i	.0521217	.0060598	8.60	0.000	.0400993	.0641442
SIZE _i	.0282144	.0114483	2.46	0.015	.0055013	.0509275
GOV _i	.0671849	.0220569	3.05	0.003	.0234247	.1109451
ECO _i	.058355	.0162731	3.59	0.001	.0260697	.0906403
SOC _i	.0328664	.0148486	2.21	0.029	.0034072	.0623256
GROWTHTOBQ	.0321465	.0154863	2.08	0.040	.0014222	.0628709
_cons	6.596587	.5851045	11.27	0.000	5.435757	7.757418
sigma_u	.7580427					
sigma_e	.09028342					
rho	.98601342 (fraction of variance due to u _i)					
F test that all u _i =0:		F(16, 100) = 29.22	Prob > F = 0.0000			

4.6. Model 2 - Final Estimate

The final estimate of model 2 showed an improvement in the R-squared after eliminating the impact of serial correlation.

Notably, it is observed that the introduction of the lagged dependent variable led to an improvement in the coefficient of determination from 40% to 48%, almost 0% (Refer to Table 11 above). By implication, this suggests that the final model accounts for almost 50% of the variation in the performance of banks; all other things are held constant. Taken together, the F-statistics also suggest that all the explanatory variables are jointly significant in explaining the endogenous variable.

Table 7: Final Estimation of Model 2

Fixed-effects (within) regression		Number of obs = 141				
Group variable: ID		Number of groups = 18				
R-sq: within = 0.4806		Obs per group: min = 6				
between = 0.0346		avg = 7.8				
overall = 0.0003		max = 8				
corr(u _i , Xb) = -0.1705		F(7,116) = 15.33				
		Prob > F = 0.0000				
ROA	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
ECO _{ii}	.0388183	.0133699	2.90	0.004	.0123374	.0652991
ENV _{ii}	.0417534	.0207406	2.01	0.046	.0006741	.0828328
GOV _{ii}	.0405458	.0085116	4.76	0.000	.0236876	.057404

SOCii		.0254755	.0116373	2.19	0.031	.0024265	.0485246
SIZEii		.0172294	.0071022	2.43	0.017	.0031626	.0312961
GROWTHROA		.0279007	.0102057	2.73	0.007	.0076871	.0481144
Lagdep		-.1700089	.0758225	-2.24	0.027	-.3201848	-.019833
_cons		6.621671	.5807967	11.40	0.000	5.47133	7.772012

sigma_u		.82245998					
sigma_e		.11322165					
rho		.98140157 (fraction of variance due to u_i)					

F test that all u_i=0: F(17, 116) = 14.02 Prob > F = 0.0000							

This section discusses the findings of the study in light of the existing literature. The discussions on the hypothesized relationships are based on the final estimated regression models. These are summarized in Table 13 below.

Table 3: Hypotheses Tests

VARIABLES	MODEL 1			MODEL 2		
	TOBINQ (β)	S.E	P-Value	ROA (β)	S.E	P-Value
ENV	0.052***	(0.006)	0.000	0.042	(0.021)	0.51
SIZE	0.028**	(0.011)	0.015	0.017**	(0.007)	0.017
ECO	0.058***	(0.016)	0.001	0.039***	(0.013)	0.004
GOV	0.067***	(0.022)	0.003	0.041***	(0.009)	0.000
SOC	0.033**	(0.015)	0.029	0.025**	(0.012)	0.031
GROWTH	0.032**	(0.015)	0.040	0.028***	(0.010)	0.007
Constant	6.597***	(0.585)	0.000	6.622***	(0.581)	0.000
Lagged (DV)	0.223***	(0.067)	0.001	0.170**	(0.076)	0.027
R-squared	0.663			0.481		
Prob > F =	0.000			0.000		
NB:						
Standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

4.7. Economic Disclosures and Firm Profitability

Under models one and model two, H2c and H2d were validated at a 0.1% significance level. In H1a, the result suggests that a one-unit improvement in bank economic distribution will result in about a 5a. In the case of H1b, the finding was that a unit improvement in the financial disclosure of banks would result in a corresponding increase in their return on assets by about 4%, all other things held constant. Comparatively, although both models demonstrated a significant positive association between financial disclosures and financial performance, it appears that the first model (using Tobin's Q) had a more substantial effect.

Consistent with Nobanee and Ellili (2017) and Shrivastav and Kalsie (2017), the results depict those financial disclosures have the highest impact on financial performance under H1b, compared to other dimensions of sustainability. Nobanee and Ellili (2017) studied sustainability (i.e., economic, environmental, and social) disclosure practices of banks in the United Arab Emirates. In their study, Nobanee and Ellili (2017) segmented the banks under consideration into two, including conventional banks and Islamic banks. The study's findings that financial disclosures are higher for both types of banks. A study by Hinson et al. (2015) also concluded that economic indicators were the most disclosed dimensions of sustainability.

On the contrary, the findings of Bonsón and Bednárová (2015) do not collaborate with this study. Instead, they found that firms disclosed more governance information than environmental, economic, and social information. The differences in findings might be attributed to the differences in the sustainability disclosure mediums emphasized by each study. Whereas the study focuses on sustainability reportage via annual reports, Bonsón and Bednárová (2015) emphasized website r. Besides, the choice of sustainability framework adopted in the conduct of each study may account for the differences in the results. Thus, whereas the current study employed the sustainability frame developed by the global reporting Initiative, Bonsón and Bednárová (2015) adopted the Spanish Accounting and Business Association's (AECA) sustainability index.

Concerning why firms disclose more economic content relative to other sustainability indicators, some scholars point to regulatory requirements concerning disclosures of financial information (Aboagye-Otchere et al., 2012). Another strand of the literature believes that increased financial disclosures can enhance a firm value and reputation in the long run (Bonsón & Bednárová, 2015; Shrivastav & Kalsie, 2017). Notably, the argument has also been made that increased financial disclosures demonstrate a firm's commitment to accountability and transparency.

Additionally, Sahore and Verma (2017) and Gillan et al. (2010) corroborate our finding that economic reporting positively influences firm value. It is held in the literature that firms with good financial standings are more likely to increase their disclosures on economic matters. It may explain why economic reporting has a positive association with financial performance. Besides, it is believed that stakeholders are increasingly becoming sensitive to issues bordering on sustainability. Hence, they tend to reward firms who make extensive disclosures about their sustainability practices, enhancing firm performance. Contrary, Nobanee and Ellili's (2017) findings concluded that no significant relationship exists between financial disclosures and firm performance. Such mixed findings in the literature may signify the need for further research.

4.8. Governance Disclosures and Firm Performance

The study sought to examine whether banks' disclosure of governance indicators influences their financial performance and firm value. According to the sustainability framework developed by the Global reporting initiative, governance disclosures encompass reporting on the company mission, vision, strategy, organizational structure, board characteristics, and board composition, among others. From the results presented in table 13, we fail to reject hypotheses H2a and H2b. the study found a significant positive relationship between governance disclosures and financial performance for models one and two. Specifically, Under H2a, the finding suggests a one-unit improvement in governance disclosures will result in about a 6.7% increase in the Tobin's Q of banks, all other things being equal. Accordingly, Under H2b, findings suggest that a one-unit improvement in the governance disclosures of banks will culminate in about a 4.1% improvement in the return on banks' assets. The findings contradict the earlier study by Nobanee and Ellili (2017) but corroborate with Shrivastav and Kalsie (2017). Whereas Shrivastav and Kalsie (2017) found that a positively significant relationship exists between governance disclosures and firm performance, Nobanee and Ellili (2017) failed to establish any significant relationship. Notwithstanding the mixed findings, there is some degree of convergence in the literature concerning the positive association between financial performance and governance disclosures (see Dalton et al. 1999; Gillan & Starks 2007; Love, 2010).

4.9. Social Disclosure and Firm Performance

The study examined whether social disclosures influence the financial performance of firms. The social dimension of sustainability entails disclosures on human resources, labour practices, impact on society, and corporate social responsibility. The result of the study validated H3a and H3b. The study results indicate that social disclosures have a significant favourable influence on financial performance and firm value. Under H3a, data in Table 13 reveals that a unit improvement in the social disclosure of banks will culminate in about a 3.33% increase in their Tobin's Q. Additionally, under H3b, the findings suggest that a one-unit improvement in the social disclosure of firms will lead to about a 2.5% increase in the return on assets of banks.

A related study by Mishra and Suar (2010) contended that responsible social practices by businesses enhance corporate reputation, which in turn can lead to a favourable perception of the firm by customers and other stakeholders and lead to increased business performance. That is, according to the consumer inference theory, consumers are more likely to increase their demand for a company's product if they perceive it to be socially responsible (Brown & Dacin, 1997). Besides, Consumers may associate high product quality with proactive corporate citizenship (Maignan & Ferrell, 2001; Mishra & Suar, 2010). Mishra and Suar (2010) explain further, stating as follows. Alternatively, irresponsible behaviour by firms agitates stakeholders. They often react by boycotting the company, reducing its consumption, initiating legal action against the company, and spreading lousy word-of-mouth about irresponsible business practices (p.576).

4.10. Environmental Disclosure and Firm Performance

Environmental reporting includes disclosing sustainability indicators such as energy consumption, waste management, emissions, and biodiversity. There have been persistent arguments in the literature concerning whether environmental reporting impacts financial performance and firm value. Whereas one strand of the literature has established a positive relationship between the two variables (Sulaiman & Mokhtar, 2012; Wahab et al., 2017; Graham, Harvey & Regional, 2005), another strand of the literature finds a negative relationship between the two variables (Chiong, 2010). Some studies do not find any significant relationship between the two variables (Nor et al., 2016; Sarumpaet, 2005). In most cases, those who find a negative relationship between environmental reporting and firm performance explain that managing environmental responsibility may erode profits; hence the higher the environmental cost, the lower the financial performance. Other

scholars have also argued that although environmental responsibility may not translate to increased profitability in the short run, it has long term benefits such as boosting firm reputation and prestige, enhancing legitimacy, as well as increasing the long-term value of the firm

In the current study, there are divergent findings concerning whether environmental reporting influences firm performance. In the first model, the results suggest that environmental reporting has a significant positive effect on firm performance, as measured by Tobin's Q; nonetheless, the second model (using return on assets as a measure of financial performance) did not establish any significant relationship between the two variables. Specifically, Under H1a, the findings suggest that a one-unit improvement in the environmental disclosure of banks will result in about a 5.2% improvement in firm profitability, all other things being equal. However, under H1b, although the result shows that a unit improvement in environmental reporting can enhance profitability by about 0.42%, such an outcome was statistically insignificant. Thus, the contradiction in model I and model II findings can mainly be attributed to the differences in performance measures. In other words, whereas the accounting measure of performance suggests that no statistically significant relationship exists between environmental reporting and return on assets, the market-based performance measure has established a significant positive relationship between environmental reporting and Tobin's Q. These findings complement the existing literature, which argues that environmental reporting may not impact profitability in the short-term, but may have an impact on the overall firm's value. That is, Tobin's Q, which established a positive relationship, has been by several studies to measure firm value. In contrast, return on assets has also been used as an accounting profitability measure.

4.11. Bank Size, Growth, and Firm Performance

Firm size was used as a control variable in the study. Generally, the literature agrees that larger firms report more sustainability information than smaller firms (Brammer & Pavelin, 2006). It is believed that large firms are more visible in the public domain and would disclose more information to improve their reputation and gain a favourable position among stakeholders (Cormier & Magnan, 2003). Besides, being able to adequately value and report environmental sustainability performance might be challenging to smaller firms that (due to financial challenges) cannot employ qualified personnel for such a task. Consistent with the existing literature, the study finds a significant positive relationship between Bank Size and performance for both of the models. Under H4a, the finding suggests that Tobin's Q of firms will improve by 2.8% with a unit increase in firm size. Besides, using the second model, a unit increase in bank size will increase the return on assets by 1.7%, all other things being equal. Besides, bank growth (measured by year-on-year change in assets) established a statically significant positive relationship with return on assets and Tobin's Q.

5. CONCLUSIONS AND RECOMMENDATIONS

Generally, increased sustainability disclosures tend to enhance firm performance. Nonetheless, it appears the effect of sustainability reporting is more felt in the long term than in the short term. Additionally, it can be said that sustainability reporting has to do with information disclosure. Any increment in disclosure practices is more likely to impact stock market-based performance measures (Tobin's Q) than accounting performance measures (return on assets). It may explain the efficient market hypothesis, which states that asset prices reflect all available information. Consequently, increased disclosures may paint a positive picture of firms' sustainability practices, thereby boosting stock prices and overall firm value (measured by Tobin's Q). Besides, firms tend to disclose more sustainability information when company laws mandate it, and this was reflected in the disclosure rates for financial and governance information, which are mostly mandatory. Comparatively, larger firm sizes are positively associated with increased sustainability disclosures. It is believed that large firms have the necessary financial resources to absorb the cost of sustainability disclosures.

Besides, larger firms may have the resources to employ skilled personnel who can adequately measure and report sustainability. To sum everything up, the study results suggest that disclosing sustainability practices has implications on firm performance; however, such effects may not be felt in the short-run but in the long term. Accordingly, the study concludes that market-based performance measures are more responsive to sustainability disclosures than accounting-based performance measures. Generally, firms that disclose more sustainability information are likely to enjoy increased performance over time. Customers and other stakeholders are increasingly becoming interested in firms that are more sustainability-conscious than otherwise. Hence the study recommends that banks pay attention to all the dimensions of sustainability, not only those mandated by law. Banks should not consider themselves less environmentally sensitive and disclose less environmental information. Secondly, the 21st century has witnessed technological innovations that have widened the mediums of corporate communications.

The study recommends that firms go beyond the traditional means of disclosing sustainability information through annual reports. Using social media platforms, firms can post their sustainability information on Facebook, Twitter, Instagram, and YouTube. The uniqueness of these social media platforms lies in their ability to facilitate real-time engagement with stakeholders and almost no cost. Besides, a wider audience can be reached when information is disclosed on social media

platforms. The disclosures can be organized into several media types: video, audio, 3D animations, etc. These enhance the richness of communicated information.

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THE CAUSAL RELATIONSHIP BETWEEN BITCOIN ENERGY CONSUMPTION AND CRYPTOCURRENCY UNCERTAINTY

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Samet GURSOY¹, Hilmi Tunahan AKKUS², Mesut DOĞAN³

¹Burdur Mehmet Akif Ersoy University, Bucak ZTYO, Department of Customs Management, Burdur, Turkey.
sametgursoy@mehmetakif.edu.tr, ORCID: 0000-0003-1020-7438

²Balıkesir University, Savastepe Vocational School, Department of Wholesale and Retail, Balıkesir, Turkey.
tunaakkus@balikesir.edu.tr, ORCID: 0000-0002-8407-1580

³Afyon Kocatepe University, Bayat Vocational School, Department of Business Administration, Afyon, Turkey.
mesutdogan07@gmail.com, ORCID: 0000-0001-6879-1361

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ABSTRACT

Purpose- Investigating the relationship between the energy consumption for Bitcoin and the price and policy uncertainties in the cryptocurrency markets.

Methodology- It was preferred for unit root tests of series the Zivot-Andrews Unit Root Test, which takes into account structural breaks. Depending on the stagnation of the variables at different levels, the Toda-Yamamoto (1995) causality test was applied by using weekly data in period 19.02.2017 and 07.02.2021.

Findings- One-way causality was found on the indices of cryptocurrency price uncertainty and cryptocurrency policy uncertainty from bitcoin energy consumption. In addition, it is understood from the Chi-Square Test Statistic (13.16980) coefficient that the change in bitcoin energy consumption is more dominant on the crypto money policy uncertainty. It was reached that changes in bitcoin energy consumption have an effect on both price and crypto money policies in all crypto markets.

Conclusion- In line with these results, it is concluded that the uncertainties in the crypto markets are under the influence of many external political factors. This study investigated the effect of price and political uncertainty on bitcoin energy consumption in the entire cryptocurrency market, but it was concluded that bitcoin energy consumption is not only linked to crypto markets, but also under the influence of government interventions, bans, ill-recognition, and developments and movements in other financial markets.

Keywords: Bitcoin energy consumption, bitcoin mining, cryptocurrencies, crypto money price uncertainty index.

JEL Codes: G00, G19, P43

1. INTRODUCTION

The way the real economy works has completely changed with the widespread use of the internet. The fact that all internet users can interact at the same time has reduced the costs of accessing information. Internet-based electronic marketplaces use information technology (IT) to match buyers and sellers with lower transaction costs. The internet age and developments in financial technology and innovations such as mobile payments, blockchain applications, the development of digital payment methods, and digital currencies have led to the emergence of new financial instruments. Cryptocurrencies, one of these new tools, allow real-time transactions, open algorithm and transaction history storage. With these features, it is among the investment instruments with high investor interest. Of course, this investor interest is heading in different directions with the uncertainties and risky movements in the financial markets.

Coins such as Bitcoin, which deviate from government or standard economic operations, were introduced in 2008. Cryptocurrencies are an innovation that emerged as a result of investors losing their trust in mainstream currencies due to excessive market uncertainty (Demir et al. 2018). Especially in times of high economic uncertainty, investors either restrict their investments, wait for the current conditions to settle, or try to find suitable strategies to reduce uncertainty around the world. Interestingly, the cryptocurrency market is emerging as a risk management tool for domestic and international investors of stock and commodity markets worldwide, during periods of high uncertainty in particular (Haq et al. 2021: 2).

However, when there is a significant level of uncertainty in the markets, a “wait and see” investment strategy is used by investors, which leads to an increase in the value of the cryptocurrency (Jiang and Ashworth, 2021: 1-2). While it is effective in crypto pricing and accordingly, it is thought that it may have possible effects on crypto energy consumption. In addition, attempts have been made to measure and evaluate the risks and uncertainties occurring in crypto markets. These indexes that Crypto Money Price Uncertainty Index and the Crypto Money Policy Uncertainty Index created by Lucey et al. (2021), are existed in this direction.

On the other hand, Bitcoin mining comes first among the methods used to obtain Bitcoin. In the Bitcoin mining process, a proof-of-work problem must be solved first. It should be ensured that the block header value of a certain length is passed through the SHA256 hash algorithm twice, and the resulting value is less than the target value provided by the system, thus preceding a certain amount of 0. There is a very serious competition among the miners in the network and a significant amount of electricity is consumed in the execution of this large number of transactions (Balcısoy, 2017: 2).

The process of producing Bitcoin, called Bitcoin mining, uses Blockchain technology and basically only needs hardware and electricity consumption. Possible changes in Bitcoin prices and crypto markets are thought to have an impact on the demand for Bitcoin mining. In addition, both the business world and researchers have started to discuss the energy consumption of Bitcoin mining. In this context, which factors are effective on bitcoin energy consumption has been the source of motivation for this study.

This study was designed to investigate the possible effects of price and policy uncertainties on bitcoin energy consumption in crypto markets, limited to preferred periods and variables. In this direction, following the introduction, in the second part, summaries of recent studies on the subject will be presented. Then, in Chapter 3, the econometric model to be used in the application part of the study will be introduced and the findings will be presented in the form of tables and graphics. In the last section, the findings obtained from the analysis will be interpreted in comparison with the literature studies. In addition, the benefits of the findings obtained from this study for investors and policy makers and those who will do academic studies in this field will be evaluated and suggestions will be made.

2.LITERATURE

In many studies which were taken into account macroeconomic factor effects on cryptocurrencies; Fang et al. (2020), Honak (2021); its relationship with capital markets; Shahzad et al. (2022), Dobrynskaya, V. (2021), Pillai et al. (2021), Huwaida and Hidajat (2020), Gürsoy and Tuncel (2020), Baur, Hong and Lee (2018); the relationship between bitcoin and other cryptocurrencies and commodities; Elsayed et al. (2022), Long et al. (2021), Singh (2021), Buğan (2021), Hassan et al. (2021), Ferreira and Pereira, (2019), Dyhrberg (2016); The relationship between energy consumption and environmental factor; Geels, (2022), Yan et al. (2021), Corbet et al. (2021), Badea and Mungpiu-Pupăzan (2021), Gallersdörfer et al. (2021), Jane et al. (2020), Egiyi and Ofoegbu, (2020 Stoll, (2019), Mora et al. (2018), ; Its relationship with global risks and uncertainties, investment risks; Sarkodie et.al (2022), Diaconăşu et al. (2022), Böyükaslan and Ecer (2021), Platt et al. (2021), Cheng and Yen (2020), (Çelik, 2020), Wu et al. (2019), Bouri et al. (2018), Hong et al. (2009) studies were observed in general. Most of these studies consider bitcoin, the most popular currency. In this study, an application made in which direct crypto currency uncertainty is selected as an independent variable. In the literature on cryptocurrency uncertainty, a very limited number of studies have found in the national literature, but it is seen that this number is higher in the international literature. Likewise, when the bitcoin energy consumption and literature are examined, it is seen that the studies have intensified in the last few years. Since this study will be the pioneer study examining the relationship between bitcoin energy consumption and cryptocurrency uncertainty, it is hoped that this aspect will contribute to the literature.

Although there are no directly similar studies on the subject, the most recent studies on Bitcoin energy consumption are as follows: Kristoufek (2020) investigated the relationship between Bitcoin mining costs, bitcoin price, Bitcoin hash-rate and Bitcoin electricity costs between in period of 2014M1- 2018M8. Bitcoin price and mining costs are closely linked. It was concluded from here that electricity costs play a primary role in Bitcoin mining efficiency. KıAytakin and Kaya (2022) found a relationship between Bitcoin and electrical energy consumption both in the short-term and in the long-term. Huynh et al. (2022) examined the relationship between bitcoin energy consumption and price, volume between 11.02.2017-18.09.2019. According to the results, Bitcoin trading volumes on energy consumption is higher than returns in the long run. Kılıç et.al. (2021) investigated the relationship between bitcoin energy consumption and energy companies. In the study using weekly data between 22.05.2017 - 10.02.2021, they tested the relationship between bitcoin energy consumption and the energy markets of the countries that produce the most bitcoin. Bitcoin electricity consumption affects energy company valuations of Russia and China; It has been observed that the USA and Russia are affected by the energy company valuations.

3.METHODOLOGY

The aim of this study is to reveal whether there is a causality between Bitcoin energy consumption and cryptocurrency uncertainty, and its direction. However, weekly Terawatt (TW) data were obtained on regarding bitcoin energy consumption

(BENRGY at digiconomist.net. For the represent crypto markets uncertainty, it was reached the Cryptocurrency price uncertainty index (UCRYPRI) and cryptocurrency policy uncertainty indices (UCRYPOL) created by (Lucey et al. 2021). Cryptocurrency uncertainty and indices data were created from weekly observation values and accessed from <https://brianmlucey.wordpress.com/2021/03/16/cryptocurrency-uncertainty-index-dataset/>. The application used weekly data consisting of 208 observations between 19 February 2017 and 7 February 2021. The optimal lag length was determined according to the Akaike information criterion-AIC after the series were recovered from the unit root, that is, after they were made stationary. It has been observed that the variables are stationary at different levels in the analyzes of the unit root tests. Toda-Yamamoto (1995) causality, which is a suitable method for this situation, was preferred. More than one equation has been established in the form of paired tests, in which each variable is included as both dependent and independent variables.

This method was introduced to take the Granger causality test to a higher level. Some problems in the Granger causality test were tried to be eliminated with this model. In order to apply the Granger causality test in time series analysis, the series must first become stationary and become stationary at the same level. After this condition is met, cointegration should also occur in order to demonstrate that there is a long-term relationship between the series that become stationary at the same level. Only the Granger causality test can be performed between the series that are stationary at the same level and have a cointegration relationship between them. However, the Toda-Yamamoto test revealed that there can be causality between time series that are stationary at different levels, and that the causality test can be performed without even the need for a stationarity test. This model can also be tested regardless of whether there is cointegration between the series without considering cointegration (Toda and Yamamoto, 1995).

In first stage of the test, that is to determining the lag length (k) in the model with the VAR model. Then, in the second stage of the model, the variable with the highest degree of integration (d_{max}) is added to the lag length (k) of the model. In the third step, the VAR model is estimated according to the latency with the level values of the series ($k + d_{max}$) In the last step, the coefficients from (d_{max}) are added to the constraints and the significance of the added constraints is tested using the modified Wald statistic. The VAR model developed by Toda-Yamamoto (1995) is as follows;

$$Y_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}Y_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}X_{t-i} + u_t \quad (1)$$

$$X_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i}X_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i}Y_{t-i} + v_t \quad (2)$$

The main hypothesis and alternative hypothesis are handled as follows

H0: Variable X is not Granger cause of variable Y.

H1: Variable X is the Granger cause of variable Y.

The success of the Toda-Yamamoto causality test is directly related to the correct determination of the (d_{max}) value of the series (k) in the model.

4. FINDINGS

In this section, presented the results of the tests applied to reveal the causal relationship between the BENRGY, UCRYPRI and UCRYPOL variables.

The main hypothesis of the research is as follows;

H0: There is no causal relationship between Bitcoin Energy Consumption (BENRGY), Cryptocurrency Price Uncertainty Index (UCRYPRI) and Cryptocurrency Policy Uncertainty Indices (UCRYPOL).

H1: There is a causal relationship between Bitcoin Energy Consumption (BENRGY), Cryptocurrency Price Uncertainty Index (UCRYPRI) and Cryptocurrency Policy Uncertainty Indices (UCRYPOL).

The models consist of the BENRGY, UCRYPRI and UCRYPOL variables are as follows

The equations for BENRGY and UCRYPRI;

$$BENRGY_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i}BENRGY_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i}UCRYPRI_{t-i} + u_t \quad (3)$$

$$UCRYPRI_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i} UCRYPRI_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i} BENERGY_{t-i} + v_t \quad (4)$$

In the Toda-Yamamoto test, the main hypothesis and alternative hypothesis are established as follows.

H0: The BENERGY variable is not the Granger cause of the UCRYPRI variable.

H1: The BENERGY variable is the Granger cause of the UCRYPRI variable.

The equations for BENERGY and UCRYPOL;

$$BENERGY_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i} BENERGY_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i} UCRYPOL_{t-i} + u_t \quad (5)$$

$$UCRYPOL_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i} UCRYPOL_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i} BENERGY_{t-i} + v_t \quad (6)$$

The main hypothesis and alternative hypothesis are established as follows.

H0: The BENERGY variable is not the Granger cause of the UCRYPOL variable.

H1: The BENERGY variable is the Granger cause of the UCRYPOL variable.

The equations for UCRYPRI and BENERGY;

$$UCRYPRI_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i} UCRYPRI_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i} BENERGY_{t-i} + u_t \quad (7)$$

$$BENERGY_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i} BENERGY_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i} UCRYPRI_{t-i} + v_t \quad (8)$$

The main hypothesis and alternative hypothesis are established as follows.

H0: UCRYPRI variable is not Granger cause of BENERGY variable.

H1: The UCRYPRI variable is the Granger cause of the BENERGY variable.

The equations for UCRYPOL and BENERGY ;

$$UCRYPOL_t = a_0 + \sum_{i=1}^{k+d_{max}} a_{1i} UCRYPOL_{t-i} + \sum_{i=1}^{k+d_{max}} a_{2i} BENERGY_{t-i} + u_t \quad (9)$$

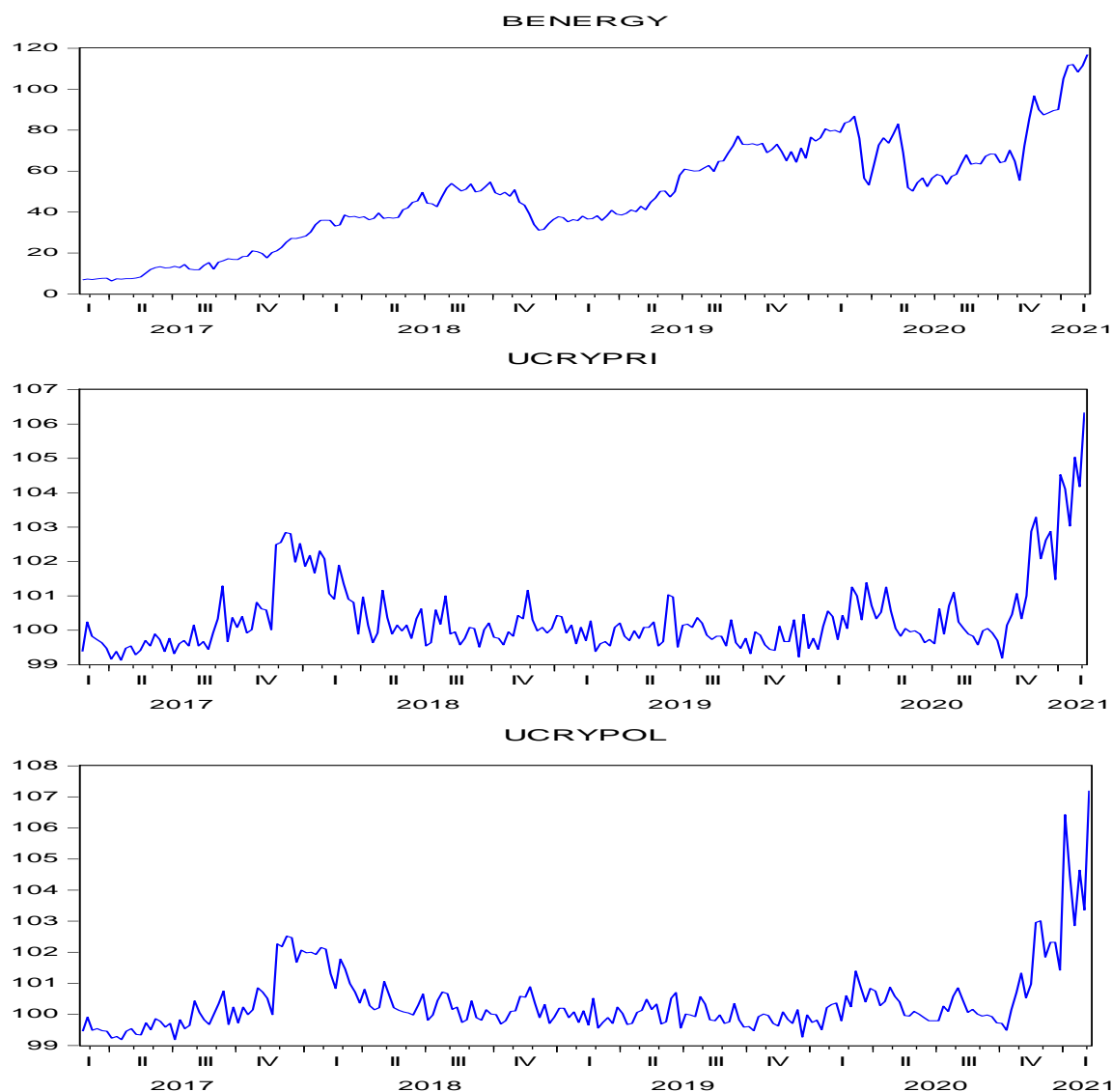
$$BENERGY_t = \beta_0 + \sum_{i=1}^{k+d_{max}} \beta_{1i} BENERGY_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{2i} UCRYPOL_{t-i} + v_t \quad (10)$$

The main hypothesis and alternative hypothesis are established as follows.

H0: UCRYPOL variable is not Granger cause of BENERGY variable.

H1: The UCRYPOL variable is the Granger cause of the BENERGY variable.

Figure 1: Price Series of Variables



4.1. Zivot-Andrews Unit Root Test Results

For the series, the C model was taken into account to determine the breaks of the series in the Zivot-Andrews test. The first difference of the non-stationary series at the level was taken and the Zivot-Andrews unit root test was applied again. findings are shown in Table 1.

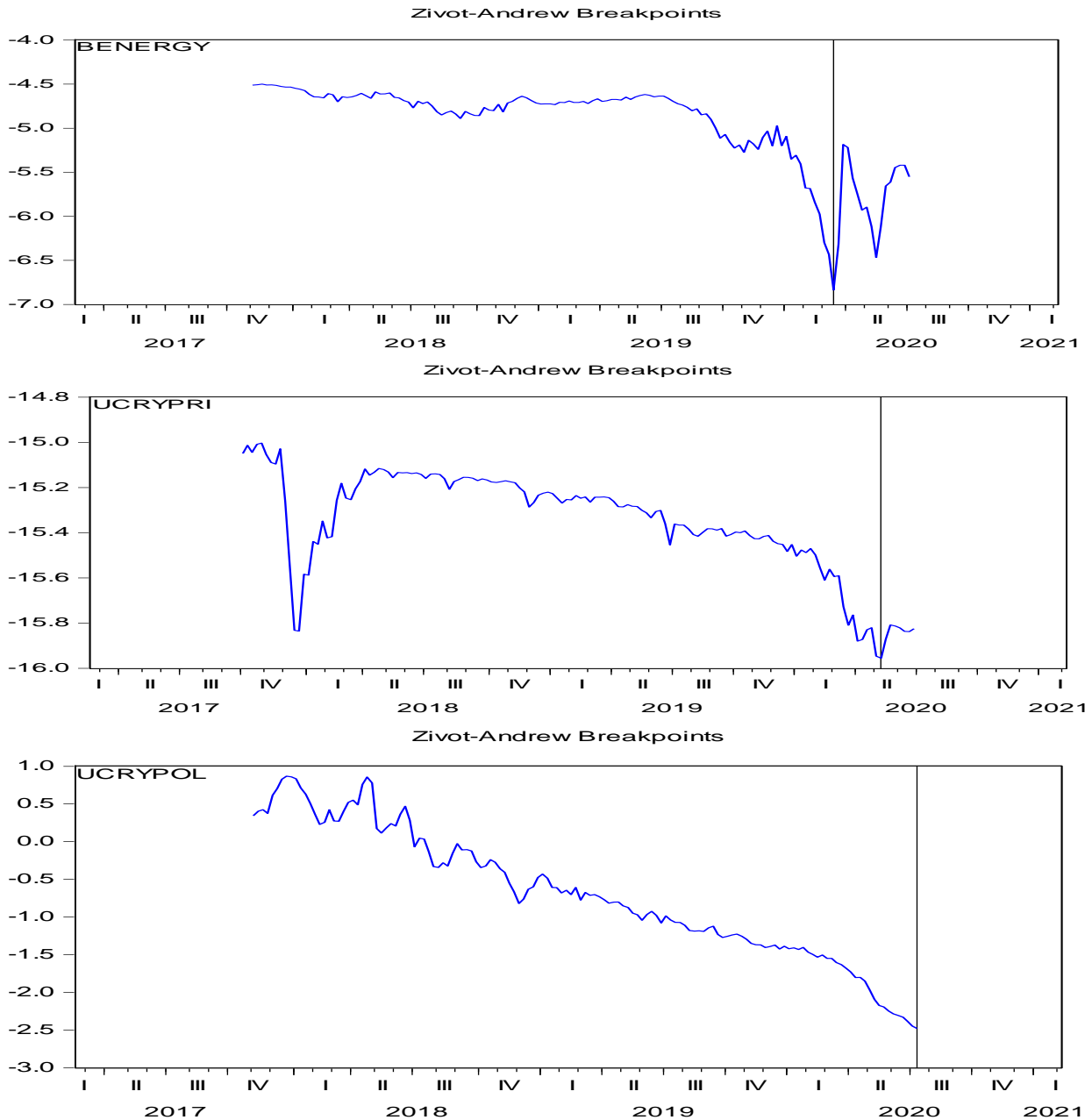
Table 1: Zivot-Andrews Unit Root Test Results

Zivot-Andrews (Model C)						
Variables	Level	Level Break Date	Critical Values	1. Difference	1.Difference Breaking Date	Critical Values
	(T) Statistics			(T) Statistics		
BENERGY	-3.21	17.05.2020	-5.08	-6.83*	15.03.2020	-5.08
UKRYPRI	-2.69	07.05.2020	-5.08	-15.95	10.05.2020	-5.08
UKRYPOL	-7.47	12.05.2020	-5.08	-7.47	-	-5.08

*: it is significant at 5% level

According to the results obtained from the ZA unit root test, BENERGY and UCRYPRI were found to be stationary at I (0), that is, level, while the UCRYPOL variable became stationary at I (1), that is, at the first difference. In addition, there was no unusual situation in the said breaking dates, and the dynamism in political and economic policies caused them to break. Figure 2 shows the graph showing the breaking dates of the series below.

Figure 2: Breaking Dates of the Series



Looking at the results of the unit root tests applied, it was observed that the series became stationary at different levels. In addition, lag lengths were tested in the form of paired tests, and the model was constructed considering that the most appropriate lag length was according to the AIC criterion. Lag length tables are shared below.

Table 2: Lag length Graphs

VAR Lag Order Selection Criteria						
Endogenous variables: BENERGY UCRYPRI						
Exogenous variables: C						
Sample: 2/19/2017 2/07/2021						
Included observations: 196						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1182.171	NA	606.4489	12.08337	12.11682	12.09692
1	-752.4208	846.3441	7.871421	7.738988	7.839338	7.779615
2	-733.5173	36.84258	6.761057	7.586911	7.754162*	7.654622
3	-723.1854	19.92582	6.338274	7.522300	7.756451	7.617095*
4	-716.8254	12.13580*	6.187889*	7.498219*	7.799270	7.620099
5	-714.5968	4.207158	6.301425	7.516294	7.884245	7.665258
6	-712.1195	4.626031	6.401083	7.531831	7.966683	7.707880
7	-707.1881	9.107924	6.341867	7.522328	8.024080	7.725461
8	-705.6240	2.856944	6.503257	7.547183	8.115836	7.777401
9	-703.1541	4.460905	6.607888	7.562797	8.198350	7.820099
10	-702.0201	2.024980	6.806915	7.592042	8.294495	7.876428
11	-697.5720	7.852258	6.779394	7.587469	8.356823	7.898940
12	-694.0960	6.065284	6.819978	7.592816	8.429070	7.931372

Table 3: Lag length Graphs

VAR Lag Order Selection Criteria						
Endogenous variables: BENERGY UCRYPOL						
Exogenous variables: C						
Sample: 2/19/2017 2/07/2021						
Included observations: 196						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1177.877	NA	580.4519	12.03956	12.07301	12.05310
1	-757.3589	828.1631	8.278216	7.789377	7.889727	7.830004
2	-740.8873	32.10293	7.289122	7.662115	7.829366	7.729826
3	-729.2026	22.53464	6.739644	7.583700	7.817852	7.678496
4	-723.3536	11.16090	6.614128	7.564833	7.865884	7.686713
5	-711.2578	22.83395	6.090343	7.482222	7.850174	7.631187*
6	-708.5402	5.074708	6.171513	7.495308	7.930160	7.671357
7	-700.0975	15.59311	5.899221	7.449975	7.951727	7.653108
8	-696.0447	7.402654*	5.897657*	7.449435*	8.018088*	7.679653
9	-692.3223	6.722991	5.916446	7.452269	8.087821	7.709571
10	-691.1233	2.141130	6.090603	7.480850	8.183303	7.765237
11	-686.7604	7.701759	6.071258	7.477147	8.246501	7.788619
12	-683.0057	6.551644	6.090256	7.479650	8.315904	7.818206

4.2. Toda-Yamamoto Causality Test Results

Toda-Yamamoto causality test was used to see if there is any causality between the variables. The tests were performed one by one among the variables in the form of a double test. While performing the Toda-Yamamoto test, the lag length of the series was found according to the Akaike information criterion-AIC, and the maximum integration degree d_{\max} was found according to the ZA unit root test. Then, by applying Wald statistics to the k-lagged values in this model, it was tried to determine whether there was a causal relationship. Test results are given below.

Tablo 4: Toda-Yamamoto Causality Test Results (Model 1)

Dependent Variable	Independent Variable	dmax	k	Chi-Square Test Statistic	Chi-Square P-value	Relationship
UCRYPRI	BENERGY	0	4	8.676757	0.0697	Yes
UCRYPOL		1	7	13.16980	0.0681	Yes

*: Statistically significant at the 5% level. The optimal lag length was determined according to the AIC criterion, dmax= the maximum stationarity level according to the Zivot-Andrews unit root test, k=VAR lag length.

According to the results of table 4, it was reached A causality relationship from the BENERGY to UCRYPRI at the 5% significance level. H0 hypothesis was rejected. H1 hypothesis could not be rejected. On the other hand, it was seen that the H1 hypothesis could not be rejected and the H0 hypothesis was rejected at the correct 5% significance level on UCRYPOL from BENERGY. Therefore, it was determined that there is a statistically significant causality relationship in BENERGY variable over other variables.

Tablo 5: Toda-Yamamoto Causality Test Results (Model 2)

Dependent Variable	Independent Variable	dmax	k	Chi-Square Test Statistic	Chi-Square P-value	Relationship
BENERGY	UCRYPRI	0	4	4.135214	0.3880	No
	UCRYPOL	1	7	7.824952	0.3483	No

*: Statistically significant at the 5% level. The optimal lag length was determined according to the AIC criterion, dmax= the maximum stationarity level according to the Zivot-Andrews unit root test, k=VAR lag length.

According to the findings in Table 5, the H0 hypothesis was accepted at the 5% significance level from UCRYPRI to BENERGY. H1 hypothesis was rejected. On the other hand, the H0 hypothesis was accepted at the correct 5% significance level on BENERGY from UCRYPOL. H1 hypothesis was rejected. lastly, it was found that there was no statistically significant causality relationship in the BENERGY variable over other variables.

5. CONCLUSION

The concept of energy has always been of vital importance in the progress of humanity. Undoubtedly, since it is not possible to have infinite energy, using it effectively is as important as reaching the source of energy. Accordingly, it is not only the results of crypto money mining, that is, crypto money energy consumption, but also what factors affect this energy consumption. In this context, in this study, unlike the literature, it is aimed to investigate the relationship between the energy consumption for crypto money and the uncertainties in these markets.

Considering the findings obtained from the analyzes; It has been seen that the changes in Bitcoin energy consumption have a one-way causality effect on the crypto money price uncertainties and crypto money policy uncertainties. It is understood from the Chi-Square Test Statistic (13.16980) that Bitcoin energy consumption has a more dominant effect on cryptocurrency policy uncertainty when compared to cryptocurrency price uncertainty. In addition, it has been found that cryptocurrency price uncertainties and policy uncertainties do not have an effect on the energy consumption of a bitcoin. While it can be interpreted that bitcoin energy consumption acts more independently from crypto currency uncertainties, it can also be interpreted that bitcoin mining is not the only factor affecting bitcoin prices in crypto money markets. Because there are cryptocurrencies such as ethereum, which are not limited in terms of supply in the crypto money markets. In this case, uncertainties in crypto markets and bitcoin did not have an effect on energy consumption. In addition, although it is not the same issue when compared with the literature studies, Demir et al. (2018) reached results in the same direction, and results in the opposite direction were obtained with Cheng and Yen (2020). However, in this study, it has been found that the change in bitcoin energy consumption is effective in crypto money markets, especially on crypto money policies.

This study has limitations in terms of both the variables it applies to and the observation interval, and it has searched for a relationship only by considering the relationship between selected variables. In this context, the empirical findings and interpretations were made based on these results. After that, for further studies in this area, models can be developed that include variables that have a direct impact on mining such as government sanctions and costs on bitcoin energy consumption.

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