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MODERATING IMPACT OF THE BOARD OF DIRECTORS ON ENVIRONMENTAL ACCOUNTING AND MARKET REACTIONS IN SOUTH AFRICA

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ABSTRACT

Purpose-The UN environment challenge 2030 was set to develop and enhance approaches to sustainable development. The study was carried out to investigate the impact of environmental accounting on market reactions in Africa and more so the moderating impact of the board of directors on the said relationship.

Methodology- The study used 119 listed firms on the Johannesburg stock exchange with the period spanning 2008-2019. We used Investment variable regression model for the study using share price and adjusted market returns as proxy for market reactions and environment accounting as reported in annual integrated reports as a proxy for environmental accounting

Findings- Results obtained show that environmental accounting has a positive and statistical relationship with market reactions and the board of directors does moderate the relationship between market reactions and environmental accounting. The study shows that firms in South Africa are taking sustainability accounting correctly by accounting for the environment. This supports the legitimacy theory and also supports the notion that firms are taking the lead in climate change consideration. We are the first to make such a study in an African setting and thus we hope that regulators will pay more attention to the reports and workings of firms and their contribution to the environment.

Conclusion- The study supports stakeholder and legitimacy theories as it shows that directors carry out decisions for the benefit of all stakeholders, and firms carry out decisions to prove their legitimacy in fulfilling their societal obligations which include taking care of the environment as any responsible citizen would. In order to achieve the UN environmental goals of 2030 of a cleaner environment, we need everyone on board including firms, investors and the public. Investors can help push firms be more sustainable and take care of the environment in which they operate by refusing to buy the assets of firms engaging in pollution or purchasing assets for firms that are environmentally compliant.

Keywords: Environment accounting, market reactions, board of directors, South Africa.
JEL Codes: Q56, G00, G30

1. INTRODUCTION

When covid-19 struck the world, the environment was the biggest benefactor as it saw a record break less pollution than before. Stakeholder theory states that businesses should do their work while taking into consideration all stakeholders. Thus sustainable accounting calls for doing business while thinking of the future. But does the board of directors moderate the relationship between environmental accounting and market reactions?

The two dire questions that any company should ask are (Campbell, 2013) (1) what should accounting account for. (2) To whom is the company accountable? The intricate questions are observed in models like stakeholder continuum and Gray et al seven positions of corporate responsibility. A careful examination of these questions leads to the concept of environmental accounting.

This is so because companies are viewed as citizens of a society and thus owe it to the public to give back to the society just like any other citizen.

Accounting is so crucial a tool for assessing the performance of a company and its operations (Tan OScario Archie, 2021). The role of accounting is getting more crucial, especially with sustainability views given the decline in climate change (Makarenko & Plastun, 2017).

The Board of directors is crucial in running a firm (Khalil & Ozkan, 2016) especially in approving reports (Rensburg & Botha, 2014). They are involved in policing the firm to see that agency costs and earnings management are maintained (Khalil & Ozkan, 2016). They are responsible for approving integrated reports (Traxler et al., 2020) which report contains environmental accounting and has an impact on stock markets on the day the reports are used (Samy, 2019).

Markets react through the signaling theory effect and react differently to the news coming out from the companies (Connelly et al., 2011). It is believed and taught that markets will punish companies that are deemed not to be ethical or environmentally friendly. This is usually termed reputational damage by the companies (Jean-paul louisot, Sophie Gaultier, 2009).

South Africa is a unique economy with the economy being carried by the 70% of the population able to work (AMPS, 2011). It has a big share of the world's minerals and mining (Department of trade and industry, 2013). This means mining and all kinds of pollution. South Africa officially became part of the BRICS countries in 2010, making it one of the emerging economies in the world (Conway-Smith, 2011).

With regards to financial publications, there have been more than 160,000 publications of financial information by listed companies in circulation (AMPS, 2011). These publications which are mostly integrated reports do a detailed list of the environment accounting taking place in each company and how the business is being affected by the environment and how it affects the environment. Furthermore, South Africa has had integrated reporting as one of the core requirements for being listed on the stock exchange since 2010 making it the best sample choice.

South Africa was chosen as it has the best-developed Stock exchange in Africa (Maubane et al., 2014), Better regulations in Africa (Maroun & Atkins, 2015), Is the second-largest economy, and is involved in a number of mining companies and heavy construction industry in Africa.

This Article has three contributions namely; (1) it supports the stakeholder theory by showing the moderating impact of the board of directors on environmental accounting and market reactions. (2) It goes on to show if the markets in South Africa are woke in the sense that they do care about the activities of any business that operates within their sphere. This is good leverage in the hands of consumers as it makes companies and businesses think of the wider impacts apart from profits. And (3) it shows how South Africa has awakened to the global call to companies to do account for the environment and the society they live in as citizens. This has an implication that Companies and businesses are taking the frontline in the fight against climate change.

We are the first to examine this relationship and we hope that other African economies will take a look at such methods as seen in South Africa and thus promote accounting for the environment in their respective countries.

The rest of the paper is organized as follows; the theoretical framework followed by literature and hypothesis development, methodology and modelling, results and discussions and finally the conclusion and recommendation section.

2. THEORETICAL FRAMEWORK

2.1. Stakeholder Theory

This theory describes the inter-relationship between the many actors involved in an entity and offers an alternative purpose for the firm(Ramachandran, 2020). This theory was intended for firms to find ways of managing their varying set of stakeholders who include almost everyone from shareholders to the government to the general public or society at large.

The theory is most of the time linked to corporate social responsibility. Management should know that every decision it makes affects everyone in the society and thus should look to optimize decisions for the benefit of all people. Managers should not only look at maximizing the shareholder's wealth or look out for managerial interests at the expense of other individuals who will be affected by the same decision.

2.2. Legitimacy Theory

Legitimacy theory has got quite a few definitions for example,(Burlea-schiopoiu & Popa, 2013) Defines it as a medium that supports companies and businesses in developing and realizing voluntary and social disclosures so as to fulfill their societal agreements that empower the acknowledgment of the objectives and survival in a stormy environment.

(Suchman, 1995) defines legitimacy theory as the general perception that the works of an organization are appropriate, desirable, and proper within societal norms, values, and definitions. This goes on to say that the operations of the business/ entity should be in line with the expectations of society. Where the operations of the entity go against the expectations of the society, the organization can be punished by the society through reputational damage. This punishment can range from dumping their shares to boycotting their products and services.

The global village, climate activists, and the new generation of society that cares about their environment have put enormous pressure on organizations to account for the environment they reside in and re-evaluate their systems.

3. LITERATURE AND HYPOTHESIS DEVELOPMENT

Accounting is so crucial a tool for assessing the performance of a company and its operations (Tan OScario Archie, 2021). The role of accounting is getting more crucial, especially with sustainability views given the decline in climate change (Makarenko & Plastun, 2017). Accounting used to be limited to financials and what affects the company directly until the introduction of environmental accounting. Businesses are citizens in societies where they reside and thus contribute positively or negatively to the society they reside in. This had to be accounted for.

(Che Ahmad et al., 2015) states that environmental accounting at the company level details identification, measurement, recognition, and disclosure of environmental costs, contingencies, and liabilities in company reports for the benefit of all stakeholders. The disclosure of such information is increasingly becoming more paramount for the wide varying stakeholders.

The Board of directors is crucial in running a firm (Khalil & Ozkan, 2016) especially in approving reports (Rensburg & Botha, 2014). They are involved in policing the firm to see that agency costs and earnings management are maintained (Khalil & Ozkan, 2016). They are responsible for approving integrated reports (Traxler et al., 2020) which report contains environmental accounting and has an impact on stock markets on the day the reports are used (Samy, 2019).

Integrated reporting refers to a concise communication of how a company's strategy, performance, governance, and prospects lead to value creation over the short, medium, and long term (IIRC, 2013). Integrated reporting combines both non-financial and financial performance measures in such a way as to communicate corporate strategy (Ernst &Young, 2012).

Integrated reporting as per the integrated reporting standards board lists that an integrated report should include an accounting for the environment. Although this environmental accounting is debatable as it considers direct environment accounting and doesn't consider environmental costs for example psychological impact on the society, It gives a hint that the company is committed to taking care of its environment.

South Africa has a lot of companies involved in the mining and construction industry which do report about their activities in annual integrated reports. Especially those listed on the Johannesburg stock exchange. Pollution is the major cause of environmental degradation (Tan OScario Archie, 2021) (Temba 2019).

Since environmental accounting is synonymous with company performance(Che Ahmad et al., 2015)(Rachael, 2020), The markets react to the information contained in those integrated reports when the reports are issued by companies. Since these reports contain accounting for the environment, conscious investors and consumers who read them take actions depending on their set of beliefs as any rational investor would. This leads us to believe that and formulate the following hypothesis;

H_1: Markets react to environmental accounting by listed companies.

H_2: The relationship between environmental accounting and market reactions is moderated by integrated reporting.

4. METHODOLOGY AND MODELLING

Data for investigating the moderating relationship between environmental accounting and market reactions in South Africa is got from a combination of Dongbei University of finance and economics Osiris and individual company audited integrated annual reports from 2008 to 2019.

The study is based on a sample size of 246 listed companies on the Johannesburg stock exchange. And the data is computed for results using Stata software. Table X shows the variables under study together with their definitions and measurements

The independent variable used is environmental accounting. Due to a lack of a clearly defined measure of environmental accounting, we adopt the use of binary system where 1 stands for the environment being accounted for in the annual reports and zero otherwise.

Market reactions, which is the dependent variable has got two measures i.e., (1) share price and (2) adjusted market returns. Share price refers to the value of a single asset price at a given date on a stock market. A share price is a great tool and informant

of market reactions because it acts as a signal of what is taking place in the company's business. This is so through the signaling theory(Connelly et al., 2011). For that reason, it is adopted in this study to account for market reactions.

Adjusted market returns refer to Adjusted market returns (Ferguson et al., 2018) that are computed over 250- day estimation window ending ten days prior to the event window (the day audit reports are released to the public) with returns on the All Ordinaries Index that proxies for market returns.

4.1. Model Specification

To investigate the moderating impact of integrated reporting on the relationship between environmental accounting and market reactions, we employ instrument variable model using the following specification;

$$y = \alpha + \beta_1 xea + \beta_2 xoy + \beta_3 xassets + \beta_4 xmbr + \beta_5 xroa + \beta_6 xlev + \varepsilon \quad (1)$$

Where y represents market reactions (share price), α is the intercept of the equation, $\beta_1\beta_2\beta_3\beta_4$ are coefficients of the regression. xea representing environment accounting, xoy represents operating income, xassets represents assets, xmbr representing market to book ratio, xlev signifying leverage or gearing ratio and ε represents the error term.

Equation 1 is that it does not take into account the moderating role of board of directors and thus leads us to develop the equations further

$$y = \alpha + \beta_1 xbod + \beta_2 xoy + \beta_3 xassets + \beta_4 xmbr + \beta_5 xroa + \beta_6 xlev + \varepsilon \quad (2)$$

Where Xbod represents the board of directors and all other variables are the same as discussed above.

This leads to the last breakdown of the last equation following the order seen below, where it takes into account the moderating impact of integrated reporting on environmental accounting and market reactions.

$$y = \alpha + \beta_1 xea + \beta_2 xbod + \beta_3 x(ea * bod) + \beta_4 xoy + \beta_5 xassets + \beta_6 xmbr + \beta_7 xroa + \beta_8 xlev + \alpha \quad (3)$$

We used assets, market to book ratio, leverage, return on assets, and operating income following(Ferguson et al., 2018)(Bandyopadhyay et al., 2014)(Davidson et al., 2004)(Chan et al., 2021)(Hossain et al., 2014) who all examined and found the above variables controlling for Market expectations in their different studies.

4.2. Additional Tests

We tested for multi-collinearity using the Pearson correlation matrix and variance influence factor as depicted in Tables 5 and 6. We also tested if our endogenous variables were truly endogenous and results are presented in Table 1 suggest that we were correct in treating our variables assets, operating income, return on assets, and leverage as endogenous variables.

Table 1: Endogenity Results for the Endogenous Variables Used

Durbin (score) chi2(1)	0.0676 (p=0.000)
Wu-Hausman F (1,1424)	0.067414 (p=0.000)

Results from Table 1 show that we were right in the usage of our endogenous variables.

We next tested for over identification to find out if our model is correct in predicting the results as seen below in Table 2. And the test results show a high p-value for both Sargan and Basmann suggesting that our model is valid and correctly specified.

Table 2: Over Identification Test

Sargan (score) chi2(1)	0.12323 (p=0.4515)
Basmann chi2(1)	0.1229 (P=0.4519)

We then carried out a test to see if our instruments are weak and test results presented below show a large value of F-statistics and high R-sq thus we reject the null hypothesis that our instruments are weak and accept the alternative hypothesis that our instruments are not weak as depicted in Table 3.

Table 3: First Test Results of the Instrument Variable under Study

Variable	R-sq	Adjusted R-sq	Partial R-sq	F(3,1423)	Prob>F
Earnings quality	0.8111	0.8105	0.8107	108.808	0.353
minimum eigen value		108.808			

5. RESULTS AND DISCUSSIONS

5.1. Descriptive Statistics

The descriptive statistics in Table 4 show the mean values of the variables under study. The environmental accounting mean is 0.9 because most of the firms in the sample size did do the accounting as it's a mandatory requirement to be listed on the Johannesburg stock exchange. They do so through an integrated report (Rensburg & Botha, 2014). The board of directors has a mean value of 0.9825 meaning that 98% of the firms sampled had a board of directors in place which is a good corporate governance skill (Khalil & Ozkan, 2016). The board of directors and accounting for the environment are presented in annual integrated reports (Rensburg & Botha, 2014) which are released annually and have an impact on share price value.

Table 4: Descriptive Statistics

	N	Mean	SD	Max	Min
EA	1428	0.9818	0.1337	1	0
BOD	1428	0.9825	0.1312	1	0
Share price	1428	2.8012	1.1435	5.4997	-0.7959
Adjusted market returns	1428	0.1029	0.7582	5.8927	-2.3010

5.2. Correlation Results

We used both the Pearson correlation matrix as seen in Table 3 and the variance influence factor in Table 5. A look at Pearson results shows that none of the variables has any value reaching 0.9 which is the cut-off point as per (Afifa et al., 2020). Multi-collinearity issue arises when two variables correlate (beta) value of more than 0.8 (Gujarati, 2003). The variables under study do not suffer from multi-collinearity issues as they are below 0.8.

Table 5: Pearson Correlation Matrix

	EA	BOD	Share price	Adjusted market returns
EA	1.0000			
BOD	0.0900	1.0000		
Share price	0.2665	0.2283	1.0000	
Adjusted market returns	0.0277	0.0191	-0.0340	1.0000

The correlation results as seen in Table 6 have results all below the correlation threshold of 0.7 as suggested by Gujarati meaning our variables do not suffer from multi-collinearity.

Table 6: VIF Results

Variable	VIF	1/VIF
EA	5.28	0.1893
BOD	5.28	0.1893
MBR	1.00	0.9983
LEV	1.00	0.9994
Mean vif	2.556	

The variance influence factor value of our variables also supports that there is no multi-collinearity issues as it is below the 5 threshold (Gujarati, 2003).

5.3. Regression Results

Results following hypothesis 1 about the impact of environmental accounting on market reactions show that environmental accounting is statistically significant 99% level. And so are operating income, assets, leverage, and the constants statistically significant with the R-sq being at 0.49. Apart from leverage which has a negative statistical significance, environmental accounting, operating income, assets, and the constants do observe a positive statistical significance.

Table 7: Results for Regression for Hypothesis 1

	Share price
EA	2.540**
	(3.20)
OY	0.0670***
	(4.04)
Assets	0.0990***
	(4.77)
MBR	-0.00204
	(-0.36)
ROA	0.00499
	(0.95)
LEV	-0.00517*
	(-2.23)
_cons	0.515*
	(2.28)
N	1424
R-sq	0.49

With equation $y = \alpha + \beta_1 Xea + \beta_2 Xoy + \beta_3 Xassets + \beta_4 Xmbr + \beta_5 Xroa + \beta_6 Xlev + \varepsilon$ .With *t* statistics in parentheses* $p <$ 0.05, ** $p < 0.01$, *** $p < 0.001$.

The results seem to suggest that an increase in environmental accounting is associated with a 2.5 times change in market reactions which suggests that markets pay close attention to environment matters. And that market reactions bring about 1% change in operating income and assets.

Table 8: Regression Results for Hypothesis 2

	Share price	**Share price**	**Share price**
EA	1.629***		0.900*
	(7.17)		(2.29)
OY	0.0659***	0.0706***	0.0701***
	(3.98)	(4.25)	(4.30)
Assets	0.0983***	0.104***	0.0755***
	(4.75)	(5.02)	(3.66)
MBR	-0.00197	-0.000864	-0.00289
	(-0.34)	(-0.15)	(-0.51)
ROA	0.00499	0.00504	0.00426
	(0.95)	(0.96)	(0.83)
LEV	-0.00519*	-0.00509*	-0.00538*
	(-2.24)	(-2.18)	(-2.36)
BOD		1.287***	0.245
		(5.99)	(0.68)
BOD*EA			0.803***
			(7.36)
_cons	0.456*	0.743***	0.302
	(2.15)	(3.66)	(1.42)
N	1424	1424	1424
R^2	0.49	0.495	0.51

Table 8 shows regression results of hypothesis 2 with *t* statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The table shows that environment accounting drop significance from 95% to 90% in relation to market reactions.

When hypothesis 2 is considered, Environmental accounting stays positive and statistically significant at 90% confidence interval. The board of directors is also statistically significant and so are operating income, assets, leverage, and constants at an R-sq of 0.51. For every increase in share price, there is an increase in board participation (Khalil & Ozkan, 2016). it's worth noting though that when the board of directors is introduced as a moderator, the relationship between environmental accounting takes a turn as environmental accounting loses part of its earlier statistical significance

5.4. Discussions

Environmental accounting is founded on the back of legitimacy theory. For a firm to exist in continuity, it must do so in conjunction with societal norms and values (Suchman, 1995). Otherwise, the society through the market pays attention to the workings of the firm(Connelly et al., 2011) and from there decide on how to act either through reputational damage or not buying its assets on the stock exchange (Grossman & Miller, 1988).

Firms are citizens of the society in which they reside(Campbell, 2013) and as such are mandated to take care of the environment in which they operate. This helps to serve the interests of all stakeholders. The market is more concerned with the risk outlook of the firms invested in (Campbell, 2013), and where the environmental risk is potentially significant, a report is needed to discuss how the firm is going about the risk mitigation process.

Firms that do carry out environmental accounting have been found to be profitable(Budiono & Dura, 2021). This is because markets reward firms that do take care of society as responsible citizens(Campbell, 2013). Usually, firms do environmental accounting to protect their image(Budiono & Dura, 2021) as the fear of a fallout with environmentally conscious investors will lead to reputational damage and a loss in value of its assets and firm performance(Jean-paul louisot, Sophie Gaultier, 2009). Firms are now increasingly becoming more conscious of environmental accounting(Kabir & Akinnusi, 2012).

Even after controlling for firm specifics like in Nigeria(Che Ahmad et al., 2015), environmental accounting was found to improve firm profitability. The improved profitability sends a signal(Connelly et al., 2011) to the market about the welfare of the firm which translates to higher asset values for the firm. This explains the significant relationship between environmental accounting and market reactions in our study as also seen by(Rachael, 2020).

The leadership of the firm specifically the board of directors is so crucial in promoting and supervising environmental accounting (Hutman falih Chichan et al., 2021). They do so by providing the leadership necessary to carry out environmental management accounting which foresees environmental disclosures and decisions related to the protection of the environment. They need to be independent to carry out their duties(Khalil & Ozkan, 2016). In doing so, they act as a bridge between environmental accounting and markets through the signaling effect. This relationship can explain why in our study; the board of directors has got a statistically significant relationship with market reactions.

(Rachael, 2020) suggests that firms do environmental accounting for the sake of corporate benefits and good reputational nudge and cost reduction. This means that paying attention to environmental accounting is also paramount to the survival, growth, and good performance of a firm (Şimşek & Öztürk, 2021). As markets now pay more attention to environmental accounting and sustainability reports(Asuquo et al., 2018)(Che Ahmad et al., 2015)(Şimşek & Öztürk, 2021).

Table 9: Robustness Checks of Hypothesis 1

	Adjusted market returns
EA	0.585***
	(3.76)
OY	-0.00940
	(-0.83)
Assets	-0.0986***
	(-6.95)
MBR	0.0116**
	(2.96)
ROA	-0.000300
	(-0.08)
LEV	-0.00261
	(-1.64)
_cons	0.0586*
	(0.40)
N	1424
R-sq	0.57

Following the equation $y = \alpha + \beta_1 Xea + \beta_2 Xmbr + \beta_3 Xlev + \varepsilon$ .With *t* statistics in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ and using adjusted market returns as a proxy for market reactions.

Table 10: Robustness Check for Hypothesis 2

	Adjusted market returns	Adjusted market returns	Adjusted market returns
EA	0.585***		0.863**
	(0.156)		(0.274)
OY	-0.00940	-0.00704	-0.00974
	(0.0114)	(0.0114)	(0.0114)
Assets	-0.0986***	-0.0937***	-0.0964***
	(0.0142)	(0.0142)	(0.0144)
MBR	0.0116**	0.0121**	0.0116**
	(0.00392)	(0.00393)	(0.00393)
ROA	-0.000300	-0.000242	-0.000246
	(0.00360)	(0.00361)	(0.00360)
LEV	-0.00261	-0.00254	-0.00259
	(0.00159)	(0.00159)	(0.00159)
BOD		0.349*	-0.297
		(0.147)	(0.252)
BOD*EA			-0.0329
			(0.0762)
_cons	0.0586	0.256	0.0966
	(0.146)	(0.139)	(0.149)
N	1424	1424	1424
R^2	0.57	0.51	0.58

Table 10 shows the robustness check of regression results of hypothesis 2 with Standard errors in parentheses* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. This was done to find out if our study is viable by using another proxy of market reactions called adjusted market returns.

The results from the robustness checks support our study in that it shows that indeed, environment accounting does affect market reactions even when we use an alternative proxy for market reactions. Furthermore, it supports the novelty raised that the board of directors moderates the relationship between environment accounting and market reactions.

6. CONCLUSION AND RECOMMENDATION

The study was carried out to investigate the impact of environmental accounting on market reactions in Africa. Moreover the moderating impact of the board of directors on the same relationship. The sample selected was South Africa because it has the best-developed stock markets, is a strong emerging economy in the BRICS, and is the second-largest economy in Africa with well-developed regulations and a rule of law.

We find that other things being equal, environmental accounting has an impact on market reactions, and the board of directors moderates the relationship. Results of the relationship between environmental accounting and market reactions are statistically significant and so was the moderating impact of the board of directors. Even after controlling for effects of market reactions with other control variables

Our study was subject to some limitations such as lack of data as not all firms had the data needed for the period of the study. Second, our measure of environmental accounting is subjective and prone to measurement errors. Finally, the study is centered around Africa and South Africa in particular and may not apply to other countries in the world.

The study has three contributions despite the limitations, 1) it supports the stakeholder theory by showing the moderating impact of the board of directors on environmental accounting and market reactions. (2) It goes on to show if the markets in South Africa are woke in the sense that they do care about the activities of any business that operates within their sphere. This is good leverage in the hands of consumers as it makes companies and businesses think of the wider impacts apart from profits. And (3) it shows how South Africa has awakened to the global call to companies to do account for the environment and the society they live in as citizens. This implies that companies and businesses are taking the frontline in the fight against climate change.

We recommend studying research into the impact of social-psychological effects on environmental accounting by listed firms. And that firms should take the lead in ensuring the UN set goals of environmental sustainability by 2030 but they need regulations from regulators and governments.

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A CONCURRENT TRIANGULATION MIXED METHODS STUDY ON BASEL II/III CAPITAL MODELING TECHNIQUES IMPLEMENTATION IN ZIMBABWEAN BANKS

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ABSTRACT

Purpose- While extending two extant studies, this paper pioneers a holistic test and critical examination of the usefulness of Basel II/III capital modeling implementation in sixteen Zimbabwean banks.

Methodology- A mixed method approach was adopted where quantitative and qualitative research designs were concurrently combined under equal status. Quantitative data was collected with self-administered structured questionnaires distributed to 120 Risk Managers and manifest archival content analysis carried on 160 audited annual financial statements for 2011-2020. Qualitative data was collected with latent archival content analysis from purposive samples of 35 audited annual financial statements and 20 previous survey reports both for 2011-2020. Data analysis was carried out with descriptive statitistics and interpretative methods.

Findings- This paper finds deep implementation of Basel II/III capital modeling methods, sufficient data and skills, violation of the proportionality principle, existence of information asymmetries and low levels of market discipline and supervision in Zimbabwean banks. The violation of proportionality principle is shown by the fact that local banks are implementing advanced capital modeling methods at the same pace or even higher than internationally active banks. The existence of information asymmetries is shown by divergence of perspectives between regulator and banks. While the regulator is enforcing proportionality, banks are adopting advanced methods for their internal purposes regardless of size. The usefulness of Basel II/III capital modeling in Zimbabwean banks as a tool for managing risk based minimum capital requirements is not clear given the violation of the proportionality principle by banks and existence of other parallel higher capital requirements enforced by the regulator.

Conclusion-This paper makes two specific contributions to knowledge. First it adds empirical evidence to two previous studies thus contributing to literature on proportionality and Basel II/III capital modeling practices in Zimbabwean banks. Second, it proposes policy recommendations to improve capital management in Zimbabwean banks.

Keywords: quantitative risk management, capital modeling, global capital regulation, concurrent triangulation, mixed methods, financial engineering.
JEL Codes: G10, G20, F30

1. INTRODUCTION

The Reserve Bank of Zimbabwe adopted Basel global capital regulations to comply to international capital modeling standards. Precisely the central bank adopted Basel I in 1995, Basel II in 2010 and Basel III in 2019 (Zimbabwe Basel II Technical Guidance, 2011, Zimbabwe Monetary Policy Statement, 2018). However, due to the impact of Covid19 pandemic dates for Basel III implementation were shifted to 2027 (BCBS,2020). Hence currently banks in Zimbabwe are in a transition phase from Basel II to Basel III bringing the reason for using Basel II/III in this paper. Basel II/III aims at promoting financial stability, levelling the plain field of competition, achieving simplicity and comparability among internationally active banks (BCBS ,2006; BCBS ,2011; Dowd et al., 2011; BCBS, 2017). As in other jurisdictions the Reserve Bank of Zimbabwe adopted Basel II/III in a proportionality philosophical manner. According to BCBS (2019) proportionality can be loosely defined as setting tailored prudential and administrative requirements commensurate with the banks' risk profiles to achieve a common objective. This tailored approach seeks to accommodate differences in banks' business models, systemic importance, cross border activity and their risk profiles (BCBS,2019). The Reserve Bank of Zimbabwe in applying a proportionality philosophy, theoretically states that advanced capital modeling methods are the prerogative of Pan African and international banks which are classified as "internationally active banks." On the contrary simple capital modeling methods are designed for local banks

falling within the bracket of "smaller banks" (Zimbabwe, Basel II Technical Guidelines,2011). In short bank size is directly correlated to capital modeling methodology.

Since the adoption of Basel regulation in Zimbabwean banks, two empirical studies examine capital modeling methods. First, using mixed methods, Muvingi (2011) studies qualitative factors hampering Basel implementation in Zimbabwean banks. He finds these to be poor governance, weak supervision, presence of imperfect markets, asymmetric information, lack of data, skills shortages, poor technology, poor access to finance and high operational costs. Second, using a survey, Matanda (2015), studies Basel II capital modeling methods adoption in merchant banks. He finds that banks were implementing simple methods such as modified standardised approach for credit risks, alternative standardised approach for operational risks and standardised approaches for market risks. Further he empirically shows that Basel II is not suitable for emerging markets like Zimbabwe, because market circumstances are different to those of developed economies. He agrees with Muvingi (2011) on factors hampering Basel implementation in Zimbabwean banks. While extending on their work, this paper pioneers first, a holistic test of Basel II/III capital modeling implementation and second, critical examination of its usefulness in terms of its proportionality framework and existences in the face of other parallel higher minimum capital requirements. Furthermore, this paper focuses on Basel II/III capital modeling methods implementation in all types of Zimbabwean banks in a strategic practitioner and policy influencing direction.

This paper seeks to answer these research questions. What is Basel II/III capital modeling theory? To what extent have Zimbabwean banks implemented Basel II/III? Are banks following the proportionality principle? How useful is Basel II/III risk based minimum capital requirements given pre-existing higher capital requirements? This paper is structured as follows. Section 2 provides the theoretical perspectives for Basel II/III capital modeling for credit, market and operational risks. Section 3 states and justifies the concurent triangulation mixed methods methodology adopted in this paper. Section 4 provides results and discussion. Section 5 provides conclusion and implications from a risk manager's and policy perspective.

2. LITERATURE REVIEW

Zimbabwe comprises thirteen commercial banks, five building societies, and one savings bank (Zimbabwe Monetary Policy Statement,2021). In this paper two building societies are merged into their parent companies, bringing the number to sixteen banks. Merging is done because both building societies and their parent banks are governed by the same financial regulation. In compliance to Basel II/III banks are supposed to determine regulatory and economic capital. Valdez (2012) defines capital as the amount a firm sets more than assets to withstand and absorb all risks from unexpected losses, remain solvent with high probability and be able to cover its obligations with customers. Regulatory capital is the minimum amount of capital required at a given horizon for a specified confidence interval by the regulator (Elizalde and Repullo, 2007; BCBS, 2009; Valdez,2012; Van Vuuren and De Jongh, 2017). It is calculated using "one size fit" formulas and industry averages (BCBS, 2010). There is no standard definition for economic capital in the banking industry (BCBS, 2009; BCBS, 2010). Several authors agree that economic capital is the self-assessed minimum amount of capital required by a bank to limit the probability of solvency to a given confidence level over a specified time horizon for all material risks (Elizalde and Repullo, 2007; BCBS, 2010; Valdez,2012; Van Vuuren and De Jongh, 2017). According to Basel Committee (2009) economic capital covers the unexpected losses from rare probability events. Economic capital is higher than regulatory capital because it applies higher confidence levels (BCBS, 2010). This paper focuses on strategic financial engineering which does not require intensive mathematical treatment.

2.1. Basel II/III Theoretical Framework

As mentioned in section 1, the Reserve Bank of Zimbabwe adopted Basel I in 1995, Basel II in 2010 and Basel III in 2019 (Zimbabwe Basel II Technical Guidance, 2011, Zimbabwe Monetary Policy Statement, 2018). However due to impact of Covid19 pandemic Basel III implementation have been shifted to 2027 (BCBS,2020). Currently banks in Zimbabwe are in a transition phase from Basel II to Basel III. Basel II/III aims at promoting financial stability, levelling the plain field of competition, achieving simplicity and comparability among internationally active banks (BCBS ,2006; BCBS ,2011; Dowd et al., 2011; BCBS, 2017). As in many other jurisdictions the Reserve Bank of Zimbabwe adopted Basel II/III in a proportionality philosophical manner (BCBS,2019; Zimbabwe Basel II Technical Guidelines,2011). Proponents of capital regulation state that countries implement Basel regulations to enhance financial stability, market discipline, accessibility to international markets, international competitive standing, international perception, risk management practices, reputational image, and production efficiency (Ward, 2002; Alexander,2014; Bessis,2015; Jones and Zeitz, 2017). Other scholars argue that, Basel adoption is not very useful but rather is a result of peer pressure from the international world, standards setting bodies such as International Monetary Fund and World Bank (Ward 2002; Jones and Zeitz, 2017). Opponents of capital regulation theoretically and empirically doubt the usefulness of global capital regulation (Benston and Kaufman, 1996; Dowd,1996; Dowd, et al.,2011; Haldane,2017). Rather they provide evidence that global capital regulation is the source of capital inadequacies and liquidity crises in the banking sector.

Basically Basel II/III is made up of three mutually reinforcing pillars (BCBS, 2006; BCBS,2010; Alexander, 2014). Pillar 1 provides formulae for definitions of capital and determination of minimum capital requirements (BCBS, 2006; BCBS;2017).

The Reserve Bank of Zimbabwe set the minimum capital at 12% (Zimbabwe Basel II Technical Guidance, 2011). The capital adequacy ratio (CAR) is calculated as:

$$\text{CAR} = \frac{\text{Net Capital Base}}{\text{Credit risk weighted assets (RWA)} + 12.5\,(\text{Market RWA} + \text{Operational RWA})} \geq 12\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{Net Capital Base} = (\text{Tier 1} + \text{Tier 2} + \text{Tier 3}) - \text{Goodwill} - \text{Investments} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Tier 1 is core capital, Tier 2 is supplementary capital, and Tier 3 is subordinated debt allocated to market and operational risks only. Basel III also encompasses changes in quality of capital, macroprudential tools, leverage ratio, operational risk modeling method and liquidity risk management.

Pillar 2 is supervisory review process where the regulator assesses how banks determine their capital needs relative to the material risks, they face. It comprises the Internal Capital Adequacy Process (ICAAP) which is an assessment of the adequacy of regulatory and economic capital done by the bank and the supervisory review process (SREP) done by the supervisor (Zimbabwe Basel II Technical Guidance,2011). Basel III enhances firmwide governance of Pillar 2. Pillar 3 provides market discipline and disclosure framework to promote transparency among banks. As such depositors, investors, and other external parties should access quarterly and annual information on definitions of capital, capital structure, capital adequacy, risk exposure, and assessments (BCBS, 2006; Zimbabwe Basel II Technical Guidance, 2011). Furthermore, Basel III introduces disclosure of key metrics for regulatory and economic capital covering definitions of capital, capital structure, risk exposures and methods of capital modeling. The disclosed information must be complete, readable, timely, reliable, and material (Zimbabwe Basel II Technical Guidance, 2011). This paper focuses on Basel II/III Pillar 1 capital modeling methods for credit, market, and operational risk.

2.2. Credit Risk Capital Modeling

Credit risk is the probability of losses from the borrower's default or deterioration of credit ratings (Bluhm et al., 2010; Bessis, 2015; Baesens, et al., 2016). Since a considerable size of the balance sheet consists of loans to customers and most bank failures are the result of the customer's defaults, credit risk is a major source of bank risk. Modified Standardised and Internal Ratings Based Approaches (IRB) are approved by the Reserve Bank of Zimbabwe for credit risk capital modeling.

2.2.1. Modified Standardised Approach

In the absence of an external ratings market, the Reserve Bank of Zimbabwe adopts the modified standardised approach (MSA). Under this method regulatory capital is determined by risk weights and exposures in book values (Zimbabwe Basel II Technical Guidance, 2011). The risk weights for exposures are provided by the central bank while ratings are determined using either the supervisory rating scale or obtained from an approved external rating agency domiciled in Zimbabwe (RBZ Guideline Number 04/BSD, 2004). MSA is a conservative method designed for simple banks with less sophisticated financial models (Zimbabwe Basel II Technical Guidance, 2011).

2.2.2. Internal Ratings Based Approach

This is an advanced credit risk modeling method approved to banks that have satisfied prescribed minimum quantitative and qualitative criteria set by the regulator (Basel II Technical Guidance,2011). The internal ratings-based approach (IRB) comprises the foundation internal ratings based (FIRB) and advanced internal ratings based (AIRB). Banks that apply FIRB will rely on their own internal estimates for probabilities of default (PD) but are given supervisory estimates for the loss given default (LGD), asset correlations (R), exposure at default (EAD), and effective maturity (M). On the contrary banks that use AIRB methods determine their own internal estimates for all parameters except for asset correlation which is provided by the supervisor (Zimbabwe Basel II Technical Guidance, 2011). Estimates of credit risk are based on internal and external data where necessary, and are rooted on historical, empirical, and judgmental evidence reflecting recessions and booms (BCBS 2006; Zimbabwe Basel II Technical Guidance,2011; BCBS, 2016). The IRB approach is designed for large international banks with sophisticated, large databases, and high-quality internal risk measurement systems.

Theoretically economic and regulatory capital should converge for banks that implement AIRB (BCBS, 2006; Zimbabwe Basel II Technical Guidance, 2011). As a rule, banks that use IRB approaches, should report deviations of regulatory from economic capital to the central bank (Zimbabwe Basel II Technical Guidance, 2011). The Merton- Vasicek Asymptotic Risk Factor Model is used to estimate capital in IRB for banking book exposures viz: corporate, sovereign, bank, retail, and equity exposures (Vasicek,2002; Gordy, 2003; Zimbabwe Basel II, Technical Guidance,2011). The general formula is shown:

$$K = \sum_{i=0}^{N} LGD\left[\times N\left(\frac{N^{-1}(PD) + \sqrt{R}\,N^{-1}(0.999)}{\sqrt{1-R}}\right) - PD\right] \times \frac{1 + (M - 2.5) \times b(PD)}{1 - 1.5 \times b(PD)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where k is the capital requirement, PD is the probability of default, LGD the loss given default, R is the asset correlation, M is maturity, N^{-1} inverse of normal distribution, N is normal distribution and b(PD) is maturity adjustment function. The maturity adjustment function is calculated by:

$$Maturity\ adjustment\ b(PD) = (0.11852 - 0.05478.ln(PD))^2 \quad (4)$$

The risk weighted assets (RWA) for credit risk are thus a function of 12.5 multiplied by capital requirement (k) and exposure at default. Five parameters namely PD, EAD, LGD, M, and asset correlation (R) are used in credit risk capital models. Engelmann and Rauhmeier (2012) defines PD as the likelihood that a loan will not be repaid over a given time horizon. PD is a binary classification problem that is calculated from historical data for all clients' segments. Engelmann and Rauhmeier (2012) states that there is no precise preferred method to estimate PD under Basel II/III, however logit regression is popular in academic literature and practice. Data for PD modeling should be five years and not more than seven years old (BCBS,2006). Financial ratios are used for corporates while obligor specific factors are applied in retail portfolios over a one-year horizon (Zimbabwe Basel II Technical Guidance, 2011).

Exposure at default (EAD) is an estimate of the outstanding amount in case an obligor has defaulted (Engelmann and Rauhmeier,2012). It comprises the amount currently drawn and estimates of the future drawdowns. Estimates of future drawdowns describe how clients may decide to draw unused commitments called credit conversion factors. Since credit conversion factors are the only unknown variables, estimating EAD is equivalent to estimating the credit conversion factors. The credit conversion factor depends on the type of the loan and borrower. According to the Basel Committee (2006), EAD must not be lower than the book value of balance sheet receivables and must be calculated without considering provisions. Long run EAD averages reflecting downturn conditions which are calculated at facility level must be utilised. Four methods namely Credit Conversion Factor (CCF) Method, Current Exposure Method (CEM), Standardized Method (SM) and Internal Model Method (IMM) are used to estimate EAD (see BCBS, 2006).

LGD measures the credit loss a bank is likely to incur in the event of default (BCBS,2006). Once a default event has occurred, LGD has three types of losses: the loss of the principal, the carrying costs of non-performing loans (interest income foregone) and workout expenses (collections, legal etc.). For retail portfolios, long run LGD averages that reflect downturns and data more than five, but less than seven years is used. For banks, sovereigns and corporates data must be no shorter than seven years (Zimbabwe Basel II Technical Guidance, 2011). LGD modeling is done by four methods namely Market LGD, Workout LGD, Implied Historical LGD, and Statistical LGD (see BCBS,2006). Zimbabwean banks are recommended to apply Workout LGD (BCBS, 2006; Zimbabwe Basel II Technical Guidance, 2011).

Credit portfolios comprise instruments with different effective maturities. Intuition and empirical evidence show that capital requirements increase with time to maturity. Long term loans are riskier than short term loans because they are likely to be affected by rating downgrades over time. Maturity has a strong effect to obligors with low probabilities of default as well as loans that will be affected by rating downgrades. The maturity adjustment function in Basel II/III reflects the potential deterioration in credit quality of loans with longer maturities. The average portfolio effective maturity is set at 2.5 years except for repos which are set at 6 months (Zimbabwe Basel II Technical Guidance, 2011). The asset correlation reflects the effect of the systematic risk factor. Banks are supposed to use fixed asset correlations derived by the Basel Committee (BCBS, 2006; Zimbabwe Basel II Technical Guidance, 2011). The asset correlations are based on Lopez (2004)'s empirical observations which are (a) Asset correlations decrease with increasing probabilities of default. The higher the probability of default the higher the idiosyncratic risk component of obligors. (b) Asset correlations increase with firm size meaning that idiosyncratic risks are higher for smaller firms.

2.3. Market Risk Capital Modeling

Market risk is the risk of losses in, on and off-balance sheet positions arising from movements in market prices of interest rates, commodities, equities, and foreign exchange (BCBS, 2017; Hull, 2018). Market risk is calculated for the trading and banking books (BCBS,2017). The trading book comprises assets held for short term trading and hedging such as default, interest rate, credit spread, equity, foreign exchange, and commodities. The banking book is made up assets held for long term trading as foreign exchange and commodities (BCBS, 2017). Market risk in Zimbabwean banks is determined by interest and foreign exchange risk because banks are not permitted to trade in equities and commodities (Zimbabwe Basel II Technical Guidance, 2011). Banks determine the market risk capital using either the standardised approach, internal models' approach or partially both (Zimbabwe Basel II Technical Guidance, 2011).

2.3.1. Standardised Approach

The standardised approach (SA) is a bucket risk weighting method for interest rate risk, equities, commodities, and foreign exchange (BCBS,2006; Jorion 2007). This approach serves two main purposes (Zimbabwe Basel II Technical Guidance,2011). It provides a method for calculating capital requirements for small banks with simple business models and a fallback in the event of inadequate internal market risk models. The second purpose is of importance for larger or more systemically important banks. In Zimbabwe, market risk under SA is calculated for interest and foreign exchange risk. Interest risk is calculated using either the maturity ladder or duration approach (Zimbabwe Basel II Technical Guidance,2011). Foreign exchange risk is computed by measuring the exposure in a single currency position and inherent in a bank's mix of long and short positions in different currencies**.** The SA approach is criticised for lacking risk sensitivity, excluding diversification, and failing to capture risks associated with more complex instruments (BCBS, 2012; BCBS,2013; BCBS,2017). Thus, Basel Committee (2017) propose a new standardised approach but is yet to be approved by the Zimbabwean central bank.

2.3.2. Internal Models Approach

The internal models' approach (IMA) is approved for banks that satisfy quantitative and qualitative standards imposed by the central bank (BCBS, 2006; Zimbabwe Basel II Technical Guidance,2011; BCBS, 2017). The method is designed for sophisticated banks with huge databases and complex financial models. The method theoretically ensures that regulatory and economic capital converge (Zimbabwe Basel II Technical Guidelines,2011). Market risk for internal models' approach is determined by any of these three approaches: value at risk, expected shortfall and bubble value at risk (BCBS, 2006; Wong, 2011; BCBS, 2013; BCBS, 2017). Value at risk (VaR) used to be the sum of traditional VaR and incremental default charge (specific risk charge). Its parameters were 10 trading days or horizon of two calendar weeks, 99% confidence interval, average VaR over 60 trading days, historical data for one-year period updated at least quarterly, supervisory determined multiplier, and the specific risk charge calculated over 250 days at the 99.9% confidence interval (Zimbabwe Basel II Technical Guidance, 2011).

Following the 2008 great financial crisis, the Basel Committee introduced Basel 2.5 for market risk. Under this method, capital for market risk is calculated as the sum of traditional value at risk, stressed value at risk and the incremental risk charge (BCBS, 2009; Smit et al., 2011; Kou et al., 2013; Chen, 2018). The formula for calculating market risk is shown:

$$Market\ risk\ capital = Traditional\ VaR + Stressed\ VaR + Incremental\ risk\ charge \quad \text{(5)}$$

This method addresses procyclicality and regulatory arbitrage (BCBS, 2013; Chen, 2014; BCBS, 2017; Chen, 2018). Traditional VaR is calculated for 10 days at 99% confidence interval. Stressed VaR is calculated with 10-day 99th percentile and one-tailed confidence interval with model inputs calibrated to historical data from a continuous 12-month period of significant financial stress (BCBS, 2009). This addresses tail events and procyclicality in stressed financial markets. Incremental VaR is the additional charge that captures credit risk in the trading book caused by default and credit migration. The incremental VaR is calculated for one-year horizon at 99.9% confidence interval (BCBS, 2013). From a regulatory perspective Basel 2.5 has not been applied in Zimbabwe (Zimbabwe Basel II Technical Guidance, 2011).

Internal VaR approach is criticised for relying on the 10-day VaR metric which is not subadditive (Dowd and Blake, 2006). It also fails to capture credit and market liquidity risk because there is no distinct boundary between trading and banking books (Kou et al., 2013; BCBS, 2013; Emmer et al., 2015; Visser and Van Vuuren, 2016). Currently the Basel Committee on Banking Supervision suggests replacement of VaR with expected shortfall because it is subadditive, coherent and stable (Wong, 2011; BCBS, 2017; BCBS, 2020). Further, expected shortfall measures tail risk, liquidity and is calibrated to stress conditions on base horizon (BCBS, 2013; BCBS,2017; Chen, 2018). Expected shortfall is calculated at 97.5% confidence level. However, expected shortfall is not elicitable, very sensitive to parameter misspecification, difficult to backtest, increases model risk, and regulatory arbitrage (Gneiting,2011; Emmer et al., 2015). ES is still in early phases of Basel III implementation.

Wong (2011) suggests replacement of both expected shortfall and VaR with bubble value at risk. This is because bubble value at risk accounts for countercyclicality, extreme events, and market bubbles. Wong (2011) argues empirically that BuVaR is more accurate than VaR. Visser and Van Vuuren (2016,2018), based on an empirical study from South African banks show the superiority of bubble value at risk over expected shortfall and VaR. However, bubble value at risk is largely academic and not common in real world practice. VaR and expected shortfall for market risk are estimated with Historical Simulation, Monte Carlo Simulation and Variance Covariance. Historical simulation is a non-parametric method that uses relative historical differences in market prices to create the distribution of potential future losses and profits for a portfolio (Jorion, 2007; Bessis, 2015; Visser and van Vuuren, 2016). As the historical simulation method depends on observed market variations, no statistical calculations are required. Large banks prefer historical simulation because it is simple and intuitively logical (Visser and van Vuuren, 2016). However, this method suffers from instability and reliance on historical data. The data for historical simulation must be robust and furthermore the older the data, the less relevant it is for the current market.

Monte Carlo simulation is a non-parametric method which assumes that information about the combined distribution of market changes is available. Monte Carlo simulations generate the correlated random variables to model a probability distribution for statistical analysis. This method assumes a normal distribution (though this restriction can be relaxed). VaR is calculated by identifying prominent factors and constructing a joint distribution by fusing historical data with observed returns. Simulation is then performed over many scenarios. Monte Carlo simulation is a very flexible approach that incorporates time variations, volatility, expected returns, fat tails and extreme scenarios in risk factors (Jorion, 2007; Bessis 2015; Visser and Van Vuuren, 2016). Its shortcomings are complicated underlying mathematics, considerable computing time and expensive infrastructure from an intellectual capital perspective (Jorion, 2007). The variance covariance approach is applicable to VaR computation only. The variance-covariance method assumes that portfolio returns are normally distributed. VaR is then expressed as a multiple of the standard deviation of the portfolio's return. The method determines the variance-covariance matrix which is a diagonal matrix with all variances of the return and covariances between the assets (Bessis, 2015; McNeil et al., 2015). Variances are calculated using standard deviations of market returns while covariances combine standard deviations of market returns with the correlations between market returns. This method is also called the Delta Analytical Method.

2.4. Operational Risk Capital Modeling

Operational risk is the indirect or direct probability of loss resulting from inadequate or failed internal processes, people, systems, and external events (BCBS,2006). This definition includes legal risk but excludes strategic and reputational risks (BCBS, 2006; BCBS, 2016). Einemann et al., (2017) cites that operational risk modeling is challenging because of the dominancy of low frequency high severity events (LF/HS). These events demand an accurate reflection of heavy tails of the loss distribution. The central bank in Zimbabwe prescribes the Alternative Standardised Approach (ASA), Advanced Measurement Approach (AMA) and Standardised Measurement Approach (SMA) (Zimbabwe Basel II Technical Guidelines,2011).

2.4.1. Alternative Standardised Approach

The alternative standardised approach (ASA) is designed for simple banks with simple financial models (Zimbabwe Basel II Technical Guidance, 2011). Banks categorise their activities into three business lines viz retail banking; commercial banking; and all other activities**.** The operational risk capital charge for a banking institution equals the sum of the average for these three business lines. The capital is calculated as:

$$K = \sum_{t=1}^{6} \left[\frac{0.12 \times m \times LAR_t}{6}\right] + \sum_{t=1}^{6} \left[\frac{0.15 \times m \times LAC_t}{6}\right] + \sum_{t=1}^{6} max\left[\frac{(0.18 \times AGI_t), 0}{3}\right] \quad (6)$$

Where K is the total operational risk regulatory capital charge, m is 0.035 fixed scaling factor, $\mathrm{LAR_t}$ is the total gross outstanding loans and advances for retail area, $\mathrm{LAC_t}$ is the total gross outstanding loans and advances for commercial banking, $\mathrm{AGI_t}$ is adjusted gross income and t is half yearly observation period. The total regulatory capital for operational risk is a function of K multiplied by 10. The capital for retail and commercial segments is determined from the last six consecutive half-yearly balances of total gross outstanding loans and adjusted average gross income over three years for other activities (Zimbabwe Basel II Technical Guidance,2011).

2.4.2. Advanced Measurement Approach

Banks qualifying for advanced measurement approach (AMA) determine their own capital estimates from internal models after satisfying minimum and qualitative criteria prescribed by the regulator (BCBS,2006; Zimbabwe Basel II Technical Guidance, 2011; Peters et al.,2016). AMA is designed for large banks with huge databases. The method theoretically ensures convergence of regulatory and economic capital (Zimbabwe Basel II Technical Guidance, 2011). As a rule, banks must explain deviations between economic and regulatory capital to the Central bank (Zimbabwe Basel II Technical Guidance, 2011).

Under AMA confidence intervals for regulatory capital are set at 99.9%, and economic capital set from 99.95% to 99.99% for one-year horizon (BCBS,2006; Shevchenko and Peters, 2013; Cruz et al., 2015). Dependence modeling is allowed if approved by the regulator (Shevchenko and Peters, 2013; Cruz et al., 2015). Data for modeling should be between five and seven years (BCBS,2006). However, for banks that are still new or have not yet collected data, AMA models can be built from at least three years of data (Zimbabwe Basel II Technical Guidance, 2011). This method is criticised for suffering from data scarcity, unstable parameters, and high sensitivity of data to extreme events (Cope et al., 2009; Embrechts and Hofert, 2011; Cohen, 2018). According to Cohen (2018) AMA lacks theoretical basis and faces difficult dependence modeling.

Three steps are followed in AMA modeling. These are classifying events to business lines, choosing the data elements, and selecting the modeling approach. Events are classified by seven broad risk categories and eight business lines as shown in Table 1.

Table 1: Operational Risk Classification

Business Line Code	Business Line	Event Type	Operational Risk Type
BL1	Corporate Finance	ET1	Internal Fraud
BL2	Trading and Sales	ET2	External Fraud
BL3	Retail Banking	ET3	Employment Practices and Workplace Safety
BL4	Commercial Banking	ET4	Clients Products and Business Practices
BL5	Payment and Settlement	ET5	Damage to Physical Assets
BL6	Agency Services	ET6	Business Disruption and System Failures
BL7	Retail Brokerage	ET7	Execution, Delivery and Process Management
BL8	Asset Management		

Source: Aroda,2016

There exist four data elements for AMA modeling namely internal data, external data, scenario analysis, and business environment and internal factors control exist (Cope, 2012; Aroda et al., 2015; Aroda, 2016). Internal data is the first step in using AMA. Banks must have credible, comprehensive, timely, complete, and robust internal loss data for operational risk measurement (Aroda,2016). Additionally, each bank should determine an appropriate threshold for loss data (Zimbabwe

Basel II Technical Guidance, 2011). This information includes gross loss amounts, date of the loss event and any recoveries, as well as descriptive information about the drivers or causes of the loss event. Data used for regulatory capital purposes must have a minimum of five-year observation period. When a bank first moves to AMA, a three-year historical data window is allowed, subject to written approval by the Reserve Bank (Zimbabwe Basel II Technical Guidance, 2011). Internal loss data is classified into eight business lines by seven event types to determine the unit of measure (UoM) or alternatively a cell.

Relevant external loss data (ELD) must include, where available, data on the gross loss amount and loss event category, information on any recoveries to the extent that these are known, the nature and scale of the operation where the event occurred and any other available information that would assist in assessing the relevance of the loss event to the banking institution (Aroda, 2016). External loss data is obtained from vendor, consortia, and own internal external database (Cruz et al., 2015; Aroda, 2016). However external data suffers from reporting or truncation, control, scale data capture and representativeness biases (Aue and Kalkbrener, 2007; Chaudhury, 2010; Ganegoda and Evans ,2014).

Scenario analysis is based on expert opinion obtained from workshops, surveys, focus group discussions, and so on. This is used as a supplement where internal and external loss data do not provide enough robust estimates of the bank's exposure to operational risk. Scenario analysis should be consistent, comprehensive, and capture all material sources of operational risk across the bank. Scenarios should be reviewed annually to ensure they reflect current operational risk profiles of the bank. Expert opinion data suffers from presentation, anchoring, huddle, context, inexpert opinion, over/under confidence, and gaming biases (Chaudhury, 2010; Aroda et al., 2016).

Business Environment and Internal Factors Control (BEICF) is the transformation of qualitative information into numerical values by a scoring mechanism (Aroda,2016). BEICF transformation differs from bank to bank. However, the most prevalent forms are key risk indicators (KRIs) and risk control (RCSA) self-assessment (Aue and Kalkbrener,2007). Key risk indicators are mostly quantitative factors used as a proxy for the quality of the control environment of the bank. Under risk control self-assessment, the bank collects experts' opinion on status of their business processes. The perceived status is rated as Amber or Green or Red RAG status which is quantified subjectively on scorecards to generate risk scenarios, exposure, and correlation to other risks. The third step is choice of AMA modeling method. Methods of AMA modeling approved in Zimbabwean banks are internal measurement methodology, loss distribution approach, structured scenario analysis, scorecard, and hybrid approach (Zimbabwe Basel II Technical Guidance, 2011).

2.4.2.1. Internal Measurement Approach

Karam (2014) states that the internal measurement approach (IMA) method assumes a linear relationship between expected and unexpected losses. Banks generally use internal data and may sometimes apply external data. According to Karam (2014) applying the internal measurement approach has three steps: categorisation of operational risk into eight business lines by seven event types, supervisory determination of exposure indicator (EI), and the scaling factor γ for each business line. The overall capital charge for a bank is the simple sum of expected loss, scaling factor and Risk Profile Index. The Risk Profile Index (RPI) is a function of exposure indicator, probability of an operational risk and the loss given event. It is a bank- specific adjustment factor that captures leptokurtic properties of the bank's loss distribution (Karam, 2014). RPI of the industry loss distribution is one, hence if the bank loss distribution has a fatter tail than the industry loss distribution then RPI would be larger than one. Thus, two banks with the same expected loss may have different capital charges because of different risk profile indices.

2.4.2.2. The Loss Distribution Approach

The Loss distribution approach (LDA) is a parametric technique based on historical internal loss data (potentially enriched with external data). Established on concepts used in actuarial sciences, the LDA involves estimation of frequency distribution for the occurrence of operational losses and a severity distribution for the economic impact of the individual losses (Moscadelli ,2004; Frachot et al., 2004; Chapelle et al., 2004; Shevchenko and Peters, 2013; Cruz et al., 2015; Morais et al., 2018). This is the most popular and cornerstone method in AMA modeling (Shevchenko and Peters, 2013; Morais et al., 2018). LDA is implemented in five steps (Frachot et al., 2003; Fountnouvelle et al.,2006): (a) Estimation of the loss severity distribution using any of these distributions: Lognormal, Log -Gamma, Weibull (shape parameter less than 1), generalised pareto and burr (BCBS, 2011). This is the most difficult aspect of operational risk modeling because data is plagued with biases. (b) Estimation of the loss frequency distribution using any of these: Binomial, Negative Binomial and Poisson probability distributions. (c) Calculation of capital requirements via the aggregate distribution of losses based on the frequency and severity distributions using Monte Carlo simulation or another equivalent technique. (d) Incorporate self-assessment and scenario analysis i.e., the experts' opinions. (e) After calibration of the frequency and severity distributions, the capital estimation is carried through the convolution of the theoretical distributions selected. The most widely used methods for convolution of distributions are Monte Carlo simulation, the Panjer recursion, and Fast Fourier transform (Morais et al., 2018).

2.4.3.3. Structured Scenario Analysis

Dutta and Babbel (2014) notes that structured scenario analysis (also called Scenario based AMA) combines severity and frequency of a potential loss over a given time horizon as linked to evaluation of scenarios. Experts provide opinions on the probability of occurrence (frequency), and the potential economic impact should the event occur (severity) from data collection methods such as workshops, surveys, questionnaires, Delphi technique, etc (Karam, 2014; Ergashev et al., 2015; Morais et al., 2018). In this case expert opinion is based on historical data, perception, judgment, and experience. Scenario-based AMA is like LDA in that both combine two dimensions of frequency and severity to calculate the aggregate loss distribution. This method is subjective and does not escape biases from human perceptions and judgements. However, the method can be combined easily with other techniques such as LDA, Bayesian inference, Change of Measure approach, and so on (Karam, 2014; Dutta and Babbel,2014; Morais et al., 2018).

2.4.3.4. Scorecard Approach

The Scorecard approach (also called the Risk Drivers and Controls Approach) is a self- assessment with a questionnaire consisting of a series of weighted risk-based questions. The questions focus on principal drivers and controls of operational risk across a broad range of applicable operational risk categories, which may vary across banks (Karam, 2014). This provides the bank's unique operational risk profile and risk weighted scores. The Basel Committee does not offer any kind of mathematical equation, but banks have proposed their own formula for calculating capital as:

$$K_{SCA} = E_{ij} \times \omega_{ij} \times RS_{ij} \quad \text{(7)}$$

Where, EI is the exposure indicator, RS the risk score and ω is the scale factor. The scorecard approach is based on forward looking self-assessment data or business internal control factors. However, if the events are rare, external data can also be applied.

2.4.3.5. Hybrid Approach

In a hybrid approach, a bank may combine different approaches for example LDA and scorecard approach. It is possible to mix scenario analysis with other approaches such as Bayesian networks (Karam, 2014).

2.4.3. Standardised Measurement Approach

The standardised measurement approach (SMA) is the new actuarial operational risk modeling method (BCBS, 2014; BCBS, 2016; BCBS, 2017). According to Cohen (2017) it is a trial-and-error method that utilises internal data only. It aims to achieve a universal solution which is applicable to all banks. External, business environment and internal factors control (BEICF) and scenario analysis data are discarded because they converged as noise in Basel II operational risk models (Cohen, 2017). SMA is made up of the business indicator (BI), the business indicator component (BIC) and the Internal Loss Multiplier (ILM) (BCBS, 2016). Under SMA capital is determined with four steps (BCBS,2016). Firstly, the business indicator is calculated from financial statement-based proxies for operational risk comprising interest, leases, and dividend component (ILDC), the services component (SC) and the financial component (FC) (see formula in BCBS, 2017). Secondly, the Business indicator component is determined by multiplying business indicator with a set of regulatory marginal co-efficient (α). Thirdly, the internal loss multiplier or scaling factor is calculated as a function of average of historical internal losses, loss component and business indicator component (see BCBS,2017). The scaling factor is ideally based on high quality data over a ten-year period. However, banks without five years of high-quality loss data must calculate the capital requirements based solely on the business indicator component. Supervisors may however require a bank to calculate capital requirements using fewer than five years of loss data if the internal loss multiplier is greater than 1 and if they believe the losses are representative of the bank's operational risk exposure (BCBS, 2016). Fourthly, operational risk regulatory capital is calculated by multiplying the internal loss multiplier with business indicator component. Supervisors, at their own discretion can set the internal loss multiplier to 1 for all banks (BCBS, 2016).

There is an ongoing debate on whether standardised measurement approach should replace all Basel II operational risk modeling methods. Some scholars argue that SMA cannot replace AMA because it introduces capital instability, risk insensitivity and super additivity which leads to significant undercapitalisation in too big to fail banks (Peters et al., 2016, Mignola et al.,2016). Again, the method is not forward-looking but an oversimplified "one size fit all" LDA applied at the institution top level (Peters et al., 2016). Moreover, SMA method discards 75 percent of data used in operational risk modeling. Cohen (2017) feels that both SMA and AMA are not practical in operational risk modeling. SMA is still new for banks in Zimbabwe and is in early phases of implementation.

2.5. Challenges of Basel II/III Capital Modeling

Several authors argue that Basel II/III capital modeling has limited application to African markets because it is designed specifically by the G20 in exclusion of most African states except South Africa (Ward, 2002; Powell, 2004; Claessens, 2015; Brownridge, 2015; Gottschalk, 2016; Jones and Zeitz, 2017; Jones and Knaack,2019). Hence due to this dominance by developed countries, Basel II/III is poorly calibrated for least developing countries' financial sectors (Barth et al., 2006; The

Warwick Commission, 2011; Jones and Knaack, 2019). Thus, challenges for Basel implementation in African countries are : higher pre-existing capital and liquidity standards than required for Basel II/III, financial infrastructure gaps because of illiquid markets, absence of derivatives and rating agencies, resource capacity constraints, weak supervision, absence of large data bases, information asymmetries between banks and supervisors, and key macroeconomic threats to financial stability such as large swings in economies and other external shocks which are not addressed in Basel II/III (Kasekende,2014; Jones and Knaack, 2019). Two empirical studies that examine Basel II implementation in Zimbabwean banks supports these views. First, using a survey, Matanda (2015), studies Basel II capital modeling adoption in merchant banks. He discovers that Basel II is not suitable for emerging markets like Zimbabwe, because market circumstances are different to those of developed economies. Second, using mixed methods Muvingi studies qualitative aspects of Basel implementation in Zimbabwean banks. Both Muvingi (2011) and Matanda (2015) find that Basel II implementation in Zimbabwean banks is hampered by poor governance, weak supervision, presence of imperfect markets, asymmetric information, lack of data, skills shortages, poor technology, poor access to finance, high operational costs, and inadequate supervisory skills for implementing Pillar 2.

3. DATA AND METHODOLOGY

This section outlines the research methodology that was used for data collection and analysis in this paper. Data was collected from sixteen Zimbabwean banks. Following the pragmatism philosophy, concurrent triangulation mixed methods where quantitative and qualitative research designs were employed to satisfy both objective and subjective goals of the study (Johnson and Onwuegbuzie,2004; Morgan,2014; Saunders etal.,2019). Pragmatists are not committed to any sort of philosophical stance (Creswell,2007; Dawadi et al.,2021). This is because essentially pragmatism "is pluralistic and oriented towards what works in practice" (Creswell & Plano Clark,2011, p.41). As a result, pragmatists use multiple methods as guided by the research problems rather than the "purist divide and war" between positivism and interpretivism paradigms. Hence, pragmatism uses multiple methods, multiple angles and multiple data collection methods as guided by the research problems (Dawadi et al.,2021).

The pragmatism philosophy was chosen because of its flexibility and ability to work with multiple research philosophies, realities, and ontological assumptions (Morgan, 2007; Creswell, 2009; Saunders et al., 2019). It was also more appropriate to this study which has a "practitioner-based" intuitive appeal. "Practitioner- based" research is often multi-purpose requiring the application of "what works" tactics and addressing objectives within epistemological assumptions of pragmatism (Tashakkori and Teddlie, 2010; Creswell, 2014). Precisely survey and archival strategies were concurrently employed in quantitative and qualitative research designs as highlighted in sections 3.1.

3.1. Research Design

This paper employed concurrent triangulation mixed methods to provide a multiple angles perspective, holistic picture, triangulation, better evidence and reduce weaknesses associated with mono or purist methods and philosophical positions (Denzin,1978; Jick, 1979; Greene et al., 1989; Santos et al., 2017, Dawadi et al.,2021). Furthermore, mixed methods were used for complementarity, provide explanations and to ameliorate validity and reliability of results (Collis and Hussey,2010; Tashakkori and Teddlie, 2010; Bentahar and Cameron,2015). In fact, mixed methods allowed for in-depth study and data consolidation from multiple perspectives in this case positivism, realism and interpretivism philosophies (Shorten and Smith,2017, Dawadi et al.,2017). Mixed methods research is where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts, or language into a single study (Johnson and Onwuegbuzie,2004; Castro et al.,2010; Saunders et al., 2019). The abductive logic of inquiry was used (Saunders et al.,2019). Abduction involved the use of induction (discovery of patterns, insights, and new theories) and deduction (testing theories/hypothesis). This entailed moving back and forth from data to theory, and from theory to data.

Creswell et al., (2003)'s mixed methods research design was adopted. The approach classifies mixed methods designs into sequential explanatory, sequential exploratory, sequential transformative, concurrent triangulation/parallel, concurrent nested, and concurrent transformative. This approach was adopted because of its consistence and ability to integrate the most important dimensions needed in this paper (Santos et al., 2017). Four dimensions namely time distribution, weight attribution, degree of combination and theorisation were considered (Creswell,2003, Bentahar and Cameron,2015; Santos et al.,2017). In the spirit of Creswell et al., (2003), Castro et al., (2010) and Dawadi (2021) concurrent triangulation mixed method design was used. This means quantitative and qualitative data were firstly collected and analysed in parallel then secondly merged at data interpretation phase with the aim of determining convergence, differences, and combinations (Creswell,2003; Santos et al.,2017; Shorten and Smith,2017). This was done to give a complete understanding of phenomenon. Using Morse (1991)'s notation the quantitative and qualitative data were given equal weight and mixed upon the integration (QUAN+QUAL) to facilitate "deep structure" data analysis and interpretations (Castro et al.,2010). The theoretical perspective adopted was that Basel II/III risk management in banks is complex and built upon multiple perspectives.

3.1.1 Quantitative Research Design

Two quantitative methods were employed to answer research objectives in line to objectivism ontological and positivism epistemological assumptions. These were survey and manifest archival strategies. These methods answered the objective of

testing Basel II/III capital modeling implementation in Zimbabwean banks. According to Check & Schutt, (2012, p.160) survey research is "the collection of information from a large sample of individuals through their responses to questions." Manifest content archival method is statistical analysis of documents for the appearance of a word or content (Potter and Levine-Donnerstein,1999). While many scholars argue that content analysis is qualitative (Krippendorff, 1980; Weber, 1985; Beattie, 2005; Scaltrito, 2015), Kondracki and Wellman (2002) argues that content analysis that examines the frequency of specific words or content and uses regression methods is a quantitative study. The objectives of the quantitative design were to provide factual, measurable, standardised data collection, explanation, and theory confirmation for Basel II/III modeling methods implementation from large sample of banks (Johnson and Onwuegbuzie,2004; Ponto,2015; Saunders et al., 2019). As such a deductive approach was used where known premises, theories and frameworks on Basel II/III were reviewed from literature and subjected to testing (Bryman, 2006). The phenomena in question were understood from an independent, objective, and external point of view (Babbie,2011).

3.1.2. Qualitative Research Design

Consistent with constructivist ontology and interpretivism epistemology a qualitative research design was used to critically examine Basel II/III capital modeling methods implementation in Zimbabwean banks. Interpretivism allowed the researchers to operate in naturalistic settings and obtain in-depth, rich, and contextual critical understanding of Basel II/III modeling methods implementation in Zimbabwean banks (Bryman, 2006; Denzin and Lincon,2005; Mohajan, 2018). This gave room to idealism, relativism, humanism and use of hermeneutics (Guba & Lincoln, 1989; Lincoln & Guba, 2000). The purposes for qualitative research are induction, discovery, exploration, new theory or hypothesis generation and thick qualitative analysis (Johnson and Onwuegbuzie,2004). Following Saunders et al., (2019), an inductive approach was applied that began with data gathering from annual audited financial statements and previous survey reports on capital management with an aim to generate new insights on Basel II/III Pillar 1 capital modeling implementation in Zimbabwean banks. Non-numerical data were collected with non-probability sampling. The few selected archival records were investigated in detail with latent content archival analysis to get contextual meanings not generalisable (Bryman,2004; Denzin and Lincoln,2011; Clough and Nutbrown, 2012). Latent content archival analysis is the understanding of interpretative, implied, and underlying meanings beyond mere frequency analysis of words or content (Holsti,1969; Babbie,1992; Morse and Field,1995).

3.2. Data Collection

Data was collected concurrently from sixteen banks over a period of six months in this manner. Firstly, quantitative data was collected with self-administered structured questionnaire, archival search, and archival disclosure checklist. The structured questionnaire comprised closed questions thus providing standardised responses and least cost data collection from a large sample (Zikmund,2003; Fellegi, 2010; Babbie 2011; Saunders et al.,2019). The questionnaire was designed to collect categorical data with a mixture of Likert scale, and "yes/no" questions. These questions were designed by the researcher based on theoretical constructs from Basel II/III Pillar 1 framework (Easterby-Smith et al., 2015, Saunders, et al.,2012; Fellegi, 2010; Collis and Hussey, 2009). The questionnaire was distributed and collected in person. The data was collected under these Basel II/III Pillar 1 themes or variables formulated from theoretical review: capital modeling method implementation, bank size and capital modeling method adoption, data & skills sufficiency, state of market discipline and supervision.

Secondly, quantitative data was also collected with archival search and a categorisation matrix or Basel II/III capital modeling archival disclosure checklist developed for manifest archival analysis. Annual financial statements and previous survey reports from 2011-2020 were downloaded from banks' and standard setting bodies' (IMF, World Bank, Basel Committee, Financial Stability Institute, Central Bank of Zimbabwe) respectively. The disclosure checklist was developed from theoretical constructs used on structured questionnaire and archival data. Themes and phrases were used as units of measurement. Summative content design was used where codes were defined from theoretical literature review and archival data (Babbie,1992; Hsieh and Shannon,2005). The coding framework was developed firstly from a predetermined structure based on the structured questionnaires, then secondly with data from a sample of five annual audited reports from five banks. The categorisation matrix was designed using Bengtsson (2016)'s four steps of decontextualisation, recontextualisation, categorisation and compilation. The categorisation matrix examined six thematic areas namely definitions of capital, capital adequacy, market risk capital, credit risk capital, operational risk capital and economic capital modeling methods implementation. Extant studies have used themes and phrases from annual reports to understand levels of disclosures in banks (Linsley and Shrives,2005, Oliveira et al., 2011, Campbell,2011; Ieasi,2012, Al-Maghzom et al., 2016; Khalil and Alam,2018). Thirdly, data for qualitative analysis were collected from annual audited financial statements and previous survey reports using thematic questions. In this case manual content analysis, narrative analysis and repetitive reading was used because of their low cost and flexibility (Scaltrito,2015; Bengtsson,2016).

3.2.1. Sampling

The objective of sampling in any study is to obtain a sample representative of the population (Ponto,2015). In this paper stratified, random and purposive sampling were used. First stratified sampling was applied to the survey. Banks were divided into four strata by bank size and ownership structure into International, Pan African, Private owned and Government owned indigenous banks. The sample size was determined at 95% confidence interval using Krejcie and Morgan's (1970) table as in

Sekaran (2003), Yamane's (1967), and Saunders et al., (2012) formulae. This resulted in sample sizes of 132,133 and 132 respectively. As a result, 160 self- administered questionnaires out of a population of 200 Risk Managers were distributed. To reduce non-response bias, questionnaires were distributed beyond those recommended by the three techniques and a follow up mail was used. 131 questionnaires were collected, representing a 75% active response rate. Out of the 131 returned questionnaires, 120 were used for data analysis because they were adequately completed.

Second, the sample size for manifest archival analysis, was determined by random sampling. The author settled for a sample size of 160 audited financial statements from 2011-2020. This sample size was determined to saturation to ensure comprehensiveness, facilitate categorisation and abstraction (Morse et al.,2002; Elo et al.,2014). The annual audited financial statements were downloaded from the banks 'official websites. These were used because they represent an accurate form of fundamental communication to shareholders, regulators, and customers (Lajili and Zeghal,2009). They also provide historical, financial, and corporate pictures (Linsley and Shrives, 2006; Ieasi, 2012). Further they are extensively distributed to the public (Campbell, 2000; Ielasi,2012).

Third, because qualitative research is idiographic in approach focusing on small samples, the sample sizes for latent archival data were determined by purposive sampling (Castro et al., 2010; Creswell, 2013). This allowed the researcher to focus on articles with the best knowledge on the topic (Kyngäs et al.,2011). Out of the 160 audited reports, 35 reports were purposively sampled for latent content analysis based on Saunders, et al., (2012) p.283 table of non- probability samples. Saunders et al. (2012) argues that cases for qualitative methods should not exceed 37 documents. The same approach was used to determine 20 reports from past surveys as adequate for further latent analysis. These previous survey reports from 2011-2020 were downloaded from World Bank, Financial Stability Institute, Central Bank of Zimbabwe, and International Monetary Fund. In both approaches the categorisation matrix provided a guiding framework.

3.2.2. Pilot

The structured questionnaire and disclosure checklist for manifest analysis were piloted in this manner. First, the structured questionnaire was piloted using Babbie and Quinlan (2011)'s two stage procedure. Academics selected from the University of Bolton and ten Risk Managers chosen by stratified random sampling reviewed the questionnaire for correctness and feasibility of study (Saunders et al.,2012). Second, the disclosure checklist and themes for latent analysis were pretested in a pilot phase to ten Risk Managers from five banks as recommended by Schreier (2012). The final structured questionnaire, categorisation matrix and themes were produced after incorporating comments from domain experts. In the three cases, ten risk managers were employed following Brace (2008), who states that pilot testing is successful in identifying the needed changes if few individuals up to ten are willing to complete and provide suggestions

3.3. Data Analysis

Quantitative data was analysed with descriptive statistics on Statistical Package for Social Sciences (SPSS) and Excel. Qualitative data was analysed hermeneutically with manual textual and narrative analysis. Data collected by the structured questionnaire was analysed with SPSS and presented in form frequency tables and bar charts following Tukey (1977)'s exploratory data analysis method (Field, 2009; Saunders et al., 2012; Hair et al., 2014). Data for manifest archival research was analysed on Excel using descriptive statistics in form of frequencies as in Copeland and Fredericks, (1968); Al-Maghzom et al., (2016) & Khalil and Alam, (2018). Data for latent archival analysis was subjected to hermeneutic, thematic, narrative analysis, pattern analysis, coding, and critical realism methods (Elo et al.,2014; Bengtsson,2016). The author was the listener, while annual and previous survey reports provided the banks' narration or story on Basel II/III capital modeling sequentially and logically.

3.4. Validity and Reliability

Validity and reliability for the three methods were done as follows. First, validity and reliability of the structured questionnaire were measured by content validity and Cronbach's alpha respectively. Content validity is established by ensuring that structured questionnaire was reviewed by academic experts from the University of Bolton and ten risk managers who participated in the pilot study (Kimberlin and Winterstein ,2008; Pallant ,2010; Mohajan,2017). The Cronbach alpha was 0.813 (Heale and Twycross, 2015, Saunders et al.,2012; Mohajan 2017). Hence results are valid and reliable. Second, validity and reliability for archival disclosure checklist were measured by content validity and inter-rater reliability. Content validity was ensured by piloting the archival disclosure checklist to a domain of ten Risk Managers (Crocker and Algina ,1986; Schreier 2012; Mohajan, 2017). Moreso, data from annual reports are regarded as valid because they have gone through external criticism by experts and independent auditors before publication respectively. Reliability for manifest content archival analysis was evaluated by inter-rater reliability (Weber,1985). Inter-rater reliability was achieved by engaging two independent economists to count the phrases from annual reports for a fee (Kleinheksel et al.,2020). According to Weber (1985) content analysis is reliable when two or more different people encode a given text the same way and their results have insignificant differences to the researcher's. Results are reliable because the researcher and independent checkers replicated the same results with insignificant differences (Marston and Shrives ,1991; Al-Maghzom et al., 2016). Third, researchers argue that generalisability, replication, reliability, and validity are not very relevant in qualitative research (Denzin

and Lincoln 1994; Guba, and Lincoln 2005). Hence for qualitative latent analysis the credibility of these results depends on genuiness of researchers (Mohajan, 2018; Kleinheksel et al.,2020).

3.5. Ethical Considerations

Ethical considerations in this study cover permission to conduct survey, informed consent, data privacy and confidentiality. Permission to conduct survey were obtained from the University of Bolton. Participants completed the questionnaire from informed consent where they had a right to withdraw their participation. The purpose of the research was explained to the participants by the researcher on the cover letter attached to questionnaire. The study ensured data privacy on two matters. Firstly, no reference is made to names of banks where questionnaires were distributed, and archival data collected. Secondly, no reference is made to any individual or bank on data analysis, presentation, and discussion of outcomes.

4. FINDINGS AND DISCUSSIONS

This section reports and discusses the results of Basel II/III Pillar I implementation in Zimbabwean banks. Significant results from quantitative and qualitative analysis are independently reported. The same results are then fused and discussed. The main findings and conclusions are presented.

4.1. Quantitative Results

Two instruments were used in quantitative analysis namely structured questionnaire and manifest content archival analysis. The structured questionnaire was completed by 120 Risk Managers and analysed on Statistical Package for Social Sciences. Table 2 shows that 77 percent of participants had more than three years of experience in risk management. The distribution of the participants were 26 percent Quantitative Risk Managers, 24 percent Operational Risk Managers, 22 percent Operational Risk Managers and 13 percent Market Risk Managers. In tems of skills: 3 pecent had Doctor of Philosophy, 53 percent masters, and 45 percent undergraduate degrees.

Table 2: Experience of Participants

Experience in years	Frequency	Proportion
At most 2	28	23%
3-5	96	38%
6-10	32	27%
11-15	8	7%
Above 15	6	5%
Sample size	120	

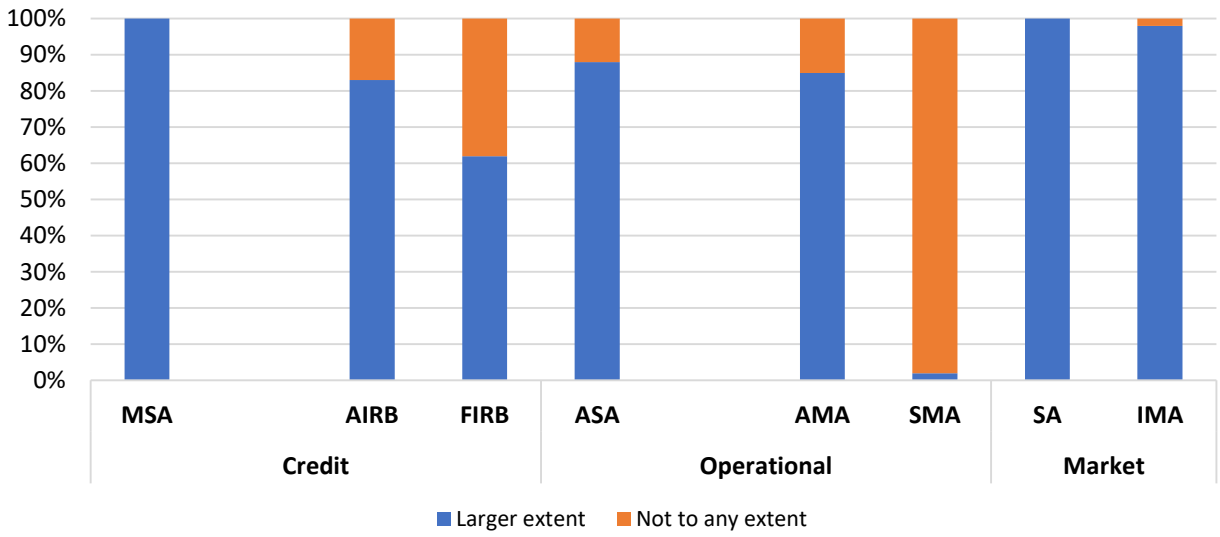
The sample for the archival analysis comprised 160 annual audited financial statements. The disclosure checklist was analysed using Excel. Frequencies, means, and variances were used to analyse the data.

4.1.1. General State of Capital Modeling Methods Implementation

Generally, the results indicate high status of capital modeling methods implementation in Zimbabwean banks. However, implementation status for new approaches such as expected shortfall for market risks and standardised measurement approach (SMA) for operational risks are still very low or almost nil. As shown in Fig 1, first, banks are compliant to credit risk modeling methods in ranking order from highest to lowest: 97 percent Modified Standardised Approach (MSA), 83 percent Advanced Internal Ratings Based Approach (AIRB), and 62 percent Foundation Internal Rating Based Approach (FIRB).

Figure 1: Adoption of Basel II/III Capital Modeling Methods

Question 4:To what extent have you have implemented the following Basel II/III methods for capital modeling. Choose the methods that best apply to your bank from the list below



Second, banks are compliant to Basel II/III operational risk modeling methods in descending order as 88 percent Alternative Standardised Approach (ASA), 85 percent Advanced Measurement Approach (AMA), and 2 percent Standardised Measurement Approach (SMA). Third, banks are compliant to Basel II/III market risk modeling as 100 percent Standardised Approach (SA) and 98 percent internal models' approach. These results show that all banks in Zimbabwe are compliant to both simple and advanced capital modeling techniques. This is contrary to an extant study in merchant banks by Muvingi (2011). He found that banks were implementing simple capital methods such as modified standardised approach for credit risk, alternative standardised approach for operational risk and standardised approach for market risk. Furthermore, these findings confirm that banks in Zimbabwe have adopted Basel II/III in a deep and comprehensive Eurocentric style. This contrasts previous literature that recommends African countries or least developing countries to implement Basel II/III in a shallow selective manner where the simple approaches are employed first rather than advanced techniques (Barth et al., 2006; The Warwick Commission, 2011; Gottschalk,2016; Jones and Knaack, 2019). In addition, these studies recommend adopting proportionality philosophy where advanced modeling techniques are the prerogative for internationally active banks and the simple capital modeling methods are for smaller and domestic banks.

4.1.2. Bank Size and Capital Modeling Method Implementation

To substantiate results in 4.1.1 a further analysis on the relationship between bank size and the capital modeling method was done. This was to prove the Basel II/III proportionality philosophy theoretical postulation that bank size is directly correlated to type of capital modeling method applied (BCBS,2006; Zimbabwe Basel II Technical Guidance, 2011). In other words, advanced modeling methods are the prerogative of larger internationally active banks and simple methods are for local banks.

Table 3: Summary of Bank Size and Capital Methodology Adoption

Question 4: To what extent have you have implemented the following Basel II/III methods for capital modeling. Choose the methods that best apply to your bank from the list below

Risk Type	Capital Modeling Method	Level of Adoption by Bank type (frequencies)			
		Indigenous Private	Indigenous Government Owned	International	Pan African
Credit	MSA	100%	100%	87%	92%
	AIRB	76%	77%	67%	53%
	FIRB	40%	71%	33%	25%
Operational	ASA	90%	100%	93%	78%

	AMA	77%	74%	60%	56%
	SMA	-	-	-	-
Market	SA	68%	61%	73%	61%
	IMA	76%	87%	80%	67%

Contrary to the proportionality philosophy Table 3 shows that smaller domestic banks, international and Pan African banks in Zimbabwe are implementing both simpler and advanced capital modelling methods in the same direction. In fact, smaller indigenous banks are implementing Basel II/III advanced financial modelling faster than larger internationally active banks (Pan African and international banks). Firstly, evidence shows that 77 percent government owned indigenous banks, 76 percent private owned indigenous, 67 percent international, and 53 percent Pan African apply the advanced internal ratings-based approach to determine credit risk capital. Secondly, evidence indicates that 77 percent indigenous private owned, 74 percent government owned indigenous, 60 percent international, and 56 percent Pan African apply advanced measurement approaches to calculate operational risk capital. Thirdly, empirical evidence indicates that 76 percent indigenous private owned, 87 percent government owned, 80 percent international, and 67 percent Pan African have implemented market risk internal models. Hence capital modeling method adopted and bank size are not correlated in Zimbabwean banks. This means banks in Zimbabwe are violating the proportionality philosophy.

4.1.3. Data & Skills Sufficiency

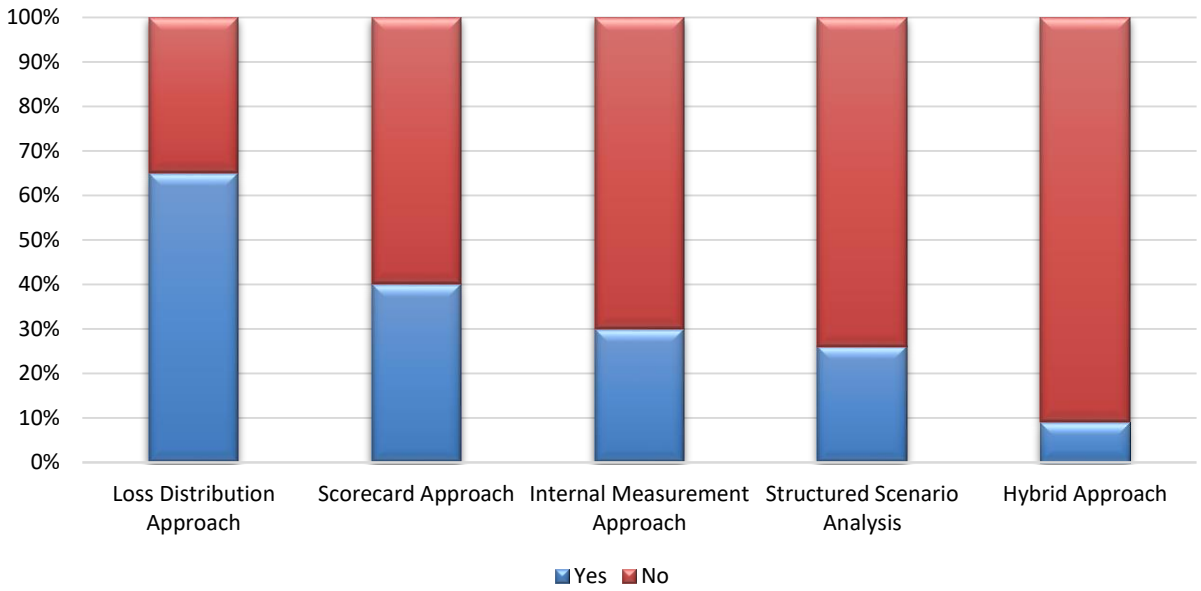
As a further follow up on bank size and capital methodology, respondents are asked questions that gauge their implementation of advanced capital modeling methods for credit, operational and market risk. These questions are intended to investigate data and skills sufficiency for Basel implementation in Zimbabwean banks. This is because the theoretical prerequisite for applying advanced financial modeling methods are huge databases and enough skills (Danielson et al.,2001; BCBS,2006; Zimbabwe Basel II Technical Guidance, 2011). Table 4 shows that Zimbabwean banks have implemented the Advanced Internal Ratings Approach for credit risk modeling with 96 percent confessing probability of default, 96 percent loss given default, 97 percent exposure at default, 84 percent maturity and 42 percent asset correlation estimation on their own.

Table 4: Implementation of IRB for Credit Risk

Question 5: Basel credit risk parameters are used in advanced credit risk modeling approaches. Do you use these parameters to estimate regulatory and economic capital for credit risk?		
Credit risk parameters	**Frequency**	
	Yes	**No**
Probability of default (PD)	115 (96%)	5 (4%)
Loss given default (LGD)	115 (96%)	5(4%)
Exposure at Default (EAD)	116 (97%)	4 (3%)
Maturity	101(84%)	19(16%)
Asset Correlation	50 (42%)	70 (58%)

However, 42% of the respondents reveal that banks apply the asset correlation provided by the supervisor, whilst 58% use their own estimates thus violating Basel II requirements. Compliance to Basel II/III four credit risk parameters validates that banks in Zimbabwe have enough data and expertise for credit risk modelling. Using a different asset correlation means regulatory and economic capital diverges. Figure 2 shows that Zimbabwean banks are compliant to AMA modelling with 65 percent adoption of Loss Distribution Approach, 40 percent Scorecard Approach, 30 percent Internal Measurement Approach, 26 percent Structured Scenario Analysis and 9 percent Hybrid Approach.

Figure 2: AMA Operational Risk Modeling Method Implementation
Question 7 Circle the AMA method your bank uses to calculate operational risk capital



Again, the results for AMA implementation validate that banks in Zimbabwe have adequate databases and skills for operational risk modelling. This is contrary to previous studies that cites inadequate data for operational risk modelling as a hindrance to Basel implementation (Danielson al.,2001; Dowd et al.,2011; Embrechts,2015). This study found that 72 percent of banks apply the VaR methodology, 23 percent both VaR and Expected shortfall and 5 percent Expected shortfall only. Banks calculated value at risk as a sum of traditional value at risk (VaR), stressed VaR and incremental VaR. Thus, banks in Zimbabwe are compliant to Basel 2.5.

Table 5: Internal Modeling Approach for Market Risks

Question 6: Indicate the statements that best describe the practice of measuring market risk capital in your bank			
Component	**Frequency**	**Computation Methodology**	**Frequency**
Value at Risk	72%	Traditional VaR	100%
		Stressed VaR	96%
		Incremental VaR	96%
Expected shortfall	5%		
Both	23%		

Banks in Zimbabwe have implemented the three market risk components. 100 percent calculate traditional VaR, 96 percent stressed VaR and 96 percent incremental VaR. These results are contrary to the regulator who reports adoption of simple capital modelling methods for market risk (Zimbabwe Basel II, Technical Guidance,2011). In summary empirical evidence from this study shows that there is sufficient databases and skills for Basel II/III capital modelling in Zimbabwean banks contrary to studies in least developing countries by Ward (2002); Powell (2004); Held and Young (2009); Muvingi (2011); Matanda (2015); Kasekende (2015); Gottschalk (2016); Jones and Zeitz (2017) and Jones and Knaack (2019).

4.1.4 State of Market Discipline and Supervision for Pillar 1

The results from thematic analysis using disclosure checklist are presented. Table 6 shows that they were 3003 phrases, with mean 601 and standard deviation 720 reported in annual audited financial statements from 2011-2020.

Table 6: Basel II/III Disclosure Results

Theme	Total Frequency	Percentage
Definitions of capital	1 885	63%
Capital adequacy	911	31%
Credit risk capital	70	2%
Market risk capital	69	2%
Operational risk capital	70	2%
Economic capital	-	-
Total	3003	
Mean	601	
Standard Deviation	720	

Banks comply to disclosure themes: 62 percent on definitions of capital and 31 percent on capital adequacy ratios because the regulator has strong focus on Pillar 1 adoption. However, they do not report methodologies they use for capital modeling as shown by results for credit risk (2%), market risk (2%) and operational risk (2%). These results indicates that banks report the implementation of simple methods to the central bank. The level of market discipline and supervision for Pillar 1 is concluded to be low.

4.2. Qualitative Results

As previously mentioned, the sample for qualitative design comprised 35 annual audited financial statements and 20 previous survey reports on Basel II/III in Zimbabwe. These were exposed to thematic analysis and repetitive reading.

Table 7: Summary of Qualitative Results

Theme	Modeling method	Question	Finding
Credit risk	MSA	What method is used in determining regulatory capital	High implementation in all types of banks
	FIRB		Not yet implemented but draft rules completed in 2011
	AIRB		Not yet implemented but draft rules completed in 2011
Operational Risk	ASA	Same as above	High implementation in all banks since 2011
	AMA		Not yet implemented but rules completed in 2011
Market risk	SA	Same as above	High implementation in all types of banks
	IMA		Nil but draft rules completed in 2011
Economic capital	What method is used to calculate economic capital		Nil reports and methods for economic capital modeling
Skills sufficiency	Are there sufficient skills for Basel II/III capital modeling		Yes, except in derivatives. Derivatives are not allowed in Zimbabwean financial market
Data sufficiency	Is there sufficient data for Basel II/III capital modeling		No clear results from reports
Pre-existing capital requirements	Are there any other capital requirements apart from Basel II/III		Yes, USD30 million minimum requirement for Tier 1 banks and USD 20 million for building societies

The results indicate that banks in Zimbabwe have high implementation of simple modeling methods, for example MSA for credit risk, ASA for operational risk and SA for market risk. Furthermore, banks are not reporting economic capital. It is not clear from the latent analysis whether Zimbabwean banks have collected sufficient data for capital modeling. However, both reports validate that skills for dealing with Basel II/III capital modeling are sufficient except in the derivatives area. Since there is no derivatives market in Zimbabwe, an absence of specialist skills in this area has zero effect on capital modeling. The usefulness of the Basel II/III is doubtful given the existence of higher pre-existing capital requirements rules for Zimbabwean banks (USD 30 million for Tier 1 banks and USD20 million for building societies). This support extant studies that have stated that the usefulness of Basel II/III capital modeling implementation is ambiguous in the presence of pre-existing higher capital requirements (Kasekende,2015; Jones and Knaack,2019).

4.3. Discussion

The fusion of the results indicates a concurrence by three research methods that there is deep Basel II/III capital modeling implementation, sufficient data and skills, violation of the proportionality principle and low levels of market discipline and

supervision. The study indicates that there is no relationship between bank size and capital modeling method adopted. However, the survey and archival results show differences on type of capital modeling method adopted. The survey results indicate that banks are implementing advanced capital modeling regardless of size. These results represent the bank's view of Basel II/III capital modeling implementation. On the contrary archival data prepared mainly by the regulator or for the regulator reveal that that banks are implementing simple capital modeling methods. It is acknowledged that archival data reveal the regulator's view. Furthermore, survey indicates that banks in Zimbabwe have implemented Basel 2.5 whereas the results from archival study are contrary. These differences reveal the existence of information asymmetries between the regulator and banks. Banks are implementing advanced capital modeling methods regardless of size for their own internal purposes such as economic capital modeling whilst reporting simple methods for regulatory purposes. Furthermore, banks are adopting Basel II/III capital modeling methods at a faster pace than their regulator. From these results, the paper concludes that Basel capital modeling implementation in Zimbabwean banks is not hampered by data and skills insufficiency but by information asymmetries between banks and their central bank. Again, from a policy perspective, the usefulness of Basel II/III capital modeling in Zimbabwean banks remains ambiguous in the presence of other parallel high capital requirements rules enforced by the regulator.

5. CONCLUSION AND IMPLICATIONS

Basel II/III miinimum capital requirements are an important ingredient in mantaining financial stability and promoting resilience in banks. Following the adoption of Basel II/III by the Reserve Bank of Zimbabwe, this paper pioneers a holistic test and critical examination of usefulness of Basel capital modeling methods implementation in sixteen banks. Concurrent triangulation mixed methods were employed to achieve objectives of this study. This involved mixing survey and archival research methods in a quantitative and qualitative research designs. First, the paper finds deep implementation of Basel II/III capital modeling methods, sufficient data and skills, violation of the proportionality principle, existence of information asymmetries and low levels of market discipline and supervision in Zimbabwean banks. The violation of proportionality principle is shown by the fact that local banks are implementing advanced capital modeling methods at the same pace or even higher than internationally active banks. The implication is that adoption of Basel II/III in Zimbabwean banks is thus creating a level field of competition between the domestic, Pan African, and international banks. The existence of information asymmetries is shown by divergence of perspectives between regulator and banks. While the regulator is enforcing proportionality, banks are adopting advanced methods for their internal purposes regardless of size. Second, the usefulness of Basel II/III capital modeling in Zimbabwean banks as a tool for managing risk based minimum capital requirements is ambiguous given the violation of the proportionality principle by banks and existence of other parallel higher capital requirements enforced by the regulator. These results suggest as in Jones and Knaack (2019) that Basel II/III implementation in Zimbabwean banks may not be attributed to technical considerations but are a product of inward pressure to signify sophistication and competitive standing to international community. Furthermore, it is recommended that the central bank of Zimbabwe must choose one ideology either parallel minimum capital requirements or Basel II/III. Further research should address the effects of eliminating parallel minimum capital requirements and reasons for violation of proportionality principle by domestic banks.

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APPENDICES

A. Disclosure Checklist

Theme	Phrases
Definitions of capital	Tier 1 capital, Tier 2 capital, Tier 3 capital, Tier 1 ratio, Tier 2 ratio, Tier 3 ratio, core capital, supplementary capital
Capital adequacy	Risk weighted assets, capital adequacy ratio, regulatory capital
Credit risk capital	Standardised approach, foundation internal ratings approach, advanced internal ratings-based approach, probability of default, exposure at default, loss given default, maturity, credit scoring, ratings philosophy
Market risk capital	Standardised approach, Internal measurement approach, value at risk, expected shortfall, historical simulation, monte carlo simulation, variance covariance
Operational risk capital	Alternative standardised approach, basic indicator, advanced measurement approach, Loss distribution approach, internal measurement approach, scorecard approach

Source: Tepetepe et al.,2022

B. Structured Questionnaire

1. I work in my bank as …… (*Please choose from the options provided below***)**

Position	Code	Indicate your choice by marking the appropriate selected blank block with an "X"
Quantitative Risk Manager (Financial Engineer, Actuary)	1	
Market Risk Manager	2	
Operational Risk Manager	3	
Credit Risk Manager	4	
Emerging Risk Manager e.g., Information Risk, Occupational Health and Safety Manager, Business Continuity Manager	5	
Asset and Liability Manager	6	
Capital Manager (Regulatory and Economic Capital)	7	

2. My highest qualification is …… (*Choose from the options provided***)**

Qualification	Code
PhD	1
Master's Degree	2
First Degree	3
Postgraduate Diploma	4

3. My experience in dealing with Basel II/III capital modeling is …… (*Choose the options that best describe your level of experience from the ones below***).**

Experience	Code	Indicate your choice by marking the appropriate selected blank block with an "X"
At most 2 years	1	
3-5 years	2	
6-10 years	3	
11-15 years	4	
Above 15 years	5	

4. To what extent have you have implemented the following Basel II/III methods for capital modeling. Choose the methods that best apply to your bank from the list below.

Method	Not to any extent	To a very little extent	To some extent	To a large extent	To a very large extent
Standardised approach for credit risk	1	2	3	4	5
Foundation internal ratings-based approach for credit risk	1	2	3	4	5
Modified standardised approach for credit risk	1	2	3	4	5
Advanced internal ratings-based approach for credit risk	1	2	3	4	5
Basic indicator approach for operational risk income	1	2	3	4	5
Standardised approach for operational risk	1	2	3	4	5
Advanced measurement approach for operational risk	1	2	3	4	5
Standardised Measurement approach for operational risk	1	2	3	4	5
Standardised Approach for market risks	1	2	3	4	5
Internal models approach for market risk	1	2	3	4	5

5. Basel risk parameters are used to estimate credit risk for advanced modeling methods. Do you use these parameters to estimate regulatory and economic capital for credit risk?

Risk parameter	Yes	No
Probability of default (PD)	1	2
Loss Given Default (LGD)	1	2
Exposure at default	1	2
Maturity	1	2
Asset correlations	1	2

6. Indicate the statements that best describe the practice of measuring market risk capital in your bank. Circle the appropriate boxes for each component of market risk.

Component	**Method**		
Value at Risk			
Expected Shortfall			
Both value at risk and expected shortfall			
In general value at risk is calculated using:	1 Traditional Value at Risk	2 Stressed Value at Risk	3 Incremental value at Risk

7. Circle the AMA method you use to calculate the operational risk capital in your bank.

Methods	**Yes**	**No**
Loss Distribution Approach	1	2
Structured Scenario Analysis	1	2
Internal Measurement Approach	1	2
Scorecard Approach	1	2
Hybrid Approach	1	2

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BLOCKCHAIN TECHNOLOGY AND ITS IMPACT ON AUDIT ACTIVITIES

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ABSTRACT

Purpose- Within the scope of this study, it is to conduct a comprehensive literature review on the conceptualisation, functioning, historical process, types, basic features, areas of use of blockchain technology and finally the relationship of blockchain technology in terms of an audit.
Methodology- A comprehensive literature review was conducted on the concept relationship of blockchain technology in terms of auditing.
Findings- The biggest feature of blockchain technology is that it has a decentralized verification system. In this respect, it is shown as one of the most effective areas where digital transformation is experienced. The usage areas of blockchain technology can be summarized as shown: Finance, public service, health, supply chain, education and auditing. The main impact of blockchain technology on the audit profession is to reduce the cost of monitoring and control as blockchain technology becomes more common in organizations thanks to the reliability, transparency and timeliness of the data used in auditing. Blockchain creates a more robust audit trail by using multiple sibling databases instead of a single and central database. The most important part that distinguishes blockchain technology from other technologies is that this technology is far from a centralized structure.
Conclusion- With the blockchain technology, which emerged to question the need for intermediary institutions that provide trust and to show that there is no need for trust in intermediary institutions, it is expected that many sectors from the banking and finance sector, logistics and supply chain to the health sector will be affected, especially cost and time savings. With the increasing number of blockchain technology, the existing risks both continue and new technology brings new risks. This technology inevitably affects audit activities as it does all sectors. Businesses should identify these risks and take the necessary precautions. Internal audit departments should develop themselves on blockchain, and businesses should allocate an additional budget for those working in this department and ensure that they receive training on this subject.

Keywords: Blockchain, audit, database security, distributed ledger technology, digital transformation.
JEL Codes: G10, M10, O10

1. INTRODUCTION

Blockchain technology, which has recently made a great impression in the national and international press, attracted attention by the private sector and various public institutions, and potentially as a stronger technology than the internet, is one of the biggest innovations of the digitalized age. (Celayir & Celayir, 2020). One of the expected technology advances is blockchain technology. Even though today's companies and countries have only recently attracted attention, we see that the mentioned technology has begun to enter our lives step by step, similar to the introduction of the internet into our lives years ago. The Internet's creation of a virtual world by transforming our business and social habits into digital data saves both money and time in the workflow and communication process. Similar to the way the World Wide Web was gifted to the world without obtaining any patents, the blockchain technology that has been heard in our ears recently has been gifted to the world in the same way (Erdoğan & Bodur, 2020). Blockchain with general definition; It is a technology protocol that allows data sharing with trust-based transactions such as identification and authorization in a decentralized distributed network environment without the approval or control requirement of the central authority (Celayir & Celayir, 2020). Blockchain technology offers “a secure, transparent, fast and affordable digital solution to many government problems” (Rooney, Aiken, & Rooney, 2017). The combination of these capabilities is also likely to transform auditing by automating workflows but, more importantly, increasing audit effectiveness and reporting (Rozario & Thomas, 2019). The audit process is constantly moving towards the use of digital tools. The majority of auditors are turning to digital tools and general audits (Celayir &

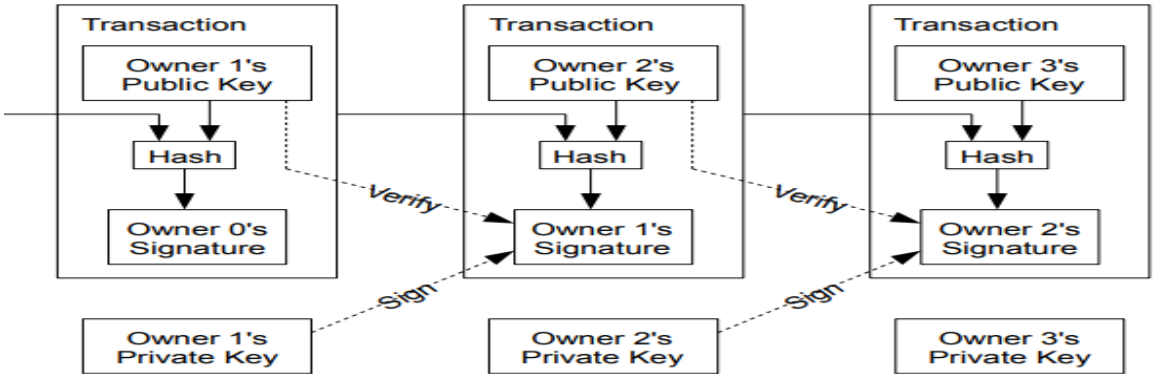
Celayir, 2020). The audit concept may need to adjust its current paradigm to adapt to such a rapidly changing environment. In addition, new audit approaches based on advanced technologies can be used to improve assurance quality (Dai, 2017). Although researchers offer the opinion that blockchain technology will affect financial instruments to a large extent at the first stage, they are of the opinion that over time, it will affect every sector with digital data in accordance with the requirements of the age (Erdoğan & Bodur, 2020). In addition, the results of the literature review show that there is a lack of awareness in the adoption of blockchain technology (Özyürek, 2021). In this article, the block chain and its relationship with the concept of auditing, which is an important subject and application area of blockchain, has been examined. In addition to these basic issues, the functioning, historical process, types, basic features and usage areas of blockchain technology were also examined (Erdoğan & Bodur, 2020).

In this study, first of all, a detailed literature review about the concept of blockchain and its functioning was made. Then, information about the historical development of blockchain technology is given. In the following sections, the types of blockchains and then their basic features and usage areas are mentioned. Finally, detailed explanations on the effects of blockchain technology, which is the main part of the study, on auditing are given.

2. BLOCKCHAIN (BT) CONCEPT AND OPERATION

Blockchain is the technology in which processes can be carried out without an intermediary (a third party). In other words, blockchain technology is a valuable database developed to solve the third-party problem required in the normal system. Blockchain can be defined as a distributed database solution approved by users participating in the network and regularly growing data set records, or data recording technology that records transactions, deals, sales and contracts and distributes them from peer to peer (Kılınç, 2020). Blockchain can generally be defined as the technology that activates the cryptocurrency Bitcoin. The reason for this is that the blockchain technology first appeared with Bitcoin. Today, the blockchain is still most widely used by Bitcoin (Kılınç, 2020). The English word equivalent of the block chain system is basically based on the "Decentralized Distributed Ledger Technology". With this technology, every data is created, its validity is verified and cryptographically blocked, so that the algorithms created can be prevented from being resolved irreversibly by people. In other words, with the blockchain technology, which is created by adding the underlying data of each created block, every transaction is recorded and it is impossible to delete (Akdemir, 2018). On the other hand, blockchain technology also creates a safe, transparent and accountable environment with the 'trust protocol'. Blockchain, which is one of the systems that tries to integrate with energy systems, has just begun to be implemented in Turkey; fault detection in energy units, cost accounting, billing, loss and leakage detection, etc. It can be used in applications (Büyükarıkan, 2021). Blockchain is a decentralized, electronic, replicated and distributed file where transactions are recorded using peer-to-peer protocols, fast digital communication, enormous computing power, and modern encryption technology. For this purpose, computers that are independent of each other are connected to each other to form a network over the internet (Gül, n.d.). The subject of blockchain technology was first encountered in Satoshi Nakamoto's work titled 'Bitcoin: A Peer-to-Peer Electronic Cash System' published in 2009. When Nakamoto's (2009) study is examined, the concept of blockchain technology is not directly encountered. However, it has been determined that the main function of the blockchain technology is to have remarkable explanations and visuals for its structure. In Nakamoto's work, the structure of the blockchain is as shown in figure 1 below (Kılınç, 2020).

Figure 1: Blockchain Structure



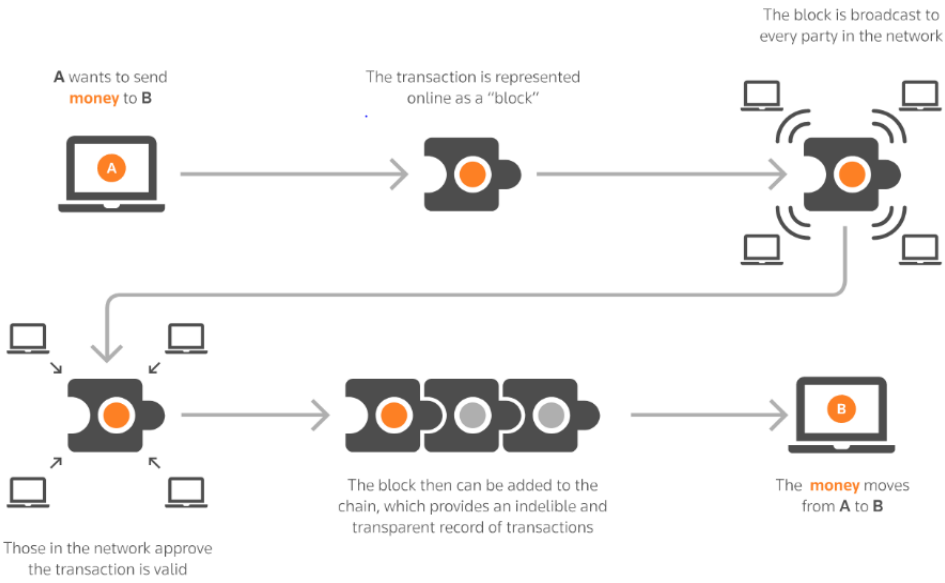
Source: (Nakamoto, 2008)

Figure 1 summarizes the data structures in the blockchain with basic explanation. As can be seen from the figure, the last link of the chain just behind forms the chain structure in such a way that it can form the first link of the next chain. As seen in the figure again, in the blockchain, every transaction made in the blocks is signed with a cryptographic signature or encryption. It is almost impossible to overcome the encryption process developed by the cryptography method. In addition, there is a time stamp for all transactions (Kılınç, 2020).

As can be understood from the above explanations, blockchain technology is an internet-based peer-to-peer network technology that uses cryptography. The peer-to-peer networks available within the system use a distributed application architecture that separates and shares peer-to-peer responsibilities joined to these networks. The network structure assumes that all users participate in the decision and task stages. In addition, this system provides all users joining the network with an identical copy of the datasets in which the information is recorded. The presented identical duplicate datasets are a summary of the operations in the entire process that have been performed before. By sharing the data sets with all users participating in the network in the blockchain operation and saving the data in many parts, it can be ensured that the users participating in the network do not have the opportunity to change their data sets unilaterally (Kılınç, 2020). With the 'trust protocol' provided by this technology, a safe, transparent and accountable space is formed (Tapscott & Tapscott, 2016). Blockchain, which is one of the systems that strive to integrate with energy systems, has recently started to be implemented in Turkey; It can be used in issues such as fault detection in energy units, cost accounting, billing, loss and leak detection, etc. (Büyükarıkan, 2021).

Transactions to be made using the blockchain infrastructure are seen by the computers on the network using the relevant software. Computers first confirm the validity of the transaction using complex algorithms. Confirmation is done by most computers verifying the transaction (consensus-consensus-unanimous). Confirmed transactions are encoded with a unique cipher to form a block. This process is called hashing. The new block is added to the previously created blocks in chronological order. Thus, the structure of the blockchain is renewed. The new chain formed later is recorded by all computers in the network (Gül, 2019)

Figure 2: Working Principle of Blockchain Technology



Source: (Are You Ready For Block Chain?, n.d)

3. DEVELOPMENT PROCESS OF BLOCKCHAIN TECHNOLOGY

In every period, data records and the use of these records have been important in order to maintain order in inter-communal relations. It has been important, especially in developing communities, that the relations between existing institutions and individuals should be regulated and that these rules should be recorded. The first study using the blockchain system was explained by Stuart Haber and W. Scott Stornetta in 1991. In this study, while protecting the confidentiality of documents, it aims to keep records in a retrospective time relationship as in the blockchain system. Later in 1992, in a second article published with the participation of Dave Bayer in Haber and Stornetta, they announced a new system that could report documents in a short time by including the cryptographic summarization function in the previous system and ensuring that the contents of the documents were not revealed (Aksu, 2021).

With the use of the Transmission Control Protocol/Internet Protocol (TCP/IP), which formed the infrastructure for the advancement of the Internet, in 1972, the foundations of blockchain technology were laid. Before TCP/IP, the telecommunications structure was based on 'circuit switching'. With TCP/IP technology, information is transmitted in very small packets that contain digitized address information. A public, shared network has been created without the need for any central authority responsible for the operation of this technology protocol. During the late 1980s and 1900s, companies such as Sun, NeXT, Hewlett-Packard, and Silicon Graphics used TCP/IP technology. It was becoming very advantageous for companies to operate on a low-cost, advantageous network structure that could be connected. So much so that CNET brought

its news to the Internet. Amazon has offered more books for sale from any bookstore, while Priceline and Expedia have streamlined the sale of airline tickets and brought unprecedented transparency. While the foundations of the network structure of the blockchain were laid in this way, Table 1 shows how it developed over time with which events (Carda, 2021).

Table 1: Development Process of Blockchain Technology

YEAR	WORK
1991	First work on secured chain of blocks
1992	Incorporated Merkle trres to the blockchain
2008	A core component of the digital currency bitcoin
2009	Bitcoin v0.1 released and announced on the cryptography mailing list and also first bitcoin transaction
2014	Bitcoin blockchain file size reached 20GB, blockchain 2.0 technologies go beyond transactions
2015	30GB
2016 to 2017	50 – 100 GB
	Pilot project based on the Nxt Blockchain 2.0 - blockchain-based automated voting systems
	An initiative of Chamber of Digital Commerce
	13.5% adoption rate within financial services

Source: (Lavanya, 2018)

The emergence of blockchain technology and the introduction of the first cryptocurrency, Bitcoin, are inextricably linked. In 2008, a study on "Bitcoin: A Peer-To-Peer Electronic Cash System" was published by a person (or a group) named Satoshi Nakamoto. In this published study, a peer-to-peer, distributed system where people can pay directly between each other is mentioned, and how the need for financial institutions or third parties can be eliminated by explaining Bitcoin, the first crypto currency, is explained. Although the blockchain technology made its name known with this study by Satoshi Nakamoto in 2008, the foundations of this technology actually date back to earlier times. Within the framework of all these developments, with the emergence of the financial crisis in the USA in 2008, the trust in financial institutions was shaken and since the 1990s, the works and thoughts of people who have been trying to find alternatives with encryption and other computer techniques for privacy and trust have been brought together and Bitcoin was introduced in 2008. Hal Finney, who has important work in cryptography and is a member of the Cypherpunk group, received 10 Bitcoin from Satoshi Nakamoto in 2009 and made the first Bitcoin transfer. Blockchain has been a technology that has been talked about and studied with increasing interest since the publication of the study (Dinçel, 2020).

4. TYPES OF BLOCKCHAIN

According to the blockchain permission mechanism, there are three types: public, private and consortium blockchains:

4.1. Open Blockchain (Public Blockchain)

In the open blockchain network system, anyone can participate in this network. The system is considered as a blockchain system that does not need a completely central authority. Ethereum and Bitcoin, which can provide the platform and programming language that can enable the use of smart contracts and allow developers to publish distributed applications, can be given as examples of this structure (Uysal & Kurt, 2018).

4.2. Private Blockchain

In the private blockchain system, only authorized users can join the network. Engagement in agreements within networks can be defined in public or permissioned styles. If the system is permission-based and those registered to this system can enter the reconciliation structures without permission, such system structures are called systems that require partial permission. In this network system, the central authority has the authority to change the rules and undo the transactions. It can be used for special system installation, cost reduction and productivity increase. Examples of private blockchain systems are shared software database providers using the blockchain technology system under the name Eris Industries and an open source distributed database provider for financial transactions with the name Multichain (Dinçel, 2020).

4.3. Consortium Blockchain

This blockchain network can be considered as a combination of public and private blockchain networks. They are systems in which nodes can be pre-selected by authorized persons or institutions. The data in the chain can be found in public or private form. This blockchain can be extended to a certain number of nodes with literacy capability in a blockchain. The consortium system is used by institutions or organizations that try to produce various models by coming together and cooperating with

each other. IBM's Hyperledger project is known as the most important example of the consortium chain type. In addition, the three types of blockchains described above are comparatively given in the table below (Ünal & Uluyol, 2020).

Table 2: Comparison of Blockchain Types

Characteristics	Public Blockchain	Private Blockchain	Consortium Blockchain
Permission Read	Public Class	Could be public or restricted	May be public or restricted
Determination of Consensus	All Miners	Only one organization	Designated set of nodes
Efficiency	Low	High	High
Immutability	Impossible to Tamper	Could be tampered	Could be tampered
Centralized	No	Yes	Partial
Consensus	Permissionless	Permissioned	Permissioned

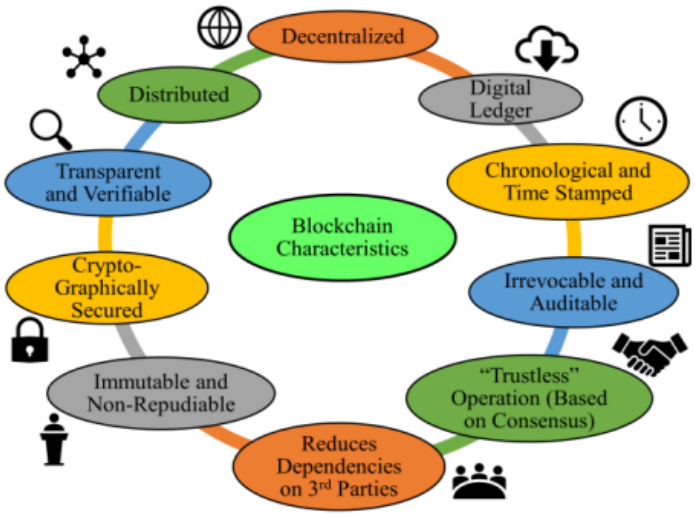
Source: (Hussain, Madni, & Shafie, 2019)

5. KEY FEATURES OF BLOCKCHAIN TECHNOLOGY

Blockchain technology has certain basic standards and is built on these criteria. These factors are explained in general below (Ünal & Uluyol, 2020).

- **Decentralization:** In the central operating systems, there is a need for a third party institution (for example, the central bank) to approve the transactions. Unlike this type of transactions, there is no other (third) party involved in transactions made on the blockchain. The approval process provided by the third party is carried out thanks to the algorithms in the initial block created in the blockchain and approved by the parties in question, allowing data consistency to be maintained (Onay, 2021).
- **Persistence:** Transactions made in blockchain technology are approved quickly. Transactions that are not valid at this stage will not be accepted. After being included in the blockchain system, it is almost impossible to undo or delete a transaction that has been performed and approved. Block discovery with invalid transactions is very simple, as there will be millions of users who have been confirmed to join the network.
- **Anonymity (Confidentiality):** It is ensured that every user in the system is entered into the system with an address that will prevent the disclosure of their identity, and it is also possible to ensure their interaction in the block chain with this address or user name.
- **Auditability:** With this feature, the system stores the balances of its users based on the transaction output model. As soon as the current transaction is recorded in the blockchain system, unspent transaction outputs turn into spent transaction outputs. With it, transactions become easily verifiable or traceable. (Kilinc, 2020).
- **Distributed:** The main feature of the blockchain is the ability to not keep data in one place, its ability to be recorded, stored and updated in a distributable format (Ünal & Uluyol, 2020). Distributed Ledger Structure The peer-to-peer distributed network allows for the historical classification of commercial transactions. A blockchain includes a distributed, highly accessible and secure proof of transaction (Uysal & Kurt, 2018).
- **Transparent:** With the blockchain system, data records are transparent at every node and the data can be verified retrospectively. For this reason, the blockchain system is considered reliable. In addition to these features, when the block chain technology is considered in its entirety, these technologies belonging to the system appear with their characteristic structures shown in Figure 3 below (Ünal & Uluyol, 2020).

Figure 3: Features of Blockchain



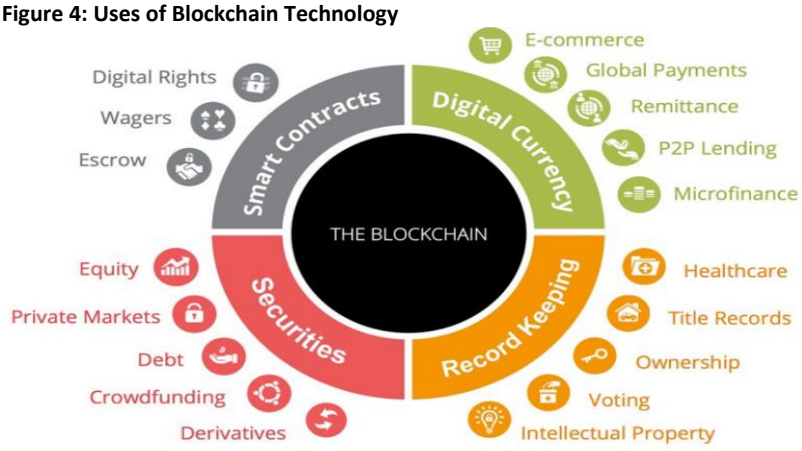
Source: (Puthal, Mohanty, Malik, & Kougianos, 2018)

The above-mentioned qualities can enable the system to be transformed into a storage medium on the basis of technology and to operate it without any central administration or authority controls. However, these features also constitute the parts of the system that receive the most criticism. Because, it brings with it important concerns about the operation of a system that cannot be controlled from both the enterprises and the state and about the access of each participant to the data. This, while using the development and advantages of blockchain technology, brings two basic classifications or application forms to the agenda (Uysal & Kurt, 2018).

6. BLOCKCHAIN USAGE AREAS

Due to the creation of an infrastructure that can develop the technologies of applications on the blockchain, this application is similar to the situation in the first formation of the internet. This technology, which is similar to the Internet, has been demanded by many sectors. However, not every work or every registration process in existing systems is suitable for the purpose of using the blockchain (Özyürek, 2021). Before making the decision to use the technology, it is necessary to determine the strengths and weaknesses of this system. The most important element of blockchain technology is its decentralized verification method. In this regard, it is demonstrated to be one of the most successful sectors where digital transformation is observed. The usage areas of blockchain technology can be summarized as shown: Finance, public service, health, supply chain, education and auditing.

Figure 4: Uses of Blockchain Technology



Source: (The Ohio State University, n.d)

Financial Services

It is widely and widely used in the financial sector through applications called virtual money. Examples of these applications are Bitcoin, Ethereum and Ripple etc. applications are displayed. Apart from virtual money applications, it is possible to come across blockchain applications in many areas. These; Currencies, Private and Government Equities, Bonds, Bonds, Future Contracts from Derivatives, Options, Swaps, Forwards etc. Voting Rights Attached to Financial Instruments, Commodities, Expenditure and Trade Records, Pledge-Mortgage/Credit Records, Service-Service Records, Crowdfunding, Micro Finance and Micro Assistance (Aksu, 2021).

Public Services

Public services are one of the areas where blockchain technology are being used extensively. The majority of government bodies are investing in blockchain technology in various sectors. According to the 2018 OECD study, whereas 26 countries launched 117 blockchain service initiatives and apps in 2017, 45 nations launched 202 initiatives and applications in 2018 (Tanriverdi, Uysal, & Üstünda, 2019). Laws and regulations, records of offending parties, passport and identity records, voting documents, title deeds, land records, records of automobiles, licenses, records of opening and closing of businesses, security and health inspections, weapons, construction permits and licenses, judicial and court records can be given as examples of areas that benefit from this system chain (Aksu, 2021). Government agencies can greatly benefit from instant and simultaneous access to a distributed database that stores records in public form. In financial transactions, each transaction can be taxed automatically because it is visible to the relevant tax offices and because the transfer of assets in this book is tracked. This transaction structure reduces the burden in terms of filing and auditing taxes and reduces the need for other intermediaries in the process (Ünal & Uluyol, 2020).

Health Services

It has a high level of potential to cope with the problems of interoperability of applications in the field of health. Blockchain can be utilized as a standard to securely communicate electronic health knowledge bases across parties such as healthcare facilities and pharmaceutical researchers (Tanriverdi, Uysal, & Üstünda, 2019). The most important problems in the health sector are the problems of selling counterfeit drugs and drug-based drugs without supervision. The drug needs to be audited as well as verified until it reaches patients from production. Thanks to the blockchain system, this transaction process has been systematized and facilitated. For example; Pharmaceutical packages leaving the factory can be authenticated and then time-stamped at each intermittent delivery point. During the drug distribution line, their identities are verified and the task of monitoring these drugs is ensured (Ünal & Uluyol, 2020).

Supply Chain

The supply chain system is another application area for the internet of things and blockchain technology. Food processing, transportation, logistics, and other industries may benefit from blockchain-based system automation, transparency, and security without the need for a third party. In their experiments, Xu et al. (2018) indicated that blockchain and RFID technologies may be utilized to monitor food quality and safety. According to the findings of a research done by Gökolan and Atalan (2022), the application of blockchain technology to traditional supply chain technology would result in a less expensive structure with the exit of more efficient and more intermediate organizations.

Education

According to the paper titled 'Innovating Pedagogy 2016' issued by the Open University in England, educational content, course credits, and certificate data may be saved and shared in a distributed framework using blockchain technology. The European Commission, on the other hand, produced a paper titled "Blockchain Education" in 2017. In this paper, blockchain technology is used for certification, lifelong learning, tuition fee payments, and student scholarship payments, among other things. Suggestions for field use are provided. Furthermore, participants can use the blockchain to manage all higher education institution applications and transactions, such as document verification. The certificate module, which is active inside the Moodle program, was coupled with the blockchain in Karataş's study, and digital certificates may be maintained within the blockchain (Dinçel, 2020).

7. THE USE OF BLOCK CHAIN IN AUDIT

The audit process first begins with the examination of the accuracy and validity of the transactions-records that are the source of the creation of financial information. This is a relatively long and laborious effort (Gül, 2019). Depending on the need for the continuous expansion of the activities of the enterprises, the need to outsource the financing has also arisen. For this reason, companies have to gain the trust of capital providers in order to reduce their capital costs. Capital providers, including lenders and investors, need financial data to monitor the financial position and performance of the firm to ensure the security of the capital they put in.

In addition, auditors are required to advance their work processes within the patterns of auditing standards by showing the necessary professional care and diligence. During the audit process, the auditors should answer with reasonable assurance,

necessary professionalism and impartiality, whether the financial information of the company complies with the principles and standards of accounting, whether it reflects the current situation of the company, whether there is an effective internal control mechanism (Kılınç, 2020). The main impact of blockchain technology on the audit profession is to reduce the cost of monitoring and control as blockchain technology becomes more common in organizations thanks to the reliability, transparency and timeliness of the data used in auditing (Cagle, 2020). This will be thanks to the real-time audit trail enabled by blockchain technology. Since the accuracy and accuracy of all transactions in the information systems will be time-stamped with real-time audit trails, the auditor can spend a significant part of his working time on performing other valuable steps of the audit process (similar to checking the internal control mechanism) instead of checking the authenticity or accuracy of these transactions. In addition, auditors can use the audit techniques they have used much more effectively and faster. For example, the auditor, who will use verification as audit techniques, will send the necessary documents to the customers of the firm in the audit process or the banks he works with, and will be able to carry out the audit processes with the feedback he receives. Even if these audit techniques are effective, they will be time consuming and will not enable the auditor to obtain objective data at all times. Instead, through public blockchain systems, the auditor will be able to easily examine the transactions he wants to examine through these systems.

The most important part that distinguishes blockchain technology from other technologies is that this technology is far from a centralized structure, as mentioned before. This helps to obtain completely objective data. Thanks to this, the audit risk will be reduced to the minimum level. Because with blockchain technology, it will be possible to detect or prevent fraudulent financial reports (Kılınç, 2020). Blockchain creates a more robust audit trail by using multiple sibling databases instead of a single and central database. Even if a block in a database is deleted, other databases synchronize themselves, fix the damaged database and undo the deletion (Gül, n.d). Confirming that a transaction has taken place is only one of the important aspects in a financial statement audit. Financial statement auditing also includes evaluating that recorded transactions are supported by relevant, reliable, objective, accurate and verifiable evidence (Bible et al., 2017).

One of the issues that blockchain technology will affect independent auditing is audit procedures or evidence collection techniques. Auditors can develop new audit procedures so that they can obtain audit evidence directly from the blockchain. The audit procedures specified in the independent auditing standard 500 have a retrospective nature (first financial statements, then book records and last documents). A small part of the financial data of the institution is taken as a sample and verification is provided. Then, a meaning is made for this sampled data set. Although the audit procedures are applied at the time of the audit activity, the transactions discussed in the sample belong to one year ago. It is foreseen that trend analysis, time series analysis and comparative evaluations can be made with continuous evidence collection (Dinçel, 2020). Auditors can use blockchain technology to automatically check the enormous number of transactions that create financial statements. For example, if all stock movement data is stored on the blockchain, auditors may calculate the stock balance remotely and in real time. As a result, the audit will progress in such a way that the auditors will be able to devote more time to other activities (Alarcon & Ng, 2018). Because blockchain allows transactions to be verified and audited without the need for a third party, it provides unparalleled clarity and confidence in internet-based transactions. As a result, portions of the audit process are effectively automated. Again, blockchain has the potential to improve the circulation of financial information (Gül, 2019).

Table 3: The Effect of Blockchain on Audit

1. Facilitation of Certification Services	The data recorded in IT is in an unchangeable structure because the auditor using the blockchain database can perform. This is a cost for the auditor but increases efficiency and time savings.
2. Supervision of All Transactions	The functionality of IT gives the auditor flexibility and accuracy since it provides an opportunity on the transactions where there is no need for sampling in the audit. Hence, it significantly increases the level of reasonable assurance.
3. Real-Time Audit	Blockchain-based accounting information systems enhance the approval of the transactions, and increase the ability for all users participating in the network. Hence, there will be no need to wait for the end of the period to carry out audit process, and audit activities can be carried out at any time.
4. Reduction in Transaction Risk	Distributed ledger structure of IT offers an advantage to add the transactions recorded in the blocks to the chain after they are approved by the parties where the risk of errors or omissions in the transactions are reduced. Therefore, the parties participating in the network transactions not agreed can not be approved.
5. Irreversibility - Irreversibility	Transactions recorded and confirmed in blocks can no longer be changed and cannot be reversed. However, in case of a faulty transaction, adding a new block with a correction to the chain can easily eliminate the problem.
6. Changing the Traditional Understanding of Control	With all these features of IT and the benefits blockhain provides, auditors enhance a better view on the businesses. New auditing models can be explored in auditing studies.

Source: (Kılınç, 2020).

8. CONCLUSION

Today, with digitalization, the way businesses do business is changing and businesses need to keep up with the change. Incorporating new technologies into existing business processes is no longer a choice but a necessity. By understanding the requirements of these technologies by the business management and with the regulations of this technology by the legislators, the highest level of efficiency will be achieved from the blockchain technology. With the increasing number of blockchain technology, the existing risks both continue and new technology brings new risks. This technology inevitably affects audit activities as it does all sectors. Businesses should identify these risks and take the necessary precautions. Internal audit departments should develop themselves on blockchain, and businesses should allocate an additional budget for those working in this department and ensure that they receive training on this subject. Thanks to the immutable, decentralized, transparency and timestamping features of the blockchain, data security is ensured and data manipulation is seriously prevented. As a result, it is expected that many sectors from the banking and finance sector, logistics and supply chain to the health sector will be affected, especially cost and time savings, with the blockchain technology that has emerged to question the need for intermediary institutions that provide trust and to show that there is no need for trust in intermediary institutions.

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RELATIONSHIP BETWEEN COVID-19 AND MONEY SUPPLY IN TURKEY: EVIDENCE FROM ARDL BOUNDS TESTING APPROACH

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ABSTRACT

Purpose- COVID-19 has been a devastating process. During this period, there was a significant increase in the money supply. So, in this process, is there a relationship between COVID-19 and the money supply? This study intends to investigate if COVID-19 and the money supply have both a short- and long-term relationship.

Methodology- Logarithmic conversions were used to examine the number of COVID-19 new cases obtained from the Association of Public Health Professionals (HASUDER) and the Turkey Republic Ministry of Health, as well as M2 weekly money supply data from the Central Bank of the Republic of Turkey (CBRT) Electronic Data Distribution System (EVDS). For stationarity tests, the Augmented Dickey-Fuller (ADF), Phillips Perron (PP), and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root tests were used. Due to the different degrees of stationarity of the series, cointegration was not possible, so the long-term relationship was evaluated using Autoregressive Distributed Lag (ARDL). Short-term analyzes included the VAR Model and the Granger Causality Test.

Findings- COVID-19 and the money supply, according to the findings, are not cointegrated in the long term. It has been discovered that the series do not move together over the long run. But in the short term, COVID-19 is a Granger cause of the money supply.

Conclusion- The increase in COVID-19 cases positively affects the money supply. An increase in the money supply also leads to inflation. Therefore, in order to cope with the inflationary process triggered by the pandemic, measures to prevent the increase in COVID-19 cases are important. These findings will be "confirming" in the design of policies in this process. This study is also a contribution to the literature due to the lack of studies investigating the response of the money supply to COVID-19.

Keywords: Covid-19, money supply, ARDL bounds testing approach, VAR model, Granger Causality.
JEL Codes: E51, E52, I15, I18, C22

1. INTRODUCTION

In December 2019, a new form of coronavirus was discovered in Wuhan, China, and the virus rapidly spread worldwide. COVID-19 was declared as a pandemic on March 11, 2020 (WHO, 2020). According to studies, the mutated virus is more deadly and spreads faster. On April 6, 2021, the total number of confirmed cases around the world was approximately 132.5 million, up 15%, while the death toll was approximately 2.9 million, up 37% (WHO) (Figure 1). The economic consequences of the epidemic are spreading at least as quickly as the epidemic itself, thanks to globalization. Following the announcement of COVID-19 as a pandemic, in addition to public health, COVID-19 has caused deepening effects in many economic areas from growth to unemployment and social welfare.

COVID-19, which started as a health problem and spread rapidly all over the world, brought a global depression with it. Following the shock of uncertainty, the efforts to hold onto life and prevent the pandemic brought various restrictions with it. While these restrictions led to firm shutdowns and bankruptcies, they caused mass unemployment and global economic problems (Çiğdem, 2020). These economic problems create a domino effect due to the interdependence between countries (Ugarteche and Ocampo,

2020), and they are becoming widespread through the aggravation of contractions in global trade, and the decline of aggregate demand on a global scale (Buchholz, 2020). The disrupted global production chains caused an unprecedented deep contraction in world trade volume and major decreases in the Gross Domestic Product (GDP) of the countries (Saad-Filho, 2020; Taymaz, 2020). The crisis created by the pandemic is based on mechanisms very different from the crises experienced before. The starting point of this crisis;

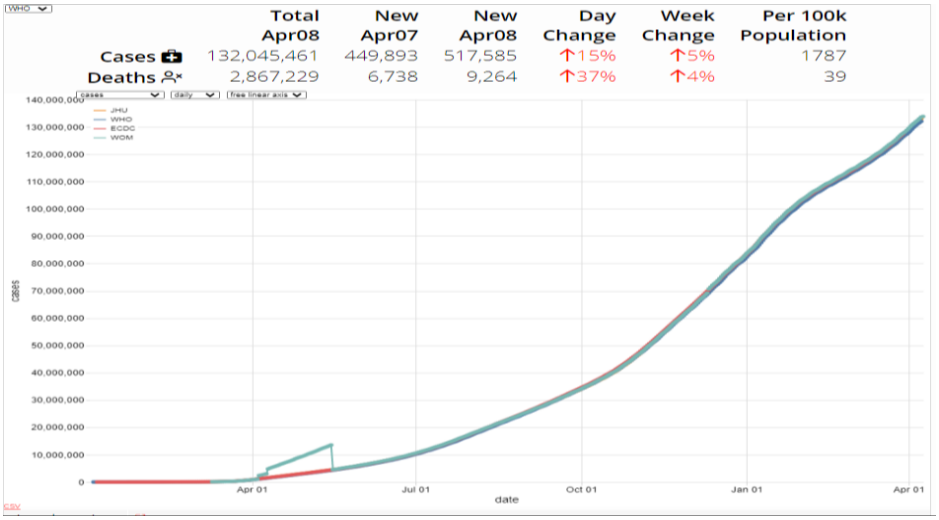
i. Cessation of activities in some sectors as a result of restrictions,

ii. Contraction in demand due to loss of income,

iii. The damage in chains and the supply system and employment losses, the damage in chains and the supply system and employment losses, and

iv. In financial markets, they are experienced simultaneously due to the collapse in asset values and commodity prices (Voyvoda and Yeldan, 2020).

Figure 1: COVID-19 Cases and Deaths Globally (WHO)



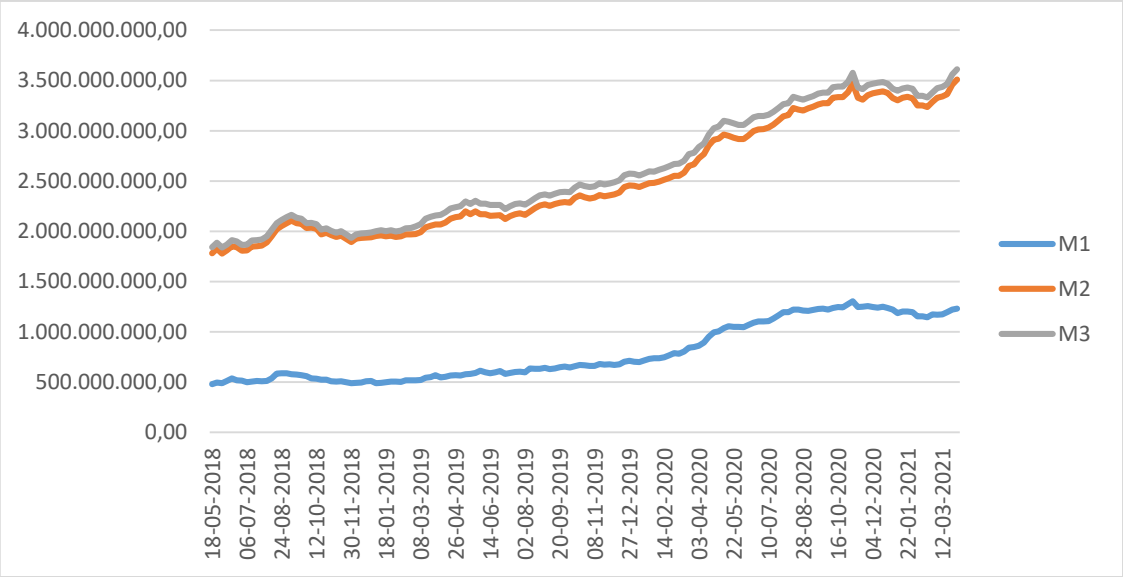
Source: World Health Organization (WHO).

COVID-19 sparked the most severe and deepest economic downturn in capitalism's history (Roubini, 2020). Under these conditions, countries implement fiscal, financial, and monetary measures to stabilize financial markets or ensure economic stability, and transfer liquidity to the markets (Elgin et al., 2020; Ugarteche and Ocampo, 2020). The process that started with COVID-19 brought a supply and demand shock with it. While the rupture of global supply chains affected the economy from the supply side, mass unemployment and loss of income affected the demand side. As a consequence of production chains' negative effects on the supply side, and consumption and investment expenditures on the demand side, COVID-19 further clarifies the ongoing recession process. In this environment, the COVID-19 Crisis affects Turkey's economy in a conjuncture in which the effects of the financial crisis of 2018 is not resolved literally (Voyvoda and Yeldan, 2020). In the face of the uncertainty created by the pandemic, whose rate of transmission has increased and is more deadly, although it has only been a year since its identification, country administrators have used different methods in combating COVID-19. Different methods brought different results. The most prominent common policy that countries have turned to has been monetary expansion.

The response of the money supply to COVID-19 and the growing inflation anxiety have not yet received sufficient attention from the researchers in the environment of uncertainty we are in. The fact that the COVID-19 process is still ongoing, as well as a lack of sufficient data, could also be factors. As a result, there is currently no established literature. Anser et al. (2021) used a cross-sectional panel in their empirical study covering 115 countries to investigate the response of the money supply to COVID-19. The study also employed innovation accounting techniques and robust least square regression. According to the findings, infected cases were the primary factor reducing the money supply. On the other hand, Saito (2021) analyzed the components of the money supply that had increased rapidly in Japan since mid-2020 and found that this increase was due to the increase in deposit money.

This increase resulted from the growth of deposits held by individuals and non-financial firms. The encouragement of bank loans, which is among the measures taken by the central bank of Japan during the pandemic process, increased bank loans. Increasing loans brought about an increase in the number of deposits. As a result, "the Helicopter Money" type of measures increased the money supply.

Figure 2: Money Supply in Turkey



Turkey has also admitted to the monetary expansion process in the COVID-19, 2019 at the end of December, which is about TL 2.5 trillion per defined M3 money supply has increased to approximately TL 3.6 trillion (Figure 2). This research aims to test empirically whether COVID-19 affects monetary expansion. The research's conceptual framework will be created first. Following that, the methodological framework will be explained. In the final section, we'll talk about the conclusions we came to from the analysis we used.

2. CONCEPTUAL FRAMEWORK OF THE MONEY SUPPLY AND ITS RESPONSE TO COVID-19

The money supply is the amount of money in circulation in a given economy at a given time (Eğilmez, 2018); a total of banknotes, coins, deposits of households and firms in circulation (CBRT, 2013). The control of the money supply, which is an effective tool of monetary policy, is in the hands of the central banks. Central Banks determine the policy rate by increasing/decreasing the money supply. The determined interest rates also affect the total expenditures. Using the money supply, central banks affect economic activity and inflation. As the inflation problem came to the fore after the 1960s, there were changes in the choice of indicators, money definitions, and determination of targets (Parasız, 2003). The money supply can be measured in a variety of ways, but in general, the money supply is classified as narrow money supply and broad money supply. The narrowest money supply, M0 (Equation 1) and M1 (Equation 2) form the narrowly defined money supply. The large money supply is also measured through the M2 and M3 channels.

Since M1 (Equation 2), which is known as the sum of money with a narrow scope, excludes money-like amounts as a result of economic developments, a broader money supply definition has become required, and M1's scope has been extended and M2 established. The M2 money supply also includes payment instruments with weaker liquid properties than M1. M2 is the sum of savings and short-term deposits in addition to M1 (Equation 3). M2 has come to the fore as an important factor in defining the money supply. Friedman suggested that M2 be the basis for controlling money supply (Orhan and Erdoğan, 2002).

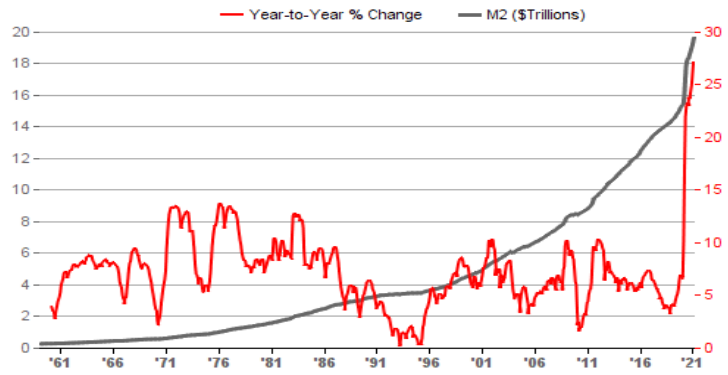
M0= Money in Circulation (Banknote + Coin) - Cash in bank vaults (1)

M1= Money in Circulation (Banknote + Coin) + Demand Deposit (TL, Foreign Currency) (2)

M2= M1 + Time Deposit (TL, Foreign Currency) (3)

Identification and measurement of money are extremely important. The changes in the amount of money are a critical factor in determining the course of economic variables. Price stability, the balance of payments, and economic growth are all affected by adjustments in monetary growth, either directly or indirectly (Orhan and Erdoğan, 2002). Therefore, the money supply is a frequently used tool. The growth in the world's money supply (in the Australia, China, Europe, Japan, and USA) increased by 14%, which is quite high compared to the past (Mousina, 2020). This expansion is thought to be related to the rapid spread of COVID-19 around the world, as well as the measures put in place. However, there hasn't been enough empirical research done on the subject.

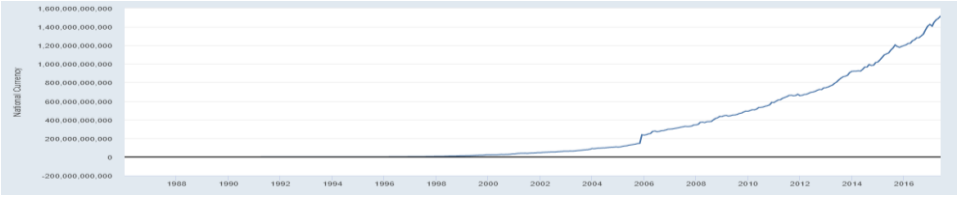
Figure 3: M2 Money Supply, Monthly Average Seasonally Adjusted (1959:01-2021:02)



Source: Shadow Government Statistics (www.shadowstats.com).

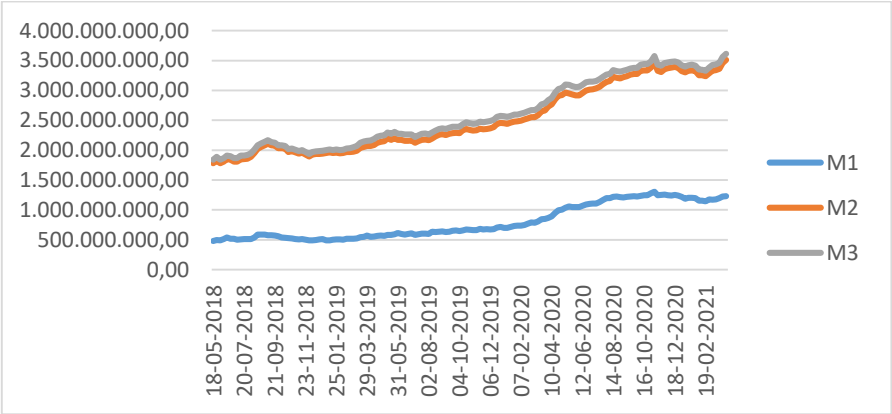
Figure 3 shows strikingly the money supply's response to COVID-19 in the USA. While Figure 4 shows the historical process of the money supply in Turkey, Figure 4 shows the shift in Turkey's money supply during the COVID-19 process. Accordingly, the beginning of an upward trend in money supply in the 2000s in Turkey, it is observed that increases in pandemic period.

Figure 4: M2 Money Supply in Turkey



Source: International Monetary Fund (IMF).

Figure 5: Money Supply in Turkey During COVID-19



As can be seen from Figure 5, M2 and M3 money supplies were 2.45 and 2.57 trillion TL, respectively, at the end of December 2019, when COVID-19 emerged, and as of April 2, 2021, these figures reached 3.5 and 3.61 trillion TL, respectively. Is this increase in money supply directly related to COVID-19? This question will be analyzed empirically in the next section.

3. DATA, METHODOLOGY AND EMPIRICAL RESULTS

To question the relationship between money supply and COVID-19 in Turkey, the number of new cases daily data were obtained from Association of Public Health Professionals (HASUDER) and the Ministry of Health and were converted to weekly data. Based on Friedman's advice, weekly M2 money supply data was provided from the Central Bank of the Republic of Turkey (CBTR) electronic data distribution system (EDDS), and subjected to analyses. Table 1 shows the variables used in the analysis, their abbreviations used and the sources obtained. COVID-19 data starting from the date of the first cases seen in Turkey as of March 11, 2020, and includes 52 observations between 13.03.2020-05.03.2021. The M2 money supply is based on billion TL, to reduce the size and stabilize it, the series will be analyzed by taking their logarithms.

Table 1: Variables

Variable Name	Data Frequency	Code	Unit	Source
COVID-19 New Cases	Annually	COVID	Ratio	HASUDER, TR Ministry of Health
M2	Annually	M2	Ratio	Central Bank of Republic of Turkey

Before starting the analysis, the graph was examined and whether the variables had a trend or not.

Figure 6: Time Path Plots of COVID-19

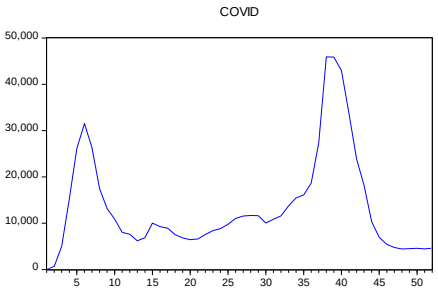
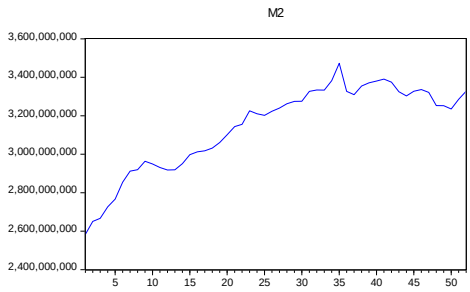


Figure 6: Time Path Plots of Money Supply



Figures 6 and 7 show that the COVID-19 variable does not have a trend, while the M2 money supply variable has a trending structure. This will be taken into account during the series' stationarity checks.

3.1. Theory

In this section, theoretical details about econometric methods used in analysis will be given.

3.1.1. Unit Root Tests

The unit-roots of variables are the first and most critical step. The degree of stationary of time series was determined using the Augmented Dickey-Fuller (ADF) and Philip-Perron (PP) unit root tests, which are the most widely used and widely accepted stagnation tests in the literature (Enders, 1995) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root test.

ADF and PP unit root tests include the following hypotheses in which the alternative hypothesis is that the assertion that the series is stationary is tested.

H_0: The time series is not stationary

H_1: The time series is stationary

In the Augmented Dickey-Fuller (Augmented Dickey Fuller-ADF) test developed by Dickey and Fuller (1981), the following equations (10) and (11) (with constant and constant trend) were estimated for the ADF test (Dickey and Fuller, 1981).

$$\Delta X_t = \beta_0 + \beta_1 X_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta X_{t-i} + u_t \quad (10)$$

$$\Delta Xt = \beta_0 + \beta_1 X_{t-1} + \beta_2 \text{ trend} + \sum_{i=1}^{k} \lambda i \Delta X_{t-i} + u_t \quad (11)$$

In the equations, X; the series under consideration, Δ; difference operator and *k*; dependent variable delays added to the equation, β and λ parameters, trend; linear time trend and u_t; represents the error term.

The Phillips and Perron unit root test was also used in the analysis to remove the ADF test's flaws and establish an alternative. Phillips and Perron (1988) developed the Dickey-Fuller method and developed the PP test based on more moderate assumptions in the distribution of errors (Çil Yavuz, 2015).

The PP test has hypothesis tests that are identical to the ADF and are expressed in the equations below (Phillips and Perron, 1988):

$$y_t=\hat{\mu}+\hat{\alpha}y_{t-1}+\hat{u}_t \quad (12)$$

$$y_t=\tilde{\mu}+\tilde{\beta}\left(t-\frac{1}{2}\lambda\right)+\tilde{\alpha}y_{t-1}+\tilde{u}_t \quad (13)$$

If the test statistic in both tests is greater than the critical values, the null hypothesis of the unit root is rejected.

Schwert (1989) revealed that the ADF unit root test is weak and sensitive to lag length selection. It is assumed to be no trend. In this context, the KPSS Unit Root Test, which was introduced into the literature by Kwiatkowski, Phillips, Schmidt, and Shin (1992), is more powerful. The KPSS test is based on the models below;

$y_t=\alpha+ +\varepsilon_t$ (14)

$y_t=\alpha+ \beta_t + \mu_t +\varepsilon_t$ (15)

$$\mu_t = \mu_{t-1} + \mu_t \qquad \mu_t \sim IID(0, \sigma_u^2) \quad (16)$$

In equation number 14, α includes the constant term, in equation number 15 it includes both the constant term and the deterministic trend. Although ε_t is stationary time, it may also have heteroscedasticity (Equations 14, 15). μ_t is a pure random walk model. The fact that y_t is a stationary process forms the basic hypothesis (Çil Yavuz, 2015) and is the reverse of the ADF unit root hypothesis.

H_0: $\sigma_u^2 = 0\ (stationary)$ (17)

H_1: $\sigma_u^2 = 0\ (stationary)$ (18)

3.1.2. Autoregressive Distributed Lag Model (ARDL)

The results of the analysis show that the sequence is stationary at different levels. In the ARDL test developed by Pesaran et al. (2001); the cointegration relationship of series which are at different levels can be questioned. Variables still need to be tested against the possibility of being stationary I2 in the second difference. In the second difference, ARDL model cannot be applied in stationary variables. Small samples can produce healthy and successful results in the ARDL test, which can be combined with long-run equilibrium error correction (ECM) and short-run dynamics.

"H_0: No cointegration between variables", as a result, ignoring the H_0 hypothesis demonstrates the existence of such a cointegration. H_0 is rejected if the F statistic bigger than the critical upper limit. H_0 is accepted when the F statistic smaller than the critical lower value. Other cointegration tests should be considered where the F statistic is between the upper critical value and lower critical value, as there is insufficient evidence to reject or fail to reject the H_0 hypothesis (Pesaran et al., 2001).

3.1.3. VAR Model

Vector autoregressive models (VAR), which are the generalized form of autoregressive models for more than one variable, have been developed as an alternative to the traditional simultaneous equation system and brought to the literature by Sims (1980). VAR model allows making predictions for more than one variable (Çil Yavuz, 2015). The VAR model is a preferred model in time series because it does not impose any restrictions and can give dynamic relationships (Keating, 1990). The Granger causality test model is the foundation of the model. If the model contains two endogenous variables, each is correlated with both its own and the lagged values of the other endogenous variable up to a certain period.

$$Y_t = \alpha + \sum_{j=1}^{m} \beta_j Y_{t-j} + \sum_{j=1}^{m} \delta_j X_{t-j} + \varepsilon_{1t} \quad (19)$$

$$X_t = \alpha + \sum_{j=1}^{m} \theta_j Y_{t-j} + \sum_{j=1}^{m} \vartheta_j X_{t-j} + \varepsilon_{2t} \quad (20)$$

When the lagged values of the dependent variables are used in the VAR model, it is possible to make accurate predictions (Kumar et al., 1995). The relationship between series can be revealed by correlations obtained as a result of these strong predictions. For the VAR model to be used for a structural analysis, three techniques are required;

i.Granger Causality Test,

ii. Impact-Response Analysis and

iii. Variance Decomposition.

3.1.4. Granger Causality Test

Due to its ease of use, it is a widely used test developed by Granger (1969) and Sims (1972) that determines the direction of the relationship between variables. One of the uses of VAR models is; it is to predict the future and provides information about predictive adequacy. The predictive adequacy of a variable is based on Granger (1969).

3.1.5. Variance Decomposition and Impact-Response Analysis

Variance decomposition "shows the rates of shocks originating from the other variable against shocks caused by itself of a series" (Çil Yavuz, 2015). If it explains the value of nearly 100 percent of the change in variance on its own, it is considered as an "exogenous variable". In this analysis, the ordering of variables is done from exogenous to endogeneous. Variance decomposition is the second function targeted in VAR. It can also be used as a side assessment about whether the variables are endogenous or exogeneous (Tarı, 2006).

Impulse-response functions are obtained after finding the appropriate lag lengths in the VAR model. With the support of tables and graphics, impact-response functions expose the shocks and their impact on variables and when they will lose their influence. This analysis demonstrates how the variables react to shocks.

In analyzing the relationships between economic variables, variance decomposition and impact-response analysis are very useful tools. In the literature, using these two analyses together is known as shock accounting (as quoted in Enders: Çil Yavuz, 2015).

3.2. Empirical Findings

This section contains the empirical findings of the research. ADF, PP, and KPSS tests were used in stationarity tests, which is the first and mandatory step in the analyzes, and the analysis results are shown in Table 2;

Table 2: ADF, PP, and KPSS Unit Root Test Results

Variables	**ADF**			
	Test Statistic	**%1**	**%5**	**%10**
LNCOVID, *Level*	-1.801869	-3.568308	-2.921175	-2.598551
LNCOVID, *1st diff*	-18.42789	-3.568308	-2.921175	-2.598551
LNM2, *level*	-2.172751	-4.148465	-3.500495	-3.179617
LNM2, *1st diff*	-5.312501	-4.156734	-3.504330	-3.181826
Variables	**PP**			
	Test Statistic	**%1**	**%5**	**%10**
LNCOVID, *Level*	-7.423539	-3.565430	-2.919952	-2.597905
LNM2, *level*	-2.169650	-4.148465	-3.500495	-3.179617
LNM2, *1st diff*	-6.633331	-4.152511	-3.502373	-3.180699
Variables	**KPSS**			
	Test Statistic	**%1**	**%5**	**%10**
LNCOVID, *Level*	0.224599	0.739000	0.463000	0.347000
LNM2, *level*	0.231968	0.216000	0.146000	0.119000

Note: In ADF research, the number of lags is determined using the Schwarz criteria, which is a more efficient criterion that produces better results than the others. The number of lags found in conjunction with Newey-West Bandwith is received in the Phillips Perron tests. The maximum lag length is nine.

Different results (ADF I_1; PP and KPSS I_0) were obtained as a result of the unit root analysis applied to LNCOVID. Since the KPSS test has higher power, it was determined that LNCOVID was stationary at the I_0 level because the results of this test, as well as the PP test, were both I_0. According to the results of all three studies, LNM2 is stationary at the I_1 level. Due to the different stationarity levels of the series, cointegration tests could not be achieved.

The series' long-term relationship was investigated using ARDL Bounds Test, and LNM2 was taken as the dependent variable because the stationarity test result was I_1. The results obtained are shown in Table 3.

Table 3: ARDL Bounds Test Results

Predicted Equality		
F Statistic	4.324785	
Significance Level	Critical Value	
	Lower Value	Upper Limit
%1	7.435	8.46
%5	5.125	6.045
%10	4.155	4.925

Dependent Variable: LNM2.

In case LNM2 is the dependent variable, it has been determined that there is no cointegrated relationship between the series (F statistics<Lower Value 5%). In the long term, it has been determined that the series do not move together.

Table 4: Error Correction Model (ECM) and Long Run Coefficients

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1.522404	0.510783	2.980529	0.0045
D(LNCOVID)	0.005258	0.002013	2.611814	0.0121
CointEq(-1)*	-0.070515	0.023725	-2.972138	0.0047
	Value	Signif.	I_0	I_1
t-Statistic	-2.972138	10%	-2,57	-2,91
		5%	-2,86	-3,22
		1%	-3,43	-3,82
Long-Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNCOVID	0.036754	0.035577	1.033095	0.3068

Dependent Variable: LNM2.

In the analysis of the short-term relationship, the error correction model obtained from the ARDL model was used. The results regarding the model are shown in Table 4.

It is seen that the error correction coefficient is negative and statistically significant as expected (0.0047 <0.05). In addition, t-Statistic is also significant at 10% level (2.972138> 2.91). It is understood that the established model meets the requirements for the ARDL Bounds Test.

A deviation from a short-term balance reaches the long-term balance after 14.18 (1/0.070515=14.18) weeks.

When COVID-19 increases by 1%, LNM2 increases by 0.036754%, but the coefficient is not statistically significant (0.3068> 0.05). The sign of the long-term coefficient shows that COVID positively affects M2.

CUSUM and CUSUM Square graphs were used to investigate the presence of structural breaks related to variables (Fig.8, 9).

Figure 8: CUSUM Test

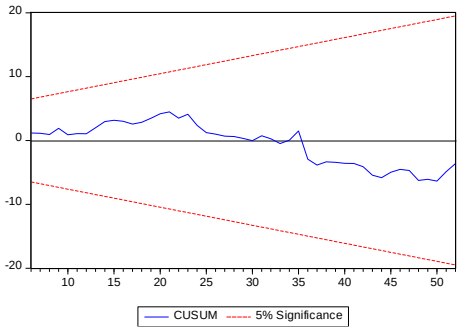
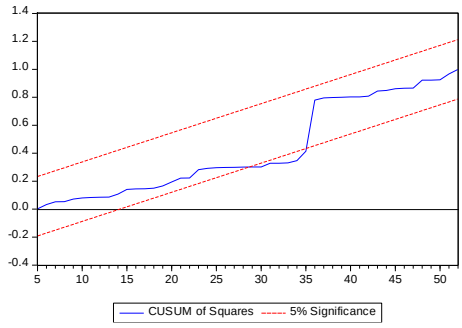


Figure 9: CUSUM Suqare Test



A break in the CUSUM Square graph was observed when the residuals of the variables were examined, but it was ignored due to the absence of any break in the CUSUM graph.VAR model was applied for short-term analysis between variables. First of all, the series has been made stationary. The appropriate lag length is decided (Table 5) and the VAR model was estimated.

Table 5: Determining the VAR Model Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	148.8721	NA	6.62e-06	-6.249878	-6.171149	-6.220252
1	165.0244	30.24248*	3.95e-06*	-6.766995*	-6.530806*	-6.678115*
2	167.6503	4.693055	4.19e-06	-6.708521	-6.314873	-6.560389
3	171.8785	7.197088	4.16e-06	-6.718236	-6.167128	-6.510850
4	173.7210	2.979303	4.59e-06	-6.626426	-5.917859	-6.359787

The appropriate lag length is decided as 1 as shown in Table 5. The VAR model should meet certain econometric assumptions based on this lag length. Four assumptions must be met for this VAR model to be accurate and usable;

1) There should be no autocorrelation,

2) There should be no heteroscedasticity problem,

3) Remains of the VAR model should conform to normal distribution, and

4) The obtained AR roots must be in the unit circle.

Since the heteroscedasticity problem emerged in the tests, the problem was eliminated by taking the lag length as 2. Analysis results testing whether there is a deviation from the assumption obtained with 2 lag lengths are given in Table 6;

Table 6: Autocorrelation

Null hypothesis: No serial correlation at lags 1 to h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	2.407513	4	0.6613	0.603335	(4, 82.0)	0.6613
2	8.933202	8	0.3480	1.136829	(8, 78.0)	0.3485

*Edgeworth expansion corrected likelihood ratio statistic.

According to the results seen in Table 6, since the probability value is greater than 0.01, there is no autocorrelation problem.

Table 7: Heteroscedasticity

Joint test:		
Chi-sq	df	Prob.
22.47520	24	0.5509

Since the probability value (0.5509) is greater than the critical value (0.05), H_0 cannot be rejected, the constant variance is valid, there is no heteroscedasticity problem (Table 7).

Table 8: Normality Test

Component	Jarque-Bera	df	Prob.
1	70.16381	2	0.0000
2	2.925638	2	0.2316
Joint	73.08945	4	0.0000

H_0 was rejected because the probability value (0.0000) was less than the critical value (0.05) (Table 8). And, the remains of the VAR model were not normally distributed, so the Kolmogorov-Smirnov Test was used. Table 9 shows the outcome of the tests.

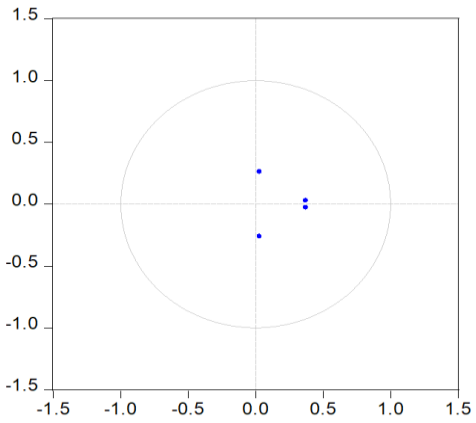
Table 9: Kolmogorov-Smirnov Test Results

		VAR00001
N		52
Normal Parameters [a,b]	Mean	.0000
	Std. Deviation	.07086
Most Extreme	Absolute	.178
Diferences	Positive	.122
	Negative	-.178
Kolmogorov-Smirnov Z		1.280
Asymp. Sig. (2-tailed		.075

[a] Test distribution is Normal.
[b] Calculated from data.

Since the probability value of the Kolmogorov-Smirnov Test (0.075) is higher than the critical value (0.05), it is seen that the model's residues are normally distributed (Table 9).

Figure 10: Inverse Roots of AR Characteristic Polynomial



Inverse roots are in the unit circle, as shown in Figure 10. As a result, the VAR model can be defined as stable, or a stationary model. The Granger Causality Test (Granger, 1980; 1981) was conducted to determine whether the variables affect each other.

Table 10: VAR/Granger Causality Analysis Results

Dependent variable: DLNM2

Excluded	Chi-sq	df	Prob.
DLNCOVID	6.384049	2	0.0411

Dependent variable: DLNCOVID

Excluded	Chi-sq	df	Prob.
DLNM2	3.914695	2	0.1412

As demonstrated from Table 10; the calculated probability value (0.0411) is less than the critical value (0.05), H_0 is rejected, a causality relationship from COVID-19 to the money supply has been determined. So COVID is a Granger cause of the money supply (M2) (Fig. 11).

Figure 11: Granger Causality Analysis Results.

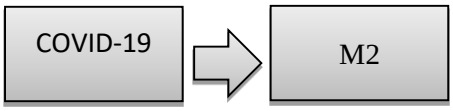


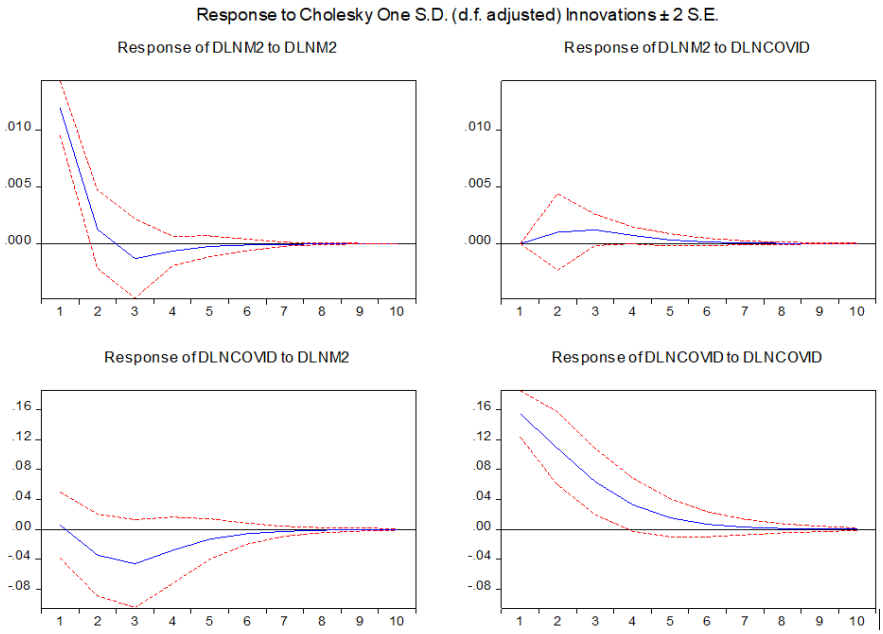
Table 11: Variance Decomposition Results

	Variance Decomposition of DLNM2			Variance Decomposition of DLNCOVID		
Period	S.E.	DLNM2	DLNCOVID	S.E.	DLNM2	DLNCOVID
1	0.011936	100.0000	0.000000	0.154278	0.141046	99.85895
2	0.012046	99.29625	0.703749	0.191409	3.270396	96.72960
3	0.012178	98.31665	1.683350	0.206874	7.715943	92.28406
4	0.012217	97.98006	2.019940	0.211348	9.130632	90.86937
5	0.012224	97.90869	2.091313	0.212305	9.416487	90.58351
6	0.012225	97.89463	2.105373	0.212492	9.472410	90.52759
7	0.012225	97.89182	2.108181	0.212527	9.483803	90.51620
8	0.012225	97.89129	2.108711	0.212534	9.485986	90.51401
9	0.012225	97.89120	2.108803	0.212535	9.486369	90.51363
10	0.012225	97.89118	2.108819	0.212535	9.486433	90.51357

The money supply can explain the whole variance (100%) by itself in the short run. The rate that can be explained by money supply falls to 97.89 percent at the end of the tenth period, while the rate that can be explained by COVID-19 increases to 2.11 percent (Table 11).

99.86% of the variance of COVID-19 is explained by itself in the short term. At the end of the 10th period, the rate that can be explained by the money supply increases to 9.49 (Table 11). Impulse-response functions were used to determine the response of the variables, despite a standard error shock given to the variables (Fig. 12).

Figure 12: Impact-Response Analysis Results



Following our analysis that we found that COVID-19 is a Granger cause of the money supply, we take into account the second graph in Fig. 11; accordingly, a standard deviation shock to COVID-19, the money supply (M2) will increasingly react and this increase will continue until the 2nd period. After the 2nd period, it will begin to decrease and the effect of this shock will decrease and disappear in the 8th period.

4. CONCLUSION

This research aims to see if there is a relationship between COVID-19, which is responsible for the deepest recession in capitalism's history, and the rise in the money supply that occurs as a result of it. The Association of Public Health Professionals (HASUDER) provided daily new case numbers for this reason. The weekly numbers were derived from this. Weekly M2 money supply data have also been obtained from the CBRT. Various analyzes have been applied by taking the logarithms of the series. First, the Augmented Dickey-Fuller (ADF), Philip-Perron (PP) unit root tests, and KPSS unit root tests were used to determine stationarity. Because of the different stability levels, cointegration could not be used, so the ARDL Bounds Test and VAR Model were used instead. The money supply variable was used as a dependent variable in the analyses since the stationary level is I1. The study discovered that COVID-19 and the money supply are not cointegrated in the long run. COVID-19, on the other hand, has been determined as a short-term Granger cause of the money supply. The rise in COVID-19 cases has a positive impact on the money supply. This result does not coincide with the study findings of Anser et al. (2021). Since an increase in the money supply often leads to inflation, policies and procedures should be designed accordingly.

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