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The Effect of the Pandemic on the RMG Export of Bangladesh: Exploring the Economic Channels of Transmission

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This study aims to empirically analyse the potential long-run and short-run effects of the COVID-19 pandemic on the ready-made garments (RMG) export growth of Bangladesh. We distinguish two transmission channels: credit growth and degree of openness to trade, through which the pandemic could affect the RMG export, using monthly time series data from June 2009 to August 2020. We employ a bounds test approach to the autoregressive distributed lag (ARDL) cointegration method. The bounds test specifies long-run and short-run relationships between credit growth, openness, and RMG exports. We found that the pandemic has a significant negative effect in the short run but a positive impact on export through these transmission channels in the long run. Thus, more credit support to this sector and opening up the economy for international trade is essential for the total recovery of the RMG export.

Key Words: ready-made garments (RMG), COVID-19 pandemic, export, Bangladesh
JEL Classification: I18, F14, L69

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Introduction

The RMG (ready-made garments) sector remains the key driver of the economic growth of Bangladesh. The sector is the largest source of export proceeds, foreign exchange reserve, and manufacturing and women's employment. The sector's contribution to the economy is almost 11.2% of the total GDP and accounts for 84% of the total export. The total market share of Bangladesh in the worldwide RMG export is approximately 6.5%, and the country continually secures the title of the second-largest exporter in RMG trading. The country aimed to increase the total apparel export by 2021, which is 8–10% of the global RMG trading and circa USD

50 billion of the export target (Akter 2020). Confronting all regional and global crises, the growth trend of RMG export is increasing.

However, the years 2020 and onwards have been critical for the RMG sector of Bangladesh. The COVID-19 pandemic and the shutdown of domestic and the European and North American markets caused enormous difficulty in maintaining this current growth pace and achieving the desired target of export growth. To minimize the unprecedented humanitarian devastation, the government declared a nationwide holiday and shut down all business and industrial activities for 62 days. Many international importers cancelled their confirmed buying orders ($3.16 billion worth) as their business units and retail outlets were closed, mainly in the EU, USA, Asia, and elsewhere due to the pandemic. The demand for Bangladeshi RMG products is 62% in EU markets alone, 21% in the USA and Canada, with the remaining portion in other countries (UNICEF 2020).

The adverse impact of COVID-19 is not limited to the RMG sector; its spillover effect has spread to other industries, consumers, and service sectors. A large number of backward linkage capital-intensive industries, such as yarn and fabric suppliers, have been affected gravely. Almost 425 yarn manufacturing, 796 fabric production, and 240 dyeing-printing-finishing enterprises and accessories suppliers such as hangers, zippers, bottoms, threads, and other small and medium enterprises (SMES) are directly connected in this RMG-value chain. In addition, 98% of the RMG companies are customers of commercial banks, almost all types of machinery and plants are insured through insurance companies, 87% of importers and 16% of exporters are clients of the insurance companies, and the government received 40% of the port usage fees from the RMG sector. The sector provides opportunities for the employment of approximately 4.1 million workers (UNICEF 2020). Thus, RMG is the crucial driver of other economic sectors, and the COVID-19 crisis in this sector has multiple chain-reactions on the whole economy. The recovery of the RMG sector is exceedingly crucial for the salvage of other sectors.

Though the pandemic is still continuing and it is unknown when it is going to end, determining the economic channel of the pandemic effect is essential for the quick recovery of RMG and the backward linkage industries. As of now, no empirical effort has been made to integrate the view that credit flows and openness to trade are important economic transmission channels for the COVID-19 effect on RMG export growth, particularly from the Bangladesh perspective. Thus, our main

aim is to investigate: (a) how credit flow and openness to trade determines export of RMG, (b) how the pandemic has affected the export performance through these two channels, and (c) whether there are long-run and short-run relationships between the COVID-19 pandemic and the RMG export growth of Bangladesh. In line with the research questions, we developed our hypotheses that more credit support and an open economy positively influence the export performance of Bangladesh, and that the ongoing pandemic may have an adverse effect on export growth of the RMG sector in the short-term but not in the long-term. To accomplish the objectives, this study employs the autoregressive distributed lag (ARDL) framework with an Error Correction Model (ECM) and bounds test of cointegration. The ARDL approach allows investigating the long-run and short-run relationships among variables. The study found that COVID-19 has a significant negative effect on export growth in the short run but not in the long run, which is conditional on more credit support and lessening of barriers of international trade.

The remainder of the paper is organized as follows. The second section explains the theoretical background and related literature. The third section elucidates the data and methodology. The fourth section illustrates the empirical results and discussion. Finally, the fifth section concludes the paper.

Theoretical Background and Empirical Literature Review

Several existing literatures have argued the issue of the impact of credit growth, openness, exchange rate, and money supply on export growth. Credit growth (extensively used as a proxy of financial development) is a crucial determinant of export performance. The theoretical relationship between credit growth and export performance was first introduced by Kletzer and Bardhan (1987). They found that countries with a relatively well-structured financial sector have a comparative advantage in industries and sectors that rely on external finance. Baldwin and Krugman (1989) and Ju and Wei (2005) also showed that financial development exogenously influences the trade performance of the economy, and thus credit growth can be considered a source of comparative advantage and has been examined from the viewpoint of economies of scale. A well-functioning financial sector channels more savings to the private sector, which facilitates companies to use external financing, and ultimately assists enterprises in surmounting liquidity constraints (Beck 2003; Svaleryd and Vlachos 2005). Rajan and Zingales (1998) underline

that credit growth helps enterprises to minimize the potential problem of moral hazard and adverse selection and to increase export growth using external financing. The role of credit flows on export has been recognized as a supply-side determinant. Berman and Héricourt (2010) use a firm-level panel dataset of developing countries and analyse the impact of financial development on export. They find that lack of credit flow adversely affects export growth and the total productivity of the firms. They conclude that more credit flow increases the number of exporters and hence overall export performance. Amiti and Weinstein (2011) and Manova (2013) also argue that more access to external finance sources encourages industries to export more. Susanto, Rosson, and Costa (2011) and Demir and Dahi (2011) point out that financial deepening positively affects bilateral trade performance, particularly in the export of the manufacturing sector, with relatively higher economies of scale. They also found that exports of developing countries depend more on financial deepening than those of developed countries. Goksel (2012) also found a negative correlation between financial constraints and export performance of a country. Since enterprises require more credit to cover their costs, financial deepening increases the country's export flow.

In addition, the degree of openness to trade is important for export growth. An open economic policy in trading with the outside world is required for export and economic growth. The impact of the degree of trade openness on export growth can be examined based on trade-growth theories. Ricardo (1817), using his concept of the 'win-win approach' or 'comparative advantage,' showed that international trade and specialization have mutually beneficial effects on countries who are actively engaged in trade. Trade openness improves output and consumption efficiency and increases the participating countries' welfare even if one country is more efficient. The empirical shreds of evidence of trade openness on export growth have produced mixed findings. A panel data study for ten Latin American countries and developing and least developed countries by Bleaney (1999) and Santos-Paulino (2002; 2007), respectively; time-series cointegration analysis for Bangladesh and Mexico by Ahmed (2000) and Pacheco-Lopez (2005), respectively; and World Bank papers (Michaely, Papageorgiou, and Choksi 1991; Thomas, Nash, and Edwards 1991; Joshi and Little 1996) for evaluation of the economic restructuring in India, all found that trade openness has a significant positive impact on export growth. Conversely, UNCTAD studies (Agosin 1991; Shafaeddin 1994), Greenaway and Sapsford (1994), and Ratnaike (2012) found no

positive or little adverse impact of trade openness on export. After the trade liberalization period, Dawson (2006) investigated the relationship between export, import, and income growth of Bangladesh. His finding reveals that trade openness raises export growth, but this impact is not significant in the long run.

Another important factor that significantly affects export growth is the exchange rate. An unstable exchange rate brings economic instability and uncertainty. The existing studies found mixed consequences of exchange rate instability on export growth. Chowdhury (1993), for example, discovered that changes in foreign exchange rates have a negative impact on international trade for G7 countries, using the error correction model. Arize, Osang, and Slottje (2000) also found that exchange rate fluctuation negatively affects the export levels of thirteen developing countries.

Hence, identification of the relationship between COVID-19 and export growth movements, particularly for the RMG sector of Bangladesh, is strongly required at the moment to initiate appropriate policy initiatives. The stakeholders, such as the government, investors, traders, and others, are keen to understand the underlying association between COVID-19 and export growth trends and the transmission channels through which the pandemic can affect them, so that the channels can be controlled to overcome the adverse impact of COVID-19 on export growth. This study is a piece of fresh evidence that investigates the economic transmission channels and the impact of COVID-19 on export movements.

Data and Methodology

EMPIRICAL SPECIFICATIONS

Based on previous studies, several macroeconomic factors such as credit growth, degree of openness to trade, exchange rate, and money supply (M2) could affect the RMG sector export growth. This study examines how the global COVID-19 pandemic can affect the sector through the channel of domestic credit and trade openness in Bangladesh. Moreover, export performance requires more credit flows and the openness of the domestic market to the global economy. The functional form of the long-run empirical model reflecting the effect of these above variables on RMG export can be specified as the following equation:

$$\mathrm{EXP}_{\mathrm{RMG}} = f(\mathrm{DC}_t, \mathrm{TO}_t, \mathrm{EXR}_t, \mathrm{M2}_t). \quad (1)$$

The transformed logarithmic equation of the function is:

$$\ln \text{EXP\_RMG}_t = \delta_0 + \delta_1 \ln \text{DC}_t + \delta_2 \ln \text{TO}_t + \delta_3 \ln \text{EXR}_t + \delta_4 \ln \text{M2}_t + \varepsilon_t, \quad (2)$$

where $\ln \text{EXP\_RMG}_t$ is the natural log of the merchandise export of RMG (including knitwear and hosiery) at month t (1 to 134); the log of total domestic credit to both public and private sector ($\ln \text{DC}_t$) is a proxy for credit growth; the log of the total merchandise export and import ($\ln \text{TO}_t$) is a proxy for openness to trade; $\ln \text{EXR}_t$ is the log of exchange rate (BDT against USD); $\ln \text{M2}_t$ refers to the money supply proxy by log of broad money; and ε_t is the error term.

We extend the analysis and identify that credit growth and trade openness are the two important channels of transmission through which the recent global pandemic (COVID-19) could affect the RMG export. Thus, we transformed Equation 2 into the following two equations:

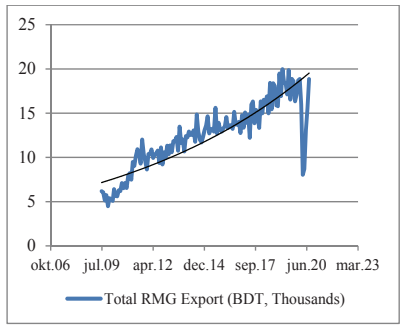
$$\ln \text{EXP\_RMG}_t = \delta_0 + \delta_1 \ln \text{DC}_t + \delta_2 \ln \text{TO}_t + \delta_3 \ln \text{EXR}_t + \delta_4 \ln \text{M2}_t + \gamma(\ln \text{DC} \times \text{COVID19})_t + \varepsilon_t \quad (3)$$

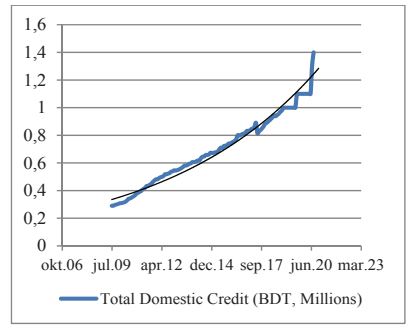
$$\ln \text{EXP\_RMG}_t = \delta_0 + \delta_1 \ln \text{DC}_t + \delta_2 \ln \text{TO}_t + \delta_3 \ln \text{EXR}_t + \delta_4 \ln \text{M2}_t + \varphi(\ln \text{TO} \times \text{COVID19})_t + \varepsilon_t. \quad (4)$$

COVID19 is the dummy variable taking the value 1 from the month when the virus was first found in Bangladesh and 0 otherwise. As per the World Health Organization, the first confirmed case of COVID-19 was found in Bangladesh in March 2020. The nationwide shutdown was enforced from March 26, 2020. We are expecting a positive sign for δ_1, δ_2, γ, and φ in the long-run and a negative sign for γ and φ in the short-run.

DATA AND STYLIZED FACTS

The monthly time series data used in this analysis covers the period July 2009–August 2020. The data on RMG export, domestic credit, trade openness, exchange rate, and money supply is collected from the Monthly Economic Trends data of Bangladesh Bank. The time series plot of RMG export, credit flows and openness to trade data are represented in figure 1. Export of RMG increased sharply until February 2020 but started dropping rapidly in March 2020 due to the confirmation of cases of COVID-19 in Bangladesh and various regions of the world, especially in European and North American countries. The subsequent two months experienced the lowest fall in RMG export. The growth of credit flow into the economy





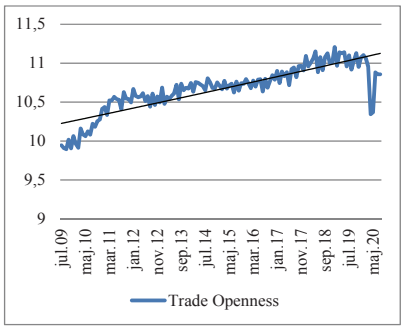


FIGURE 1

Time Series Illustration of RMG Export, Domestic Credit and Trade Openness Data

is also tending towards increase during the sample period. It was slightly stable from September 2019 to April 2020. The Government and Central Bank of Bangladesh announced several stimulus packages and lowered the policy rates and interest rate, which forces the flow of domestic credit in the economy after April 2020. Due to the shutdown of domestic industries and the lockdown of domestic and international borders, the degree of openness to trade shrinks from March 2020.

Figure 2 illustrates the early relationship of RMG export with credit flow and openness to trade. We plot RMG export in the vertical axis of each graph. The correlation of domestic credit and openness with export is strongly positive, signifying that both the explanatory variable have a favourable effect on Bangladesh's RMG export. That is, an increase of domestic credit (degree of openness to trade) leads to an increase in export of the RMG sector. Thus our initial hypothesis is that credit growth and trade openness have a positive effect on RMG export both in the long run and short run in the economy of Bangladesh. The short-run effect of COVID-19 through these two channels is negative. But the long-run effect of COVID-19 is positive. We empirically analyse these two hypotheses using important control variables in the results and discussion section.

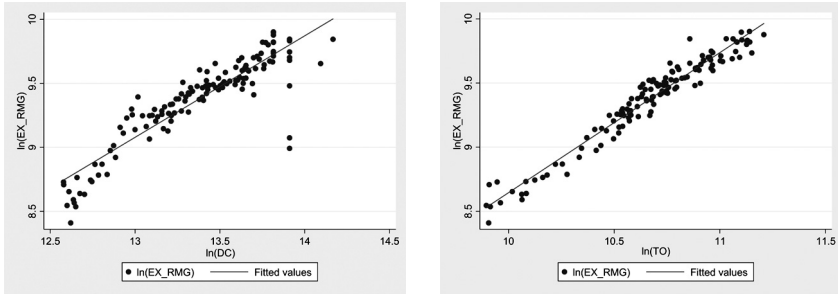


FIGURE 2 Stylized Facts

ESTIMATION STRATEGY

This study employed several relevant estimation strategies to examine the impact of credit growth, openness to trade, and the COVID-19 pandemic on RMG export flow. For examining the long-run effects of each explanatory and control variable on export, the ARDL cointegration framework developed by Pesaran and Shin (1995; 1999), Pesaran, Shin, and Smith (1996), and Pesaran (1997) is an appropriate and extensively used model. This framework has several advantages compared to other conventional cointegration frameworks such as Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990). First, while Johansen's cointegration framework requires that all sampled variables must have an identical order of integration, the ARDL cointegration approach can be applied when the order of integration is mixed (Shrestha and Bhatta 2018). The ARDL model allows both different and equal numbers of lag length order for the corresponding variables without affecting the asymptotic distribution of the test statistic (Pesaran, Shin, and Smith 1996). When the variables are integrated at I(0), at (I), or jointly cointegrated, ARDL cointegration yields effective and valid coefficients while the Johansen cointegration approach requires all the variables to be I(1) (Pesaran, Shin, and Smith 1996). Second, the model allows autocorrelation and endogeneity and yields valid *t*-statistics and unbiased estimates (Harris and Sollis 2003). Third, the ARDL error correction model (ECM) allows us to determine short-run estimates without losing valid long-run estimates obtained from the ARDL cointegration test. Fourth, the conventional cointegration framework determines the long-run correlation within the context of a system of equations; the ARDL approach allows only a single reduced form equation (Pesaran and Shin 1995).

Estimating a long-run relationship follows a two-step procedure: first, employing the ARDL bounds test to confirm the existence of a long-run

relationship of Equations 2 to 4; and second, estimating the long-run estimates of long-run relationships found in the bounds test. Following our baseline equations (2 to 4), we execute the following conditional error correction (EC) models of the ARDL cointegration approach:

$$\begin{aligned}\Delta \ln \text{EXP\_RMG}_t = {} & \delta_0 + \sum_{i=1}^{d} \sigma_i \Delta \ln \text{EXP\_RMG}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{DC}_{t-i} \\ & + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{TO}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{EXR}_{t-i} \\ & + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{M2}_{t-i} + \alpha \ln \text{EXP\_RMG}_{t-1} \\ & + \delta_1 \ln \text{DC}_{t-1} + \delta_2 \ln \text{TO}_{t-1} + \delta_3 \ln \text{EXR}_{t-1} \\ & + \delta_4 \ln \text{M2}_{t-1} + \varepsilon_t \end{aligned} \tag{5}$$

$$\begin{aligned}\Delta \ln \text{EXP\_RMG}_t = {} & \delta_0 + \sum_{i=1}^{d} \sigma_i \Delta \ln \text{EXP\_RMG}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{DC}_{t-i} \\ & + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{TO}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{EXR}_{t-i} \\ & + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{M2}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta (\ln \text{DC} \times \text{COVID19})_{t-1} \\ & + \alpha \ln \text{EXP\_RMG}_{t-1} + \delta_1 \ln \text{DC}_{t-1} + \delta_2 \ln \text{TO}_{t-1} \\ & + \delta_3 \ln \text{EXR}_{t-1} + \delta_4 \ln \text{M2}_{t-1} \\ & + \gamma (\ln \text{DC} \times \text{COVID19})_{t-1} + \varepsilon_t \end{aligned} \tag{6}$$

$$\begin{aligned}\Delta \ln \text{EXP\_RMG}_t = {} & \delta_0 + \sum_{i=1}^{d} \sigma_i \Delta \ln \text{EXP\_RMG}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{DC}_{t-i} \\ & + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{TO}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{EXR}_{t-i} \\ & + \sum_{i=0}^{d} \sigma_i \Delta \ln \text{M2}_{t-i} + \sum_{i=0}^{d} \sigma_i \Delta (\ln \text{DC} \times \text{COVID19})_{t-1} \\ & + \alpha \ln \text{EXP\_RMG}_{t-1} + \delta_1 \ln \text{DC}_{t-1} + \delta_2 \ln \text{TO}_{t-1} \\ & + \delta_3 \ln \text{EXR}_{t-1} + \delta_4 \ln \text{M2}_{t-1} \\ & + \varphi (\ln \text{TO} \times \text{COVID19})_{t-1} + \varepsilon_t \end{aligned} \tag{7}$$

where Δ refers to the first difference of the variables and d denotes the length of optimal lag. δ_1, δ_2, δ_3, δ_4, γ and φ are the long-run coefficients.

We consider the Schwarz Bayesian information criterion (SBIC) to determine the optimal lag length. The F-statistic of the Pesaran, Shin, and Smith (2001) ARDL bounds test is used to determine the long-run relationship and whether there exists cointegration among the variables or not. The null hypothesis (H0) of the test is there exists no relationship in levels, that is, $\alpha = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$, $\alpha = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \gamma = 0$ and $\alpha = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \varphi = 0$ for Equations 5, 6 and 7, respectively. The F-test statistics depend on various predetermined conditions such as the order of integration among variables should be I(0), I(1) or a mix of both, the number of independent variables, and whether the models hold intercept and/or trend. The bounds test provides two critical values. The critical values of I(0) order are called lower bound critical values and critical values of I(1) order of integration are referred to as upper bound critical values. When the F-statistics of the bounds test exceeds the respective upper critical values, we then can conclude that there exists a long-run relationship between the variables irrespective of the integration order of the variables.

Empirical Results and Discussion

SUMMARY STATISTICS AND CORRELATION MATRIX

Table 1 and table 2 illustrate the descriptive statistics and correlation matrix of the variables used in this analysis. The correlation matrix shows that the coefficient of correlation between the main explanatory variables and control variables, except M2, is positive. Though the correlation of DC, TO, and EXR is large, the variance inflation factor (VIF) test of the

TABLE 1 Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
EXP_RMG	134	9.37818	0.34243	8.40938	9.90198
DC	134	13.37826	0.38868	12.57824	14.16684
TO	134	10.67142	0.30563	9.89465	11.20808
EXR	134	4.36554	0.05705	4.23999	4.44206
M2	134	6.99970	4.93707	−0.64000	22.44000
DC × COVID19	134	0.62615	2.90299	0	14.16684
TO × COVID19	134	0.47963	2.22425	0	10.95643

TABLE 2 Correlation Matrix of Variables

	EXP_RMG	DC	TO	EXR	M2	DC × C	TO × C
EXP_RMG	1						
DC	0.9003	1					
TO	0.9746	0.8885	1				
EXR	0.7999	0.8684	0.8167	1			
M2	−0.3537	−0.3231	−0.3241	−0.2160	1		
DC × C	0.0191	0.3158	−0.0049	0.2630	0.1539	1	
TO × C	0.0219	0.3161	−0.0019	0.2629	0.1550	0.9998	1

NOTES C stands for COVID19.

TABLE 3 Variance Inflation Factor (VIF) test

Variable	Equation 2		Equation 3		Equation 4	
	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF
DC	7.10	0.140753	10.53	0.095009	10.39	0.096275
TO	5.24	0.190690	8.41	0.118839	8.25	0.121160
EXR	4.29	0.233356	4.36	0.229219	4.36	0.229466
M2	1.15	0.868052	1.23	0.814272	1.23	0.814615
DC × COVID			1.89	0.528526		
TO × COVID					1.86	0.538802
Mean VIF	4.45		5.28		5.22	

regressed results is only 5.46 (see table 3), within the range 10, indicating that multicollinearity is not a problematic issue in our analysis. The total number of observations is 134.

UNIT ROOT TEST

In order to employ the autoregressive distributed lag (ARDL) bounds test approach, we used the Augmented Dickey-Fuller (ADF) and Phillip Perron (PP) tests to check the stationarity and order of integration of the variables first.

The main assumption of the ARDL bounds test is that the order of integration should be either I(0) or I(1). For I(2), the ARDL bounds test findings could be biased (Pesaran and Shin 1998). Table 4 illustrates the results of the unit root tests. According to the ADF test, only two variables, openness (TO) and broad money (M2), are both stationary at the level, and all other variables are stationary at first difference. The PP test

TABLE 4 Findings from Unit Root Tests

Variables	ADF Test		PP Test	
	I(0)	I(1)	I(0)	I(1)
EXP_RMG	−2.013	−9.721***	−2.211	−16.555***
DC	−0.487	−5.526***	−0.428	−9.962***
TO	−2.590*	−11.955***	−2.763*	−19.014***
EXR	−1.844	−8.464***	−1.819	−10.424***
M2	−5.275***	−10.065***	−6.025***	−14.248***
DC × COVID19	−0.073	−8.096***	−0.094	−11.491***
TO × COVID19	−0.118	−12.150***	0.127	−11.470***

NOTES Test statistics ($z(t)$ value) are reported. ** and *** is the significance level at 5% and 1%, respectively.

also shows identical results to the ADF test. Therefore, variables TO and M2 are integrated at I(O), and Export, EXR, and Dummy interactions are integrated at I(1). Variables fit at I(0) and I(1), indicating that the ARDL bounds test approach is suitable for our analysis.

OPTIMAL LAG SELECTION

The selection of the optimal lag length is crucial before employing the ARDL bounds test. Inappropriate lag lengths lessen the model reliability and lead to biased estimation results. We consider the Schwarz-Bayesian information criterion (SBIC) to select the optimal lag length of each variable.

Table 5 illustrates the SBIC test findings. It shows that DC, EXR, M2, DC COVID19, and TO COVID19 are significant at first lag; EXP_RMG is significant at second lag, and TO is significant at a third lag. Thus, the SBIC recommends using a maximum of 3 lags.

TABLE 5 Selection of Optimal Lag: Schwarz-Bayesian Information Criterion (SBIC)

Lag	EXP_RMG	DC	TO	EXR	M2	DC × C	TO × C
0	0.6061	0.8723	0.3320	5.7410	6.0701	4.8560	4.3121
1	−1.1405	−4.7534*	−1.2216	2.4450*	5.7320*	3.3027*	2.7122*
2	−1.2221*	−4.7263	−1.3875	2.4714	5.7697	3.3401	2.7495
3	−1.1861	−4.6899	−1.3923*	2.4981	5.8040	3.3775	2.7852
4	−1.1972	−4.6540	−1.3914	2.5064	5.8373	3.4149	2.8227

NOTES C stands for COVID19. * is the significance level at 10%.

TABLE 6 ARDL Bounds Test for Long-Run Cointegration

Equation	*F*-Statistic	SBIC lag length crit.	Bounds crit. val.		Remarks
			I(0)	I(1)	
5	11.363	(1, 0, 1, 0, 3)	3.74	5.06	Long-run cointegration exists
6	14.155	(1, 1, 2, 0, 3, 3)	3.41	4.68	Long-run cointegration exists
7	14.076	(1, 1, 2, 0, 3, 3)	3.41	4.68	Long-run cointegration exists

LONG-RUN COINTEGRATION TEST

To determine the existence of the long-run cointegration among the variables, we employ the ARDL bounds test. Table 6 represents the summary findings of the bounds test. The null hypothesis (H0) of the test is $\alpha = 0$. As the *F*-statistic of each ARDL bounds test is higher than I(1) (upper bound), we can reject the null and conclude that there exists a long-run cointegration relationship (in all three cases) among the variables.

LONG-RUN AND SHORT-RUN EQUILIBRIUM RELATIONSHIP

Table 7 reports the long-run coefficient for the three models. Except for EXR, the sign of all long-run coefficients is positive and statistically significant, at least at the 5% level. The coefficient of EXR is negative but insignificant in all models. The results illustrate that DC, TO, and M2 have a significant positive relationship with the export of the RMG sector. Initially (column 1), the long-run elasticities for DC, TO, and M2 are 0.171, 1.070, and 0.0126, respectively, meaning a 1% increase of DC, TO, and TO will lead to an increase of 0.0126%, 1.070%, and 0.0126% in RMG exports, separately. Consequently, the findings support the hypothesis that the level of domestic credit and trade openness is a good forecaster of the country's successive level of export. More credit flow to the economy helps develop the financial sector that improves the lender's and borrower's safety in having available funds and efficient transfer of the funds from one hand to another. A sound financial sector helps enhance investment (both domestic and foreign) that expands the enterprises' productivity, to manufacture more products for exports. In other words, an economy with a well-developed financial system encourages higher export (Beck 2003; Kiendrebeogo 2012). The coefficients of the exchange rate illustrate that a 1% increase in the exchange rate leads to a decrease

TABLE 7 Long Run Relationship

Variables	(1)	(2)	(3)
DC	0.1710**	0.2370**	0.2370**
	(0.0707)	(0.0979)	(0.0979)
TO	1.0700***	0.9690***	0.9690***
	(0.0841)	(0.1270)	(0.1270)
EXR	−0.0055	−0.0052	−0.0052
	(0.0044)	(0.0042)	(0.0042)
M2	0.0126***	0.0135***	0.0135***
	(0.0036)	(0.0034)	(0.0034)
DC × COVID19		0.0376**	
		(0.0151)	
TO × COVID19			0.0511**
			(0.0202)
Observations	130	130	130
R-squared	0.867	0.898	0.898

NOTES The results of columns (1), (2), and (3) are obtained from Equations (5), (6), and (7), respectively. Standard errors in parentheses. ** and *** is the significance level at 5% and 1%, respectively.

in export by 0.005%. This is because an appreciation in the exchange rate makes imported goods and services relatively inexpensive, while depreciation makes exports become cheaper for international buyers, thus intensifying higher export competition in the domestic market. However, the negative effect of the exchange rate on export is supported by existing studies such as Vergil (2002). The long-run coefficients of the money supply are found to be positive. These findings are also suitable for the theories because when the supply of money increases in the economy, the value of the Bangladeshi Taka will decrease and thus enhance the country's export.

We introduce two interaction variables, DC × COVID19 and TO × COVID19, in order to measure the effect of COVID-19 on RMG exports. We find that COVID-19 has no negative effect on RMG export of Bangladesh through DC and TO channels in the long run. The interaction effect of COVID-19 through the domestic credit channel and openness of the economy increases the positive effect of DC and M2 but slightly decreases the positive effect of TO (Columns 2 and 3). The long-run positive effect of COVID-19 on RMG export through domestic credit channels is

expected and theoretically plausible. To combat the crisis and quick recovery of the RMG sector, the Bangladesh government and central bank have taken instant initiatives and announced 19 stimulus packages totalling 3.7% of the country's GDP. The packages include (a) packages for export-oriented industries at only a 2% interest rate a total of BDT 50 billion to pay the workers' wage bill; (b) BDT 300 billion for banks and financial institutions to make available working capital financing facilities at a 9% interest rate to the COVID-affected industries where the government will bear half of the interest amount as a subsidy; (c) BDT 200 billion for working capital loans to cottage, small and medium enterprises through banks at the above rate where the government will bear 5% of the interest rate as a subsidy and the remaining 4% will be borne by the borrower; (d) a BDT 50 billion refinance scheme for the agricultural sector with a six-month grace period and a 5% interest rate (1% interest charged on banks and 4% from the borrowers); (e) extension of the export development fund to USD 50 billion from USD 3.5 billion under the Back-to-Back letter of credit arrangement at only a 2% interest rate; and (f) a pre-shipment credit refinance scheme of BDT 50 billion for domestic products and export-oriented sectors. Moreover, the measures include a single-digit interest rate, lowering of the reserve requirement ratio and bank rate, and several stimulus packages for cottage, micro, small and medium enterprises. Monetary measures to increase the credit flow into the economy are already in effect. In addition, many countries in Europe and North America have already relaxed lockdown decisions and opened their economy for the outer world, which makes enough of a fortune for the quick recovery of the RMG sector export of Bangladesh.

Table 8 presents the findings of the short-run dynamic estimates from the ECM models. In all three cases, the error correction term (ECT_{t-1}) estimates are significant at a 1% significance level with the negative impact between 0 and negative 1, suggesting that each model can promptly converge back to long-run equilibrium after a short-run shock. The value of −0.47 signifies that the imbalance from the shock of the current period can be controlled in the next period by about 47%. It means that any disequilibrium of RMG export flow would converge back within two months. All models satisfy the fundamental diagnostic test requirements, such as heteroscedasticity, the normality of the residues, and serial correlation.

Table 8 provides the short-run coefficients of the variables. In the initial model (Equation 5), we do not find any impact of credit growth and exchange rate in the short run. Thus, the credit flow to the economy and

TABLE 8 Short Run Relationship

Variables	(1)	(2)	(3)
ΔDC		−0.6710**	−0.6710**
		(0.3120)	(0.3120)
ΔTO	0.4450***	0.3410***	0.3410***
	(0.0819)	(0.0892)	(0.0892)
ΔTO_{t-1}		−0.1530***	−0.1530***
		(0.0541)	(0.0541)
ΔM2	−0.0063***	−0.0054***	−0.0054***
	(0.0014)	(0.0014)	(0.0014)
$\Delta M2_{t-1}$	−0.0049***	−0.0049***	−0.0049***
	(0.0013)	(0.0012)	(0.0012)
$\Delta M2_{t-2}$	−0.0028**	−0.0032***	−0.0032***
	(0.0012)	(0.0011)	(0.0011)
Δ(DC × COVID19)		−0.0365***	
		(0.0076)	
$\Delta(DC \times COVID19)_{t-1}$		−0.0272***	
		(0.0074)	
$\Delta(DC \times COVID19)_{t-2}$		−0.0235***	
		(0.0063)	
Δ(TO × COVID19)			−0.0493***
			(0.0103)
$\Delta(TO \times COVID19)_{t-1}$			−0.0367***
			(0.0101)
$\Delta(TO \times COVID19)_{t-2}$			−0.0306***
			(0.0086)
ECM_{t-1}	−0.4742***	−0.4794***	−0.4794***
	(0.0724)	(0.0698)	(0.0698)
Constant	−1.8910***	−1.8190***	−1.8190***
	(0.3280)	(0.3170)	(0.3170)

Continued on the next page

the exchange rate affect RMG export only in the long run but not in the short run. Considering the interaction term in Equation 6 and Equation 7, we find a negative effect of credit on RMG export growth. The findings are statistically significant at the 5% level. In the short run, the changes in

TABLE 8 *Continued from the previous page*

Variables	(1)	(2)	(3)
Observations	130	130	130
R-squared	0.8670	0.8980	0.8980
Durbin-Watson *d*-statistic	2.0249	2.1192	2.1192
Breusch-Godfrey LM test (*p*-value)	0.5964	0.2407	0.2407
White's test (*p*-value)	0.0933	0.4457	0.4457
Jarque-Bera normality test	0.4986	0.4954	0.4954

NOTES The results of columns (1), (2), and (3) are obtained from Equations (5), (6), and (7), respectively. Standard errors in parentheses. ** and *** is the significance level at 5% and 1%, respectively.

the degree of openness to trade enhance export but, due to the COVID-19 effect, with one period lag, the changes of TO reduce the RMG exports. In all three cases, the changes in M2 have a negative effect on RMG export in the short run. Our main coefficient of interest is the interaction term, DC × COVID19 and TO × COVID19. The impact of the pandemic through DC and TO channels on RMG export growth is negative and statistically significant at a 1% level in all cases in the short run.

MODEL STABILITY TESTING

The misspecification of the functional form of the ARDL-ECM models may arise due to the volatility of the time variable. To confirm the stability of the models, we employ the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) tests (Pesaran and Pesaran 1995). The CUSUM and CUSUMSQ tests statistics are measured as the cumulative sum and the cumulative sum of the estimates' squares are supposed to be stable (Brown, Durbin, and Evans 1975). As per figure 3, the CUSUM and CUSUMSQ plots lie between the critical lower and upper bounds (red lines) at the 5% significance level. Thus, the selected models are statistically stable, and the estimates of DC, TO, EXR, M2 to EXP_RMG, and coefficients corresponding to DC, TO, EXR, M2 to EXP_RMG are reliable.

Conclusion

This study empirically analysed the potential long-run and short-run effects of the COVID-19 pandemic through credit flow and openness of trade channels on RMG export growth of the Bangladesh economy over the period from July 2009 to August 2020. Using the ARDL-bounds test

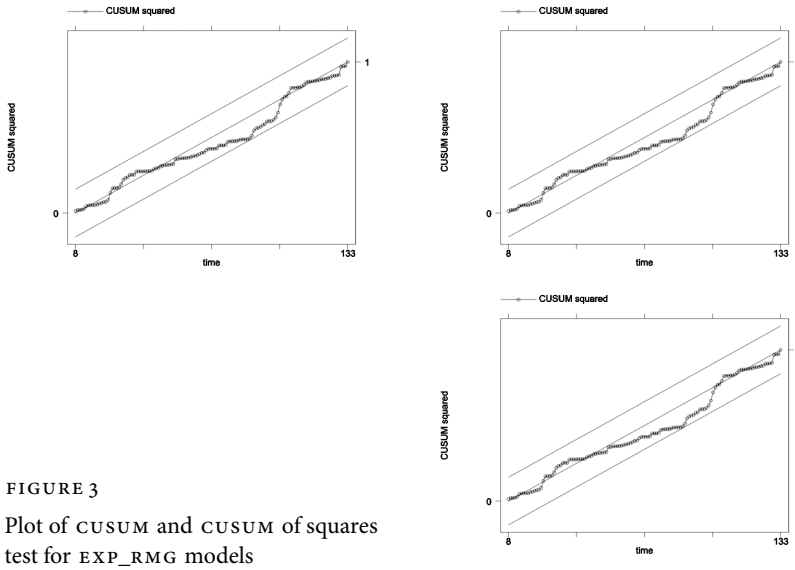


FIGURE 3

Plot of CUSUM and CUSUM of squares test for EXP_RMG models

and ECM approaches, the study primarily revealed that credit flow and openness to trade has a substantial impact on the RMG export growth of Bangladesh. The opening of the domestic economy for international trade has had a positive and significant impact on the RMG export growth of the country. At the same time, the positive effect of domestic credit support on RMG export is found only in the long run. In the short run, the effect of COVID-19 is negative and statistically significant, but in the long-run, the effect is highly significant and positive for the export of RMG. The negative effect in the short run and positive effect in the long run is theoretically plausible because injecting credit into this sector would not affect it within the shortest possible time. Higher credit to this sector and more trade activities will minimize the negative effect of COVID-19 on the export of the RMG sector. Thus, in order to alleviate the impeding export crisis of the RMG sector, emergency financial assistance and reduction of trade obstacles are required for the recovery of the sector. Assistance to this sector would be the largest contributor to poverty alleviation, women's empowerment, normalizing the supply chain management of the economy significantly, and achieve this faster.

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Sustainability and Outreach in the Microfinance Sector of Ghana

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The recent finance sector clean-up in Ghana led to the collapse of a number of microfinance institutions (MFIS), which reignited the discussion of whether MFIS can achieve much-needed financial sustainability while also meeting the goal of reaching out to the poor. In that regard, this paper explores the potential for MFIS to improve the breadth of outreach by fostering financial inclusion and to deepen the depth of outreach by targeting the poor while simultaneously pursuing self-sufficiency and profitability. Using data from the MIX database for 89 MFIS over a 20-year period, we employed fixed and random effects models to show that among other results, outreach is improved when MFIS are financed more by debt than equity and that the pursuit of profitability is a disincentive to outreach. Overall, the results suggest that with improved efficiency in the pursuit of sustainability, MFIS in Ghana stand better chances of achieving outreach both in depth and breadth.

Key Words: microfinance institutions, outreach, profitability, sustainability
JEL Classification: E60, G21

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Introduction

'Microfinance' is often used to refer to microcredit even though the term is broader and includes the general provision of financial services to the financially excluded who often intersect with the poorest in society (Ledgerwood 1998). Due to its promise to be a tool that will correct market failure by more efficiently allocating capital and expanding opportunities to the poor, it has been employed historically across the globe (Cull, Demirgüç-Kunt, and Morduch 2011a; 2011b). Over the years, its us-

age has moved from merely providing financial services, to serving as a financial intermediary and even social intermediation. Social intermediation is defined as the building of both human resources and institutional capacities with the objective of improving self-reliance among marginalized groups and hence preparing them to engage in formal financial intermediation (Hinson 2011; Edgcomb 1998). Social intermediation comes in many forms, including capacity building through various financial training on bookkeeping and business management, and even networking (Wairimu and Mwilaria 2017).

The assorted roles that microfinance plays in this regard ensures its relevance as a tool for development (Ledgerwood 1998). However, as a tool it has not been without criticism regarding its continued relevance in the ever-evolving development climate. A study in Nigeria by Kasali, Ahmad, and Ean (2015) found that in order for microfinance institutions (MFIs) to have a significant effect on poverty, efforts had to be supplemented by the government through the provision of infrastructural and social facilities. Given the structural similarities, this would not be any different in the context of Ghana. In other studies, access to microfinance was observed to lead to increasing levels of indebtedness in deprived communities and hence worsened vulnerabilities (Banerjee and Jackson 2017). Microfinance by itself is not the bane of poverty. This point is further illustrated in the study by Agbeko et al. (2016) where loan repayment rates were considerably better amongst entrepreneurs with more than fifteen years of experience in business.

Essentially, the fundamental question at hand, taken in the context of Ghana and, by extension, all developing nations, is whether the role played by microfinance significantly impacts the living situation of the poor in measurable social and economic dimensions. In tackling this question, we unavoidably encounter the inherent issue of long run financial sustainability and whether the pursuit of it comes at a detriment to outreach, thus posing a trade-off between MFI sustainability and outreach. Financial sustainability in this context is described as the ability of an entity to cover its costs internally without the need to depend on external support (Kinde 2012).

The initial adoption of microfinance and its subsequent development in Ghana was to improve the degree of financial inclusion of the poor and those mainly in the agricultural sector. Given that the economic dimension of poverty vis-à-vis consumption and income is rather rampant in the agricultural sector which also accounts for majority of the poor

population, it becomes incumbent to examine the performance of MFIs in the country to ascertain whether or not they are reaching the original goal of improving financial inclusion. The role of MFIs cannot be underestimated if they are to be seen as a major tool for combatting poverty and unemployment among the poorest in the Ghanaian communities. This is relevant as substantial reduction in poverty has been attributed to access to finance (Littlefield, Morduch, and Hashemi 2003; McIntosh, Villaran, and Wydick 2011), considering that the impact of microfinance is expected to go beyond business loans and extend into home, health, and education investment as well as the servicing of other cash needs for the poor. In this sense, MFIs become the very institutions that possess the ability to provide capital to small, micro, and medium enterprises to reach their production potential such that the trend of increasing unemployment and deepening poverty may be halted in the long run.

Yet, there have been some criticisms that microfinance does not necessarily reach the poorest populations and that there are times when the poorest of the poor are intentionally excluded from the programmes of microfinance (Scully 2004; Simanowitz 2002). Such exclusion is generally because of the dual problem of the poorest of the poor being (1) typically extremely risk averse such that they do not have the propensity to borrow for any investment ventures, and (2) being designated as bad credit risks which results in MFIs fearing to lend to them as they consider such lending to be too risky (Marr 2003; Hulme and Mosley 1996). The failure of MFIs to reach out to the poor by reason of improving their own financial performance therefore becomes detrimental to the goal of outreach and affects overall macroeconomic stability. By extension, the very purpose of correcting market failure by more efficiently allocating capital and expanding opportunities to the poor and vulnerable becomes defeated. It is no wonder that Marr (2003) argues that MFIs have failed on two accounts, the first being that they have not been able to solve the information asymmetry problem that exists between borrowers and lenders. This failure is visible among the Ghanaian poor as they generally consider credit unattainable without receiving proper or accurate information about credit worthiness. The second failure is that MFIs have excluded the poor and in the process created more poverty by their pursuit of sustainability.

Admittedly, the operations of MFIs are costly due to the associated high transactional and informational costs. This reignites the contention between the *poverty lending* approach and the *financial systems* approach

described by Robinson (2001). While the *financial systems* approach focuses on reduction of operational costs and the ability of MFIS to cover their cost of lending by the income generated from their loan portfolios, the *poverty lending* approach places emphasis on the provision of credit with reduced interest rates in an effort to reduce poverty. Given the high cost of MFI operations, it follows that focusing on sustainability inhibits the goal of reaching out to the poorest of the poor in large numbers, thus creating a trade-off between sustainability and outreach.

Considering that focusing on lending to the poor can be costly for MFIS, whereas focusing on sustainability comes at the detriment of the poor, sustainability and outreach therefore become conflicting goals with the pursuit of one affecting the other negatively (Hermes and Lensink 2011). Against the backdrop of that assertion, this paper aims to examine the relationship between the financial performance of MFIS and their capacity to reach out to the poor amongst Ghana's population. We explore whether sustainability and profitability can be pursued at the same time as outreach. The contribution of this paper is twofold. First, using multiple sustainability variables, we provide deeper insights into the real effects of sustainability measures on MFI outreach in Ghana. Secondly, we uniquely incorporate percentage of female borrowers as a measure of depth of outreach and also provide evidence that the financial performance of MFIS in Ghana directly impacts their ability to reach out to the poorest of the poor and that MFI profitability pursuits are a disincentive to outreach.

The remaining sections of this paper are structured as follows: First, a review of literature is presented in the second section to capture an overview of existing studies and highlight the need for financial sustainability of MFIS. Materials and methods used are then presented in the third section, while the empirical results and discussion of results are presented in the fourth section. The conclusion then follows in the fifth section.

Literature Review

THE NEED FOR FINANCIAL SUSTAINABILITY

The underlying argument for sustainability is the capacity of an MFI to maintain a form of consistency in performance. This does not imply that an MFI's performance is unchanging but rather borders on its reliability to continue operations into the foreseeable future. Schreiner (2000) aptly

describes the concept as the permanence of MFIS. In this sense, MFIS, in meeting their current goals, do not jeopardize future prospects. It is worth noting that an unsustainable MFI will be unable to meet the needs of the poor in the future, hence making no contribution to poverty reduction or development as intended. A reduction in future prospects is not the only risk an unsustainable MFI faces, as even in the present, such an institution is not likely to meet the goal of reaching out to the poor (Adams, Graham, and von Piscke 1984) and creates a further risk of having detrimental effects on the targeted client base (Krahnen and Schmidt 1994).

The financial performance of an MFI, while not the only important characteristic, can easily be the most influential when it comes to the sustainability of an MFI. Kinde (2012) defines financial sustainability as the ability of an entity to cover its costs internally without the need to depend on external support. We adopt this definition for the purpose of this study. However, given that this definition does not focus on the status of the MFI either as profit seeking or otherwise, this study equally does not intend to place emphasis on the status of MFIS when referring to their financial sustainability.

SUSTAINABILITY AND OUTREACH: CHALLENGES

Sustainability and outreach in microfinance studies are often viewed as trade-offs, with the pursuit of one coming at the expense of the other. The common hypothesis is that when MFIS focus on financial sustainability, they move away from their unique purpose of serving the poor who often happen to be the same group that are financially excluded (Ek 2011). A few studies have, however, pointed to the complementary nature of the two (Rhyne 1998) and there is even the assumption that sustainable MFIS can be profitable enough to continue their coverage to the poor even when donor funding discontinues.

This premise leads us to the biggest bone of contention in microfinance studies: whether an MFI that aspires to financial sustainability does so to the detriment of their original objective of reaching out to the poor or financially excluded, a concept generally referred to as 'Mission Drift.' The term is often used to denote when an organization moves away from objectives as stated or specified in their mission statement. In relation to microfinance, we will shortly explore this term as a challenge for financial sustainability. MFIS, whether for profit or not, while they may achieve financial sustainability, still contrast with traditional financial institutions

in four main ways: in ownership, the calibre of clients they target or serve, products and services offered, and finally in the methodologies adopted in lending (Visconti 2016). Another challenge therefore arises: how regulation of MFIs should differ from that of traditional institutions. The two preceding challenges are further explored below.

Mission Drift

Mission drift occurs when an MFI's average loan size increases because of a shift in the composition of its targeted clients (Engels 2009). In the pursuit of financial sustainability there is a general consensus that the process will lead to MFIs targeting less and less of the intended client base. In academic literature, mission drift is observed when MFIs have a larger average loan size or reduced proportion of female borrowers (or other excluded groups) within their portfolios, in turn leading to less access to MFIs, referred to as lower depth of outreach. This is in line with the analysis conducted by Hermes, Lensink, and Meesters (2008), who found that MFIs that have lower average loan balances and more women borrowers are less efficient.

Regulation of MFIs

Given that the services of MFIs are not confined to credit but also involve savings, insurance, and transfer facilities, effective regulation and supervision are core components for MFIs to strategize to attain financial sustainability (Gallardo 2002). This is especially the case if MFIs are to meet the demands of offering financial services to the most deprived. MFI funds are often inadequate to meet their credit demands. MFIs augment lending from private savings from their customer base and institutional savings from other financial institutions. Others can fund lending through securities issued from capital markets; this is, however, an uncommon option for MFIs in developing country economies. Whatever the choice of funding, it is vital that MFIs safeguard the funds of investors, and one way to ensure this is through their compliance with carefully thought-out laws and regulations. The benefit of this is the creation of a virtuous circle where MFIs are further able to access additional funds and reach their goals.

In regulating the operations of MFIs, another question is raised. Should laws be designed specifically for the microfinance sub-sector or incorporated in overall banking regulations (Pouchous 2012)? The second point for consideration is that compliance with regulation could lead to mission

drift. Various academic studies have tried to document the relationship between regulation and mission drift. Quartey and Kotey (2019) found a positive relationship between regulation and the breadth of outreach (measured by the number of active clients). According to the study, the relationship is most likely enhanced by the increased confidence clients have in well-regulated MFIs. Increased confidence means higher voluntary deposits which MFIs harness to raise funding. The same study, however, found no conclusive relationship between regulation and the depth of outreach when the proxy used was the average loan size. When the depth of outreach was measured by the percentage of female clients it proved a negative relationship with regulation.

Cull, Demirgüç-Kunt, and Morduch (2011a) observed different results in profit-oriented MFIs. These institutions have to comply with strict supervision due to their for-profit statuses. As a result, they tend to limit their operations away from segments of the population that are more expensive to serve (particularly women and the poor). This generally follows the broad conception that compliance with regulation is expensive and additional expenses are not welcome in for-profit institutions. Not-for-profit MFIs tell a different story, as they generally do not adjust their operations in response to regulation.

CHALLENGES FOR FINANCIAL SUSTAINABILITY IN GHANA

MFIs in Ghana face a number of challenges that serve as a barrier to their sustainability. Notable among them is the changing environment in which they operate. According to the contingency theory posited by Frese (2007), the ability of an organization to be successful is largely dependent on its deliberate actions to adapt to its environment. In relation, an MFI should be organized in such a way as to fit both its internal and external conditions. Following this premise, we can conclude that there is no right way to effectively organize MFIs to ensure sustainability. The success of an MFI is largely dependent on its ability to adapt to both the organizational and external environment. However, in the case of Ghana, there is the added complexity of rapid changes in the external environment within which MFIs operate. According to Mensah and Peprah (2018), this then suggests that institutional frameworks, regulations, supervision, co-ordination, data information and dissemination, capacity building and funding, and credit delivery management, which are important for the proper functioning of the microfinance industry, can also act as barriers to the success and sustainability of MFIs. This

point is further reinforced by Boateng (2015) who, in his study of the prospects and challenges facing MFIs in Ghana, discovered that irregular and constant changes in government policies and regulatory environment was one of the impediments to the growth and sustainability of MFIs.

Another prominent challenge to the sustainability of MFIs in Ghana is the level of capacity building and funding. In their study of the contemporary challenges facing MFIs in Ghana, Mensah and Peprah (2018) studied the relationship between capacity building and funding challenges and the sustainability of MFIs and established a negative significant relationship. This result is consistent with theory where low staff capacity as well as funding is detrimental to the sustainability of MFIs. Boateng and Agyei (2013) also affirm this relationship in their studies by showing that sampled MFIs that had funding challenges found it difficult to chalk continuous successes. For the authors, this is because such MFIs found it difficult to meet internal costs related to sustainable technology and transport to maintain their sustained continuity into the foreseeable future.

OUTREACH AS AN ASPECT OF SOCIAL PERFORMANCE

MFIs also benefit from increased outreach. MFIs that reach out to a large number of people increase their chances for achieving long-term sustainability and economies of scale (Rashem and Abdullah 2018). Outreach is the breadth and depth of the financial services provided by MFIs (Rao and Fitamo 2015). Gebrehiwot and Chawla (2016) define outreach alternatively as the ability of MFIs to provide financial services to a large proportion of the society, most especially the poorest of the poor. Two aspects arise from these definitions of outreach: depth and breadth. Depth of outreach involves inclusion of the poorest of the poor whilst breadth refers to extension of MFI services to a wider client base (Conning 1999). Schreiner (2002) and Navajas et al. (2000) extend their definitions to include worth of outreach to clients, cost of outreach to clients, length of outreach, and scope of outreach. This paper, however, focuses on only the breadth and depth of outreach.

FINDINGS FROM PREVIOUS STUDIES

Findings from studies focusing on the relationship between sustainability and its related variables and MFI outreach have been varied. In some studies we find some degree of complementarity between these vari-

ables and outreach (Nurmakhanova, Kretzschmar, and Fedhila 2015). Kattilakoski (2018) found that in MFIs in Sub-Saharan Africa, there was some trade-off between efficiency and outreach, but not a large one. Further results from the same study showed operationally self-sufficient MFIs having higher levels of outreach compared to non-self-sufficient ones. In other studies, both complementary and opposing relationships were found. Awaworyi (2020) found, through studying 1,595 MFIs in 109 countries, a trade-off between financial sustainability and depth of outreach but that sustainability reinforces breadth of outreach. Employing interest and default rates as transmission mechanisms in the study of 32 MFIs in India, MFIs were found to simultaneously attain both financial sustainability and their social mission (Sim and Prabhu 2014). An argument for such complementarity can be seen in the premise that repayment of credit, which spurs further outreach, is dependent on MFI sustainability.

In analysing microfinance impact, we see various studies asserting that microfinance raises consumption expenditure while others conclude that microfinance is more beneficial for those that are extremely poor as opposed to those that are only moderately poor (Pitt and Khandker 1998; Khandker 2005). Roodman and Morduch (2014), however, refute the foregoing results on the basis of the use of a robust linear estimator or eliminating outliers in the data. In analysing the effect of microfinance, we also see the results of randomized evaluation from authors such as Banerjee et al. (2015), who had mixed impact results with microfinance leading to increase in profits for pre-existing businesses while consumption did not increase. They also found no major changes in health or social improvements such as women's empowerment.

Other studies have implied reverse causality between financial performance and depth of outreach (Quayes 2012). In addition, depth of outreach has a positive relationship with financial sustainability and firms that are operationally self-sufficient have a smaller average loan size compared to firms that are not operationally self-sufficient. We also observe in the study of Schäfer and Fukasawa (2011) that the higher the breadth of outreach, the more the MFI can take advantage of economies of scale and scope, thus reducing the cost per borrower.

Based on these mixed results, it is clear that the results of one study or experiment can hardly be effectively generalized (Hermes and Lensink 2011). The fact that one microfinance experiment or analysis yields positive results in Asia does not necessarily mean the same results will be

achieved in South America or Africa. There are country-specific and continental differences that affect the operation of and access to microfinance. These dynamics make it necessary to evaluate microfinance performance and impact on a case-by-case basis and only then can reasonable comparisons be drawn.

Materials and Methodology

DATA AND VARIABLES

The main data for this study are derived from the Microfinance Information Exchange Market database (MIX). The MIX dataset, which is now freely available via the World Bank database, offers a wide-ranging collection of data on financial performance throughout the world and can be considered reliable as it goes through a process of auditing by MIX prior to being released publicly (Bassem 2012; Awaworyi and Marr 2014).

We use a sample of unbalanced panel data comprising of 89 MFIs in Ghana, ranging from 1999 to 2018, thus making for a 20-year period.

Dependent Variables

Outreach is sub-categorized into two aspects – depth and breadth. For measuring the depth of outreach, several authors use as proxies the average value of loans or the average value of loans as a percentage of GNP/capita (Hoepner, Liu, and Spaggiari 2011; Gebrehiwot and Chawla 2016; Awaworyi 2020). Given that the study analyses the outreach of MFIs in the same country, we use the variable 'Average loan balance per borrower' which directly matches the average value of loans as proxy for depth of outreach. We simply refer to this variable as ALBPB. We employ this variable with the understanding that depth of outreach is oftentimes greater when the loan size is smaller (Hossain et al. 2020).

Women in developing countries often lack vital sureties such as land or housing which can act as collaterals for loan accessibility, thus placing them at a certain disadvantage when it comes to credit access. This attests to the female vulnerability to poverty as described by Bhatt and Tang (2005). Against this backdrop, we fittingly employ 'Percentage of female borrowers' (PFB) as another proxy for depth of outreach to reflect a segment of the deprived population (Nwachukwu et al. 2018). The use of this variable is vital in this study as it is reported that although women play an important role in Ghanaian agriculture, they experience productivity constraints due to the lack of or limited access to credits and land (Gbedemah, Jones, and Pereznieto 2010).

TABLE 1 List of Dependent Variables

Acronym	Name	Measures
ALBPB	Average Loan Balance per Borrower	Depth of outreach
PFB	Percentage of Female Borrowers	Depth of outreach
NACB	Number of Active Borrowers	Breadth of outreach
NDVTD	Number of Depositors of Voluntary Time Deposits	Breadth of outreach

To measure the breadth of outreach, we employ the number of active clients as a proxy as it accounts for the total number of clients with access to the financial services of MFIS (Rosenberg 2009). To accurately represent this proxy, we use the 'Number of active borrowers' (NACB) variable as a relevant measure of breadth of outreach with the understanding that it is better to report active borrowers than total borrowers, which may include dormant clients/accounts, thus avoiding bias.

Additionally, we use the 'Number of depositors of voluntary time deposits' (NDVTD) as a second measure of breadth of outreach as it accounts for the number of clients with access to the non-credit services or facilities of MFIS, thus offering a better overview of the number of depositors who do not necessarily have the need for credit with the particular MFIS.

We thus use 'Average loan balance per borrower' (ALBPB) and 'Percentage of female borrowers' (PFB) as proxies for depth of outreach, while we use 'Number of active borrowers' (NACB) and 'Number of depositors of voluntary time deposits' (NDVTD) as proxies for breadth of outreach. These four variables are the dependent or response variables for the study. The detailed list of dependent variables is in table 1.

Independent Variables

The independent or explanatory variables employed in this study for measuring MFIS' financial sustainability and performance are systematically grouped into categories on the basis of financial ratios such as (see table 2):

1. Degree of efficiency of the MFIS,
2. Profitability degree of the MFIS,
3. MFIS' liquidity and risk, and
4. MFIS' capital structure.

Degree of Efficiency of the MFIS. For the 'Degree of efficiency of the MFIS,' we identify 'Cost per borrower' (CPB) as a proxy. Cost per borrower (CPB)

TABLE 2 List of Independent Variables

Measures	Acronym	Name
Degree of efficiency of MFIS	CPB	Cost per borrower
	OEXTA	Operating expense/total assets
	IED	Interest expense on deposit
	PFLO	Percentage of female loan officers
	GLP	Gross Loan Portfolio
Degree of profitability of MFIS	ROA	Return on Assets
	ROE	Return on Equity
	OSS	Operational Self Sufficiency
MFIS' liquidity and risk	PR30	Portfolio at Risk by 30 days
	LLR	Loan Loss Rate
MFIS' capital structure	DER	Debt to Equity Ratio

is measured as the operating expense divided by the average number of active borrowers and the unit of measurement is in USD. It is expected that an MFI with a higher CPB will essentially have lower financial sustainability (Awaworyi and Marr 2014) but also be positively correlated with the MFI's outreach (Kar 2010).

Similarly, we use the 'Operating expense/total assets' (OEXTA) as a cost efficiency ratio to provide a measure of the costs incurred by an MFI from the operation of its assets. In that regard, we expect that an efficient MFI will have lower OEXTA. We also consider the 'Interest expense on deposit' (IED) variable as an efficiency measure with the expectation that a sustainability-oriented MFI will balance its costs related to deposit accounts to attain an optimum level of efficiency.

Acknowledging that an MFI focusing on female borrowers would employ a significant number of female loan officers (International Labour Office 2007), we also uniquely incorporate the 'Percentage of female loan officers' (PFLO) as another variable when considering efficiency in the Ghanaian cultural setting. Given that an efficient MFI will attempt to keep the delinquent components of their growing portfolios to a minimum, we also include the 'Gross Loan Portfolio' (GLP) variable as an efficiency measure.

Degree of Profitability of the MFIS. We also select 'Return on Assets' (ROA), 'Return on Equity' (ROE), and 'Operational Self Sufficiency' (OSS) as proxies for 'Degree of profitability of the MFIS.' An MFI having its

OSS greater than 100% is considered profitable. The usage of ROE and ROA as measures for profitability is common among financial institutions as highlighted by Rosenberg (2009). While we use both ROE and ROA ratios in our models, we avoid using them simultaneously in the same model to eliminate the risk of multicollinearity.

MFI's Liquidity and Risk. As proxies for liquidity and risk, we select the 'Portfolio at Risk by 30 days' (PR30) and the 'Loan Loss Rate' (LLR) variables to account for their effects on the sustainability of MFIS. By definition, PR30 measures how MFIS are able to effectively make collections on their repayment (Tehulu 2013) and can practically be considered as the value of any loans for which the instalment or outstanding amount has not been paid past 30 days. We use 30 days as a standard given that the longer the loan remains unpaid, the higher the risk of defaulting.

The MFI's Capital Structure. 'Debt to Equity Ratio' (DER) is employed as a proxy for the capital structure of an MFI and is measured by dividing total liability by total equity. We employ this ratio to highlight the degree to which an MFI's operations are funded by debt as opposed to equity. The DER has been found to have a positive impact on an MFI's ROA, thus suggesting profitability (Abrar and Javaid 2016).

DESCRIPTIVE STATISTICS AND CORRELATION ANALYSIS

Table 3 is an overview of the summary statistics, which generally describes the character of the data sample used for all regressors and response variables. A major highlight of the descriptive statistics show that Ghanaian MFIS are barely able to cover their operational costs with an average of 1.144 observed for OSS. This number represents a struggling MFI sector and that is notably a worrying trend. With a wide range between the minimum and maximum values, the mean ROE and ROA values are rather low at 0.158 and 0.007, respectively. From the onset, one can already deduce a general level of unprofitability in the MFI sector of Ghana. It is also noteworthy to mention that the average number of female borrowers is only 0.708%, suggesting a general lack of focus on the female borrower population.

Table 4 presents the correlation analysis conducted for the independent variables employed in the study. The output offers a visualization of the patterns in the data for all regressors under consideration. It can be observed that ROE and DER have a strong negative correlation while ROA and OSS have a strong positive correlation. Additionally, GLP and

TABLE 3 Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
ALBPB	298	604.309	1430.688	1	15471
PFB	236	0.708	0.314	0.058	4
NACB	307	13653.42	25435.798	20	148020
NDVTD	41	1621.854	3265.912	0	16087
CPB	174	224.54	391.112	5	2697
OEXTA	209	0.244	0.153	0.018	0.908
IED	242	$1.901e^{8}$	$2.943e^{9}$	0	$4.578e^{10}$
PFLO	64	0.345	0.278	0	1
GLP	349	9764383.1	44667507	0	$5.010e^{8}$
ROA	209	0.007	0.113	−0.594	0.48
ROE	209	0.158	232.891	−1651	2726.667
OSS	297	1.144	0.43	0.085	4.49
PR30	232	0.1	0.107	0	0.744
LLR	191	0.384	3.295	−0.024	40.268
DER	298	5.634	45.216	−354.28	558.62

TABLE 4 Correlation Matrix

Variables	OSS	OEXTA	ROE	ROA	PR30	LLR	CPB	IED	GLP	PFLO	DER
OSS	1.000										
OEXTA	−0.468*	1.000									
ROE	0.339*	−0.628*	1.000								
ROA	0.869*	−0.659*	0.719*	1.000							
PR30	−0.124*	0.096	0.047	−0.136*	1.000						
LLR	−0.113	−0.024	0.074*	−0.129	0.421*	1.000					
CPB	−0.207*	0.351*	0.089*	−0.151	0.798*	0.421*	1.000				
IED	−0.183*	0.064	0.121	−0.120*	0.223*	0.018*	0.231	1.000			
GLP	−0.199*	0.241*	0.151*	−0.127	0.091	−0.025	0.226	0.774*	1.000		
PFLO	0.008	−0.469*	0.250*	0.132*	0.133	0.139	−0.122	0.145*	0.010*	1.000	
DER	−0.340*	0.640*	−0.997*	−0.717*	−0.072	−0.102*	−0.109	−0.111	−0.136	−0.272	1.000

NOTES * Significant at 0.05.

PFLO exhibit a weak positive relationship similar to IED and LLR. The other observed correlation figures presented are fairly standard.

ECONOMETRIC MODELLING

Econometric modelling in the field of microfinance has employed a host of techniques, with the most common techniques being the fixed effects

(FE) or random effects (RE) estimation of panel data (Abdulai and Tewari 2017; Mersland and Strøm 2014; Janda and Turbat 2013; Kar 2010). While FE is ideal when estimating impacts of variables that have varying degree in time with individual effects assumed to be correlated to the regressor, RE assumes a random variation across entities with no correlation with the regressors in the model (Torres-Reyna 2007).

In this study, we employ both fixed and random effects for the purpose of robustness. We then use the Hausman specification test to identify the most preferred model which is consistent and suitable for onward discussion. Using Fixed Effects (FE) and Random Effects (RE) models, we estimate two models for depth of outreach as follows:

$$\begin{aligned} \text{ALBPB}_i &= \alpha_0 + \alpha_1 \text{OEXTA}_i + \alpha_2 \text{ROE}_i + \alpha_3 \text{CPB}_i + \alpha_4 \text{PR30}_i \\ &\quad + \alpha_5 \text{LLR}_i + \alpha_6 \text{DER}_i + u_{it} + v_{it}, \end{aligned} \tag{1}$$

$$\begin{aligned} \text{PFB}_i &= \alpha_0 + \alpha_1 \text{OEXTA}_i + \alpha_2 \text{CPB}_i + \alpha_3 \text{LLR}_i + \alpha_4 \text{PFLO}_i \\ &\quad + u_{it} + v_{it}, \end{aligned} \tag{2}$$

where α_0 is the constant and u_{it} and v_{it} represent the Between MFI error and Within MFI error, respectively. Additionally, $\alpha_1 \ldots \alpha_6$ are coffi-cients to be estimated, with OEXTA_i, ROE_i, CPB_i, PR30_i, LLR_i, DER_i, and PFLO_i being vectors of the independent variables.

Similar to equations (1) and (2), we model two equations for the breadth of outreach as follows:

$$\begin{aligned} \text{NACB}_i &= \alpha_0 + \alpha_1 \text{ROA}_i + \alpha_2 \text{PR30}_i + \alpha_3 \text{LLR}_i + \alpha_4 \text{GLP}_i \\ &\quad + \alpha_5 \text{CPB}_i + \alpha_6 \text{OSS}_i + u_{it} + v_{it}, \end{aligned} \tag{3}$$

$$\text{NDVTD}_i = \alpha_0 + \alpha_1 \text{OEXTA}_i + \alpha_2 \text{IED}_i + \alpha_3 \text{ROA}_i + u_{it} + v_{it}, \tag{4}$$

where α_0 is the constant and u_{it} and v_{it} for equations (3) and (4) also represent the Between MFI error and Within MFI error, respectively. Further, $\alpha_1 \ldots \alpha_6$ are cofficients to be estimated, with ROA_i, PR30_i, LLR_i, GLP_i, CPB_i, OSS_i, OEXTA_i, and IED_i also as vectors of the independent variables.

Empirical Results and Discussion

The results of the Hausman specification test in table 5 present a *P*-value that is greater than 0.05 for all four models. Consequently, we do not reject the null hypotheses. By this standard, the random effects models are preferred as they offer more consistent and efficient estimators of the true population parameters.

TABLE 5 Hausman Test for Models

Item	Model 1	Model 2	Model 3	Model 4
Chi-square test value	9.26	3.106	7.712	0.835
P-value	0.099	0.54	0.173	0.659

DEPTH OF OUTREACH: AVERAGE LOAN BALANCE PER BORROWER (ALBPB)

From both FE and RE model 1 (table 5), the variables OEXTA, CPB, LLR, and DER are statistically significant, while ROE and PR30 do not achieve any statistical significance. Additionally, the variable coefficients have consistent signs in both models. However, given the results of the Hausman specification test (table 5) with *p*-value being 0.099 and Prob > Chi-Square greater than the level of significance (0.05), we do not reject the null hypothesis. Consequently, RE model 1 (table 6) is the more consistent and appropriate model and will be the basis for onward discussion.

Based on the output of RE model 1, the ratio of operating expenses to the total assets (OEXTA) is statistically significant at 1% and has a negative coefficient. This implies an inverse correlation with the average loan balance per borrower (ALBPB), thus suggesting that an increase in the operating expenses reduces the average loan balance per borrower in

TABLE 6 Model 1 – Average Loan Balance per Borrower (ALBPB)

Variable	FE	RE
Constant	127.562** (54.748)	155.45*** (45.317)
OEXTA	−396.365** (174.063)	−432.724*** (147.16)
ROE	−0.432 (0.339)	−0.523 (0.318)
CPB	2.401*** (0.224)	2.337*** (0.13)
PR30	−94.697 (269.139)	−176.032 (189.09)
LLR	−1035.811*** (327.626)	−1118.762*** (317.259)
DER	−0.865* (0.508)	−1.014** (0.484)
R-squared	0.569	0.847
Mean dep var	414.514	414.514
	F-test (20.058)	Chi-Square (335.020)
	Prob > *F* (0.000)	Prob > Chi-Square (0.000)

NOTES Dependent variable ALBPB, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parenthesis.

the Ghanaian context. This makes economic sense as Rosenberg et al. (2013) describe operating expenses as those costs related to personnel and administration. This means that the more personnel and administrative procedures that MFIS employ, the more costly it becomes for them. Given that the average loan balance per borrower is more about the loan size (amount) per borrower, an MFI that is profit oriented will seek to reduce its operating costs and offer relatively larger loan sizes as lower loan sizes will only increase their operating expenses. Thus, in an effort to achieve profitability, MFIS fail to reach out to the poor as doing so will be more costly for them.

Cost per borrower (CPB) is also statistically significant at 1% with a positive correlation. This means that a higher cost per borrower will generally correspond to a higher average loan balance per borrower. The economic implication is simple – larger loans attract higher costs due to more prestigious levels of services that such clients require. This result is consistent with the findings of existing empirical research highlighting that an increase in loan size generally results in an increase in the cost per borrower (Nawaz 2010). By inference, when MFIS strategically and efficiently reduce their cost of lending, they will be able to target the poor in Ghanaian communities. In this sense, cost efficiency will help deepen an MFI's outreach.

With a statistical significance of 1%, the loan loss rate (LLR) variable is negatively correlated with ALBPB. The InterAmerican Development Bank (2002) describes the loan loss rate as an accounting adjustment rather than a cash reserve and it is ultimately a reserve set aside by MFIS to offset any probable losses incurred. The negative correlation of LLR thus suggests that loans of smaller sizes are assumed to have lower recoverability rates. This has a negative implication on outreach as it discourages MFIS from offering smaller loan sizes, thus the poor who can only afford smaller loans will not have their loan requests granted.

Debt to Equity Ratio (DER) is statistically significant at 5% in table 6 and has an inverse relationship with the average loan balance per borrower. The DER variable offers a realistic overview of the financing structure of MFIS and answers the question of how much of an MFI's asset is funded by debt and equity. Based on the results, when an MFI is financed more by debt it is likely to offer smaller loan sizes, thus targeting the poor in the communities. The reverse also holds that when an MFI is financed more by equity, it will likely offer larger loan sizes on average. As profit-oriented MFIS have been known to offer higher loan sizes on average, we

can infer that equity holders who invest in MFIs generally do so for the sake of profit accrual.

DEPTH OF OUTREACH: PERCENTAGE OF FEMALE BORROWERS (PFB)

Table 7 presents the results of both FE model 2 and RE model 2 in estimating the dynamics of depth of outreach specific to the percentage of female borrowers (PFB). Similar to the previous model, we employ the Hausman specification test to identify which of the two models is appropriate and consistent. The results of the Hausman test (table 5) indicate the RE model to be a consistent and more efficient estimator. Therefore, we consider the output of RE model 2 for further discussion. From the results, OEXTA is statistically significant at 5% and has a positive coefficient while CPD and LLR achieve statistical significance at 1% with a negative and positive coefficient, respectively.

The results of RE model 2 indicate a positive relationship between the ratio of operating expense (OEXTA) to total assets and the percentage of female borrowers, contrary to initial assumptions that increases in operating expenses will be a reason for MFIs to shift their focus away from female borrowers. The empirical findings here indicate that the performance of MFIs in terms of their outreach towards the female population is not negatively affected by increases in operational expenditures. Nevertheless, a purely profit-oriented Ghanaian MFI seeking to either reduce costs or increase total assets, or both, would essentially shift away

TABLE 7 Model 2 – Percentage of Female Borrowers (PFB)

Variable	FE	RE
Constant	0.824*** (0.046)	0.822*** (0.053)
OEXTA	0.133 (0.085)	0.181** (0.076)
CPB	−0.0001 (0)	−0.0004*** (0)
LLR	0.287** (0.126)	0.366*** (0.115)
PFLO	−0.095 (0.076)	−0.065 (0.066)
R-squared	0.346	0.506
Mean dep var	0.797	0.797
	F-test (2.646)	Chi-Square (21.010)
	Prob > *F* (0.018)	Prob > Chi-Square (0.000)

NOTES Dependent variable PFB, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parenthesis.

from female borrowers in the communities. This result is in line with the welfarist approach that places more emphasis on the depth rather than the breadth of outreach. Woller, Dunford, and Woodworth (1999) argue that when an MFI focuses on achieving profitability and sustaining its operation, it tends to shift its attention away from the poor as it favours more creditworthy borrowers, although the poor and marginalized are supposed to be the target for microfinance operations.

Cost per borrower (CPB) is statistically significant with a negative coefficient although the effect is minor as the coefficient is closer to zero. This result suggests that the more MFIS focus on lending to female borrowers, the better their chances of slightly reducing the cost of lending. Essentially, it is necessary for MFIS to strategically seek to achieve a reasonable level of cost efficiency in order to continue focusing on female borrowers.

The output from RE model 2 also proves a positive association between the loan loss rate and the percentage of female borrowers. D'Espallier, Guérin, and Mersland (2011) concluded based on their study that when the percentages of female borrowers are high, the portfolio risks tend to be lower and there are fewer write-offs for MFIS, and thus a reduced number of loan losses. The result of our finding in the context of Ghana can be explained as MFIS shifting towards female borrowers after having suffered previous losses – thus, the higher the loan loss rate, the more they shift to female borrowers in response to previous losses and as a corrective measure. This is an alarming outcome as it points towards noticeable biases against the female borrowers and reveals that profitable MFIS will not necessarily improve their coverage to the female population when write-offs are manageable and loan losses are low.

The percentage of female loan officers (PFLO) variable is not statistically significant in this model, thus suggesting that this is not a key factor in promoting or deepening the coverage of microfinance to the female population in Ghana.

BREADTH OF OUTREACH: NUMBER OF ACTIVE BORROWERS (NACB)

In examining the breadth of outreach of MFIS in Ghana, we employ the number of active borrowers (NACB) variable as an appropriate response variable and estimate the effects that the selected regressors have on its dynamics. Similar to models 1 and 2, we use the fixed and random effects estimation to select the most appropriate model based on the results of the

TABLE 8 Model 3 – Number of Active Borrowers (NACB)

Variable	FE	RE
Constant	29778.488*** (8230.247)	22321.071*** (6928.887)
ROA	19180.658 (17376.738)	23410.792 (16319.978)
PR30	−203.395 (14932.942)	20747.673** (10492.198)
LLR	24946.726 (18092.752)	29141.521 (17759.209)
GLP	0.003*** (0)	0.003*** (0)
CPB	−90.039*** (14.896)	−72.557*** (8.316)
OSS	−12427.047* (6953.855)	−11515.462** (5843.544)
R-squared	0.701	0.748
Mean dep var	16497.028	16497.028
	F-test (35.943)	Chi-Square (292.356)
	Prob > *F* (0.000)	Prob > Chi-Square (0.000)

NOTES Dependent variable NACB, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parenthesis.

Hausman specification test. Table 8 presents the results of both FE and RE models. However, given the outcome of the Hausman test (table 5), we identify the RE model 3 as consistent, and thus the preferable model which will be the basis for further discussion.

From table 8, it is evident that ROA as a measure of profitability does not have a statistically significant effect on the number of active borrowers although it has a positive coefficient. The portfolio at risk variable with a 30-day threshold (PR30), is however, statistically significant and exhibits a positive correlation with the number of active borrowers. This outcome is contrary to the findings of Abdulai and Tewari (2017), who rightly identified portfolio at risk as a main determinant of MFIS' outreach but also established a negative correlation between portfolio at risk and MFIS' outreach. Given that this study is taken in the context of Ghana, a possible implication of our findings is that when MFIS attempt to pursue lower credit risk, their ability to effectively pursue the goal of outreach will be hampered. RE model 3 also suggests that the loan loss rate has no statistically significant effect on the number of active borrowers.

Gross loan portfolio (GLP) appears to be statistically significant in RE model 3 and has a positive correlation with NACB. This suggests that increasing the gross loan portfolio will directly increase the number of active borrowers. The implication is that MFIS can increase their breadth of

outreach without harming their own efficiency in the process. However, as the GLP measure includes both delinquent and renegotiated loans as well as current loans, it is essential for MFIS to strategically attempt to reduce the proportion of delinquent and renegotiated loans so as not to harm their profit-making attempts. Our results, therefore, indicate that the more an MFI is credit efficient, the more it can improve and increase its breadth of outreach.

Cost per borrower (CPB) is statistically significant and negatively correlated with NACB. The economic implication is that an increase in the cost per borrower reduces the number of active borrowers such that profit-oriented MFIS will reduce their breadth of outreach in an attempt to reduce the cost of lending. Operational self-sufficiency (OSS) is also statistically significant and negatively correlated with NACB, following the same pattern as CPB. This suggests that the number of active borrowers decreases when an MFI increases its outward sustainability. Ultimately, an MFI that is efficiently able to reduce its lending costs can securely increase its breadth of outreach. Thus, outreach may be hindered by profitability but efficiency, on the other hand, encourages it.

BREADTH OF OUTREACH: NUMBER OF DEPOSITORS OF VOLUNTARY TIME DEPOSITS (NDVTD)

Table 9 presents the results of both FE and RE estimates for model 4. However, the results of the Hausman test (table 5) points towards the RE model 4 being the most consistent estimator and thus, the basis for discussion.

TABLE 9 Model 4 – Number of Depositors of Voluntary Time Deposits (NDVTD)

Variable	FE	RE
Constant	2483.542 (3628.55)	3736.551** (1617.038)
OEXTA	−3639.68 (10788.983)	−9531.055** (4616.263)
IED	0.001 (0.001)	0.002** (0.001)
ROA	−686.653 (9225.356)	−6773.764 (6381.51)
R-squared	0.067	0.303
Mean dep var	1909.788	1909.788
	F-test (0.358)	Chi-Square (12.590)
	Prob > *F* (0.978)	Prob > Chi-Square (0.006)

NOTES Dependent variable NDVTD, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parenthesis.

From table 9, operating expense divided by total assets (OEXTA) is statistically significant and has a negative correlation with the number of depositors of voluntary time deposits (NDVTD). At the same time, interest expense on deposits (IED) is also statistically significant and has a positive relationship with the NDVTD. Both explanatory variables are significant at a 5% level of significance while ROA does not achieve any statistical significance in this model.

The costs of daily operational activities are captured in the operating expenses of an MFI. As such, our results indicate that when an MFI's operating costs increase, it negatively affects the number of depositors who have voluntary deposit accounts because of the transmission effects of costs, as MFIS will generally attempt to reduce that cost from a number of sources. In that regard, interest expenses paid on these deposit accounts are the most likely to be affected. The consequence of this action will be a reduction in deposits especially, as interest gain is among the main reasons for most Ghanaians holding a deposit account to begin with (Boadi, Li, and Lartey 2015). Additionally, an increase in total assets will reduce the ratio of operating costs to total assets and this will subsequently result in an increase in NDVTD. The implication is that a profit-seeking MFI will tend to have more depositors, thus profitability increases the breadth of outreach.

Interest expense on deposits (IED) captures the expense that an MFI will incur on interest-bearing deposits and this is counted as a cost for the MFI. Our results reveal a positive correlation with NDVTD and rightly so in the context of Ghana. Interest rates have become a motivator for people to save in financial institutions (Boadi, Li, and Lartey 2015). Consequently, the higher the interest expense on deposits, the more the depositor accrues in interests from holding a deposit account with the MFI. Although the correlation is positive, it is also minor. This can be explained by the generally limited trust that the Ghanaian populace have in MFIS considering the history of less, or in some cases no, regulation as compared to mainstream banks.

Conclusion

The results of the consistent models in this paper reveal that in an attempt to attain and maintain financial self-sufficiency, MFIS in Ghana inadvertently exclude the poor as they provide larger loan sizes as a cost reduction measure. This is consistent with the findings of Khan et al. (2016), who noted that microfinance outreach is deeper when smaller loan sizes

are offered, thus ensuring that the poor can have access. However, given that smaller loan sizes in Ghana are associated with higher risks of default based on our results, it is no wonder that MFIs lean more towards higher loan sizes, which then inhibits the depth of outreach. Our results also reveal that MFIs that are largely financed by equity offer larger loan sizes while those MFIs that are financed by debt tend to offer smaller loan sizes. The implication is that when MFIs focus on sustainability, they tend to shift their attention away from outreach. Additionally, our findings suggest that MFIs' depth of outreach specific to targeting the female population is not negatively affected by increases in operational costs. However, when MFIs in Ghana pursue thorough operational cost cutting, that could lead to female exclusion as no conscious attempt at targeting female borrowers will be made because of the higher costs involved in such attempts.

Furthermore, our results indicate that an MFI's attempt to achieve profitability has a negative effect on the breadth of outreach. An MFI needs to achieve operational self-sufficiency to be able to increase its outreach to the poor and at the same time cover its costs to ensure continuity (Remer and Kattilakoski 2021). We observe that an MFI that strategically reduces its cost per borrower, thus improving its cost efficiency, is able to broaden its breadth of outreach. At the same time, gross loan portfolio is observed to be positively correlated with the breadth of outreach. On the other hand, our findings also reveal that MFIs face increased risk as they broaden their outreach given the positive correlation that the portfolio at risk variable has on outreach. More so, interest expenses on deposits are observed to have a positive correlation with breadth of outreach as interest is a major factor that drives people to hold deposit accounts. However, when considering operating expenses as a ratio to total assets, we observe a negative correlation with outreach.

These findings provide deeper insights into the effects of sustainability measures on MFI outreach in Ghana and also provide evidence that the financial performance of MFIs in Ghana has a direct impact on their ability to reach out to and support the poor. The social and economic implications of these findings are enormous. First, we reveal that there are noticeable biases against female borrowers as MFIs do not deliberately attempt to improve their coverage to the female population on a *'good day'* when loan losses are manageable, and risks are low. This reveals gender equality cracks in the microfinance sector and highlights the need for government and other stakeholders to incentivize the targeting

of female borrowers to bridge any existing gaps as well as provide adequate social infrastructures that are able to connect poor borrowers to MFI services. Additionally, given the still existing lack of confidence in the microfinance sector, the establishment of a properly functioning national insurance deposit system will do well to restore the lost confidence. This has been established in countries like Canada, USA and Nigeria, and it works (Boateng 2015). Finally, having established that efficiency promotes outreach, it becomes necessary for prudent MFI regulatory bodies to incorporate efficiency standards as a matter of regulation.

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Modelling Stock Market Volatility During the COVID-19 Pandemic: Evidence from BRICS Countries

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The objective of the research paper is to identify the stock market volatility pattern of BRICS countries during the outbreak of the COVID-19 pandemic. The study is based on the time series data, which consists of the daily closing price of the BRICS countries' index for a two-year (pandemic) period from 1st January 2020 to 31st December 2021. Both the symmetric and asymmetric models of Generalized Autoregressive Conditional Heteroscedasticity (GARCH) have been employed in the study to investigate whether volatility changes over the pandemic period. The result of the GARCH-M (1, 1) model evidenced the presence of a positive and insignificant risk premium. Based on the empirical work carried out using the market index of BRICS countries, it was found from EGARCH (1,1), and TGARCH (1,1) models that there exists a leverage effect in the countries, viz. Brazil, Russia, India, China and South Africa. Since the stock price during the pandemic period triggered the entire financial market, the investors, fund managers and portfolio managers should be more aware of the uncertainty and need to adjust their investments accordingly.

Key Words: BRICS countries, conditional volatility, GARCH models, leverage effect, market return
JEL Classification: C32, C53

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Introduction

The virus called corona, which originated in Wuhan City, China has a dangerous effect on the life of humans and caused, foremost, ruin in the global market. Since stock prices are highly sensitive to major events which occur worldwide, the outbreak of COVID-19 influenced and affected the stock return widely. The stock market and its investors always react to every economic and major event which happens worldwide (De Bondt and Thaler 1990). The stock market has both a positive and

negative impact on economic events; for instance Taqi, Shamin, and Ajmal (2018), and Lodha, Kumawat, and Bapna (2018) explored the impact of demonetization on different sectors in the Indian capital market. So far, even natural catastrophes have registered significant influence on the global market. There have been many studies which made an attempt to explore the effect of natural calamities on the capital market (Kim 2011; Wang and Kutan 2013). Equally, the stock market also responded to epidemic diseases such as SARS and H7N9, which caused a negative impact on human health and the economy. For instance, Chen et al. (2009) investigated the impact on the stock market during the Severe Acute Respiratory Syndrome (SARS) outbreak. Gu et al. (2014) and Qui et al. (2018) pointed out that the social and economic impacts of H7N9 disease did not spread widely and were not as serious as in the case of SARS.

The economic effect has become worse in many countries during this current outbreak. BRICS is the emerging countries (Brazil, Russia, India, China and South Africa) that play a key role in promoting economic and regional development and thereby removing trade barriers. These countries have also faced problems in the course of the pandemic. During the outbreak of COVID-19, the stock price indexes of most of the countries were significantly diminished. Hence, to gain awareness of the impact of COVID-19 on the stock market, BRICS countries in particular are taken into consideration for the study.

The univariate GARCH model is the most popular method used to examine volatility and the extension of the GARCH-M model is the best one to identify the risk return relationship (Engle, Lilien, and Robins 1987). Further extension models, viz. EGARCH and TGARCH, will help to identify the asymmetric volatility and the existence of the leverage effect (Nelson 1991; Zakoian 1994). Hence, the present research paper focused on identifying the volatility fluctuations of BRICS countries during the COVID-19 pandemic period by incorporating different univariate GARCH family models. Therefore, based on the literature and background, the following objectives are framed:

1. To explore the volatility pattern of BRICS countries indices using a symmetric and asymmetric model.
2. To detect whether the daily return series show the leverage effect using asymmetric models.

The research paper is organized in such a way that it presents a deep background of the literature in the second section, followed by research

methodology in the third section. The study elaborates on the result and interprets it in detail in the fourth section. Finally, the study is concluded in the fifth section.

Literature Review

Several studies have scrutinized the relationship between return and risk (volatility) using the GARCH models developed by Bollerslev (1986), since it is an exact prediction of volatility in the equity market. Among GARCH models, the GARCH-M model postulates the exact relationship between return and risk. For instance, Dean and Faff (2001), Karmakar (2007), Wang and Yang (2013), Banumathy and Azhagaiah (2015), and Singh and Tripathi (2016) used the GARCH-M model in their study and proved the positive relation which exists between return and conditional variance. Yakob and Delpachitra (2006) examined the relationship between risk and return of 10 countries in the Asia-Pacific region. The result of the study revealed that out of ten, only two countries showed an insignificant relationship with negative coefficients. Zakaria and Winker (2012) empirically tested the volatility of two major countries, Sudan (Khartoum Stock Exchange) and Egypt (Cairo and Alexandria Stock Exchange) over the period of five years. Using the symmetric model of GARCH-M, the study found a positive and statistically significant relationship exists for both the markets. Further, Tah (2013) investigated the stochastic behaviour of the Nairobi Stock Exchange of Kenya and Lusaka Stock Exchange of Zambia, and using the GARCH-M model it was found that there was no significant relation between conditional variance and expected return for Kenya whereas there exists a negative and significant relation for Zambia. Similarly there exists a negative and significant abnormal return in the Indonesia Stock Exchange during the pandemic period (Endri et al. 2021). On the other hand, many studies were undertaken to capture asymmetry in volatility clustering using the variations in GARCH models called EGARCH and TGARCH. The returns of the Egyptian stock market during the period 1998 to 2009 were used to study volatility and proved that EGARCH is the best fit model for measuring volatility clustering (Ahmed and Aal 2011).

The COVID-19 pandemic has been the most susceptible period, which not only affected human life but also exaggerated the economy worldwide; for instance, the exchange rate of the Japanese Yen became stronger during COVID-19 (Narayan, Devpura, and Wang 2020). Recently, in the Indian context, a study was made by Singh, Makhija, and Chacko (2021)

which attempted to identify the effect of COVID-19 on investment and proved that the currencies volatility increased, and that the Indian S&P ESG 100 index's return and volatility does not depict any effect because of the COVID-19 crisis. Studies have been done by various researchers in examining the volatility of the stock market due to the COVID-19 virus. Ngu, Mahdi, and Szulczyk (2021) studied the impact of COVID-19 on the stock market volatility of Malaysia and Singapore with the help of the EGARCH model, using the daily closing indices between 1st July 2019 and 31st August 2020 and pointed out the existence of the leverage effect in both the markets. Mohammad, Shabbir, and Chavali (2020) proved that the Indian stock market had a positive average abnormal return during the lockdown period and a negative abnormal return during the pre-lockdown period, while the uncertainty of COVID-19 adversely affected the US stock market (Xu 2021). Bouri et al. (2021) argued that COVID-19 influenced the market very strongly for emerging stock market. The affected countries' (Belgium, China, France, Germany, Italy, the Netherlands, South Korea, Spain, Switzerland, the United Kingdom, and the United States) stock market indices showed a negative impact on their return because of the delayed market responses (Khatatbeh, Hani, and Abu-Alfou 2020). Naik and Reddy (2021) showed the evidence that the GARCH model is superior in forecasting volatility. Recently, few researchers examined the systemic risk spill over effects among global markets during the COVID-19 pandemic (e.g. Jiang, Fu, and Ruan 2019; Abuzayed et al. 2021; Choi 2022).

There are only a few studies which examined the stock market volatility among BRICS countries, for instance, Bouri et al. (2018), using the 'Bayesian Graphical Structural Vector Autoregressive (BGSVAR) model,' examined the volatility among BRICS countries concurrently with nine predictor variables (Canada, France, Germany, the Netherlands, Japan, Sweden, Switzerland, the UK and US), together with two commodity markets (Gold and Oil). The study found that the US is the major dominating predictor in BRICS, whereas the same is not present in Brazil and China, indicating that people are more conscious about the local market when compared to the US market. The risk spillovers between the BRICS stock markets and precious metal markets were examined by Jiang, Fu, and Ruan (2019) using the GARCH models and they pointed out that the volatility is long persisting and fluctuates greatly for a prolonged period.

Although there were many studies that concentrated on the pandemic impact among many developing and developed countries, there were no

sufficient studies concentrating on the BRICS countries, especially during the pandemic period. Hence, the present study concentrated on exploring the volatility clustering of BRICS countries. The present study applied symmetric as well as asymmetric GARCH models to identify the facts of return.

Research Methodology

DATA SOURCE

The present paper customizes secondary data which were collected from official websites (www.yahoofinance.com; www.investing.com). The stock indices of Brazil (BOVESPA), Russia (IMOEX), India (Nifty 50), China (SSE Composite Index) and South Africa (SA Top 10) have been taken for the study. COVID-19 originated in Wuhan city at the end of 2019; it started spreading all over the world gradually and India was a victim in January 2020 (Andrews et al. 2020). Hence, to identity and examine the volatility clustering, especially during the pandemic period, the daily closing prices of the BRICS market index have been collected from 1st January 2020 to 31st December 2021.

RESEARCH METHODS

Pertinent econometric tools, viz. the normality test, unit root test, ARCH-LM test and GARCH family model were used and have been analysed using the Eviews 10 Econometrics package. The returns (r_t) of each BRICS country were calculated using the following formula:

$$r_t = \frac{P_t}{P_{t-1}} \times 100, \tag{1}$$

where r_t is logarithmic daily return on BRICS index for time t, P_t is closing price at time t, and P_{t-1} is corresponding price in the period at time $t-1$.

BASIC STATISTICAL TOOLS USED IN THE STUDY

First, the descriptive statistics have been calculated to know whether the returns are normally distributed for the study period:

H0 *Data are normally distributed (JB = 0).*

H1 *Data are not normally distributed (JB ≠ 0).*

Second, for checking whether the data are stationary or non-stationary, the unit root test called the Augmented Dickey-Fuller Test (ADF) has been employed (Dickey and Fuller 1979):

H0 *Returns are non-stationary (there is a unit root).*

H1 *Returns are stationary (there is no unit root).*

Third, the Lagrange Multiplier (LM) test for Autoregressive Conditional Heteroscedasticity (ARCH) is used to test the presence of heteroscedasticity in the residual of the return series.

H0 *There is no ARCH effect.*

H1 *There is an ARCH effect.*

TECHNIQUE USED FOR VOLATILITY MEASUREMENT

The study used symmetric and asymmetric Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models to identify the volatility clustering and leverage effects. Symmetric models, viz. GARCH (1, 1) and GARCH-M (1, 1) were employed for modelling conditional volatility and EGARCH (1, 1) and TGARCH (1, 1) were applied for modelling asymmetric volatility.

GENERALIZED AUTOREGRESSIVE CONDITIONAL HETEROSCEDASTIC (GARCH) MODEL

Bollerslev (1986) independently developed the GARCH model, which lets the conditional variance be dependent upon previous own lags. The simplest model specification of GARCH (1, 1) is as follows:

Mean equation: $r_t = \mu + \epsilon_t$,
Variance equation: $\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \alpha\epsilon_{t-1}^2$,

where $\omega > 0$, $\alpha_1 \geq 0$, and $\beta_1 \geq 0$, and r_t is return of the asset at time t, μ is average return, ω is constant term, α is coefficient of the ARCH term, β is oefficient of the GARCH term, and ϵ_t is residual return.

GARCH-IN-MEAN (GARCH-M) MODEL

The extension of the GARCH model is the GARCH-M model that lets the conditional mean depend on its conditional variance. A simple GARCH-M (1, 1) model can be written as:

Mean equation: $r_t = \mu + \lambda\sigma_\tau t^2 + \epsilon_t$,
Variance equation: $\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2$.

The parameter λ in the mean equation is called the risk premium. A positive λ indicates that the return is positively related to its volatility.

EXPONENTIAL GARCH MODEL

This model is used to identify the presence of the leverage effect. The model was developed by Nelson (1991) and it is given by the following equation:

$$Ln(\sigma_t^2) = \omega + \beta_1 Ln(\sigma_{t-1}^2) + \alpha \left\{ \left| \frac{\epsilon_{t-1}}{\sigma_{t-1}} \right| - \sqrt{\frac{2}{\pi}} \right\} - \gamma - \frac{\epsilon_{t-1}}{\sigma_{t-1}}. \quad (2)$$

THRESHOLD GARCH MODEL

The threshold GARCH was developed by Zakoian (1994) and the generalized specification for the conditional variance is given by:

$$\sigma_t^2 = \omega + \alpha_1 \epsilon_{t-1}^2 + \gamma d_{t-1} \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \quad (3)$$

where d_{t-1} if $\epsilon_{t-1} > 0$ means 'bad news' and 0 if $\epsilon_{t-1} \geq 0$ means 'good news.' The leverage parameter γ, if significant and positive, denotes that negative shocks have a greater effect on σ_t^2 than positive shockwaves.

Results

Table 1 shows the descriptive statistics and the result of the ADF and ARCH LM test. The descriptive statistics for the original data of five market indexes during the pandemic period has been tabulated clearly. It is clear from the table that the raw dataset shows a vast difference in the mean and standard deviation value, which evidently exhibits a structural difference among BRICS countries. Figure 1 shows the daily time series

TABLE 1 Descriptive Statistics, ADF Test and ARCH LM Test of BRICS Countries

Item	Brazil	Russia	India	China	S. Africa
(a) Mean	107909.3	3318.204	13574.85	3331.205	55274.51
Standard deviation	14200.26	508.4722	2800.860	273.8620	6624.586
Skewness	−0.810510	0.054827	−0.067144	−0.810423	−0.518018
Kurtosis	3.1911	1.9362	1.8846	2.3602	2.6936
Jarque-Bera Statistics	56.5045*	24.2533*	26.7638*	64.3973*	24.7554*
(b) ADF Statistics	−27.6626*	−22.9366*	−22.6908*	−21.8792*	−22.9366*
MacKinnon one side critical values: 1% −3.4430; 5% −2.8670; 10% −2.5697					
(c) F Statistic	220.5273*	8.559979*	12.27954*	3.791872*	1.296248*
ObsR-squared (TR2)	154.1049*	154.1049*	154.1049*	3.778518*	1.298050*

NOTES Row headings are as follows: (a) descriptive statistics, (b) ADF test, (c) ARCH LM test. * Significant at 1%. Computed results based on secondary data.

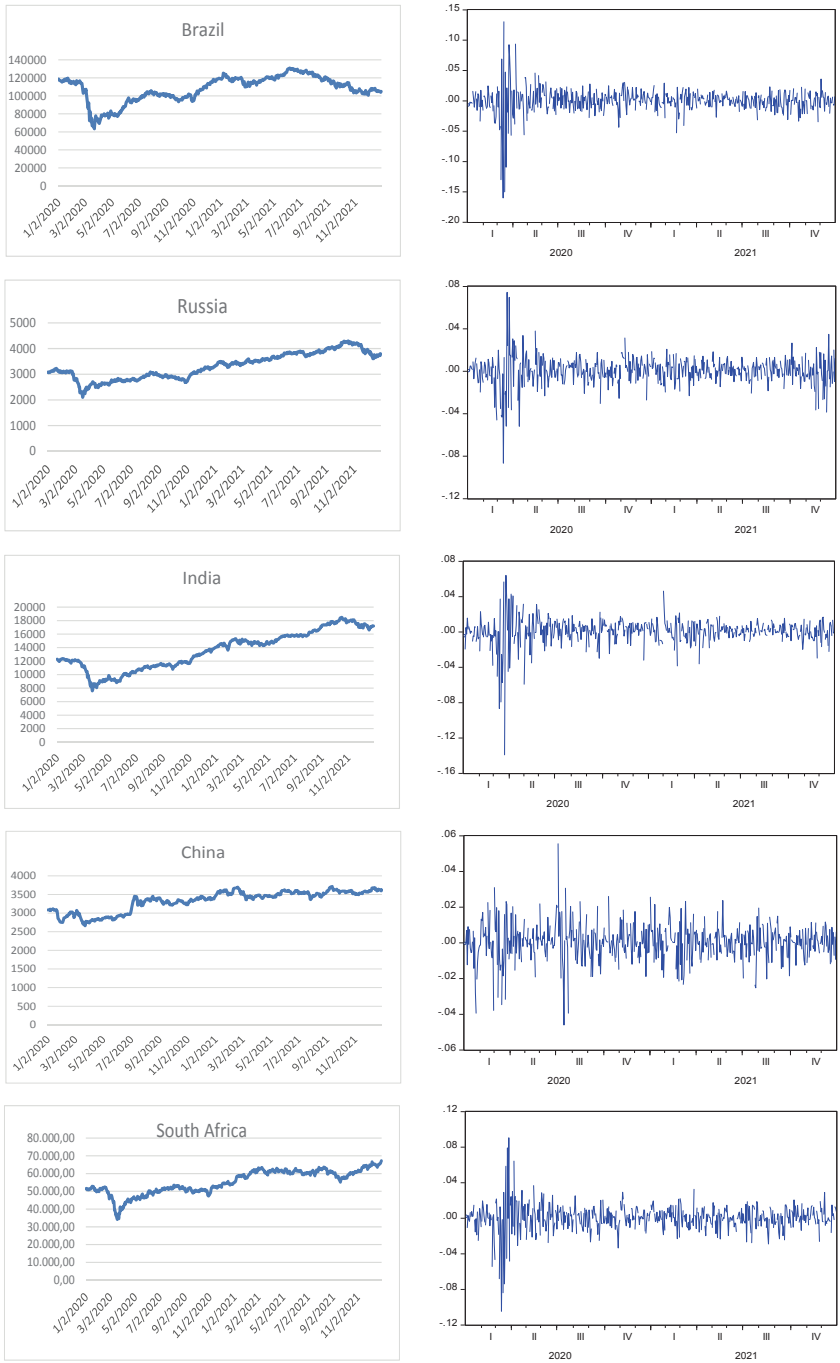

FIGURE 1 The Daily Prices (left) and the Returns (right) of BRICS Countries

data set (left) and the return series (right) of BRICS countries. It is inferred from the graphs on the right that there are bounces over the study period which denote that volatility is relatively high and low, exhibiting the volatility clustering covering the aforesaid period. All BRICS countries' stock indexes exhibit negative skewness (except Russia) and kurtosis greater than three (Brazil) indicates that the dataset has heavier tails, which does not accompany a normal distribution, i.e. there is a presence of large movements of share price over the sample period.

The value of the JB test rejects *H*o as the statistics are significant at 1%, denoting that during the period of COVID-19, the stock prices were not normally distributed. To test the stationarity, the Augmented Dickey Fuller test (ADF) is applied and the result shows that the returns are stationary at levels for all the countries. The *p* values of ADF statistics are less than 0.05, indicating that the time series data for the study period is stationary. Hence, the hypothesis *'Ho: Returns are non-stationary'* was rejected at level for the BRICS countries, as the ADF statistics are significant at the 1% level, indicating the series are stationary and exhibiting the presence of a unit root.

Before applying GARCH, it is essential to check the presence of the ARCH effect in the return series. Since the p value is less than 0.05 and test statistics are highly significant at 1% the null hypothesis *'Ho: There is no ARCH effect'* is rejected, confirming the presence of the ARCH effect in the residuals and hence the outcome permits for the estimation of GARCH extension models. The results depict the presence of volatility clustering in the return series.

Figure 1 shows the daily prices and the returns of BRICS countries.

Table 2 depicts the result of the GARCH (1, 1) model where α and β determine the short-run dynamics of the volatility. In the conditional variance equation, ARCH term (α) and GARCH term (β) are extremely significant at 1%. The sum of these coefficients (α and β) are also close to unity, indicating that the shock at time t will continue to future periods of BRICS countries, indicating that the volatility is persistent. However, it is proved that the variance equation is well specified and does not exhibit an additional ARCH effect for the entire study period by applying the ARCH-LM test on residuals.

Table 3 reports the result of the GARCH-M (1, 1) model, which is used to find the risk and return relationship among the stock index of BRICS countries. The constant (μ) in the mean equation is insignificant, which indicates that the returns are not up to the level for investment. The con-

TABLE 2 Results of GARCH (1, 1) Model

Coefficients	Brazil	Russia	India	China	S. Africa
(a) μ (constant)	0.2866	0.0294**	0.1586**	0.0104	0.3558
(b) ω (constant)	30.645*	0.0055**	0.0922*	0.0116*	3.3023**
α (ARCH effect)	0.1393*	0.0971*	0.0971*	0.1203*	0.0829*
β (GARCH effect)	0.7546*	0.8686*	0.8693*	0.7810*	0.8518*
$\alpha + \beta$	0.8939	0.9657	0.9664	0.9013	0.9347
Log likelihood	−2137.864	−196.9624	−921.9628	−151.3065	−1695.782
Akaike Info. Crit. (AIC)	8.4325	0.7911	3.6455	0.6114	6.6920
Schwarz Info. Crit. (SIC)	8.4658	0.8245	3.6788	0.6447	6.7253
(c) ARCH-LM test stat.	0.1297	0.7617	0.1039	0.1920	0.8875
Prob. Chi-square (1)	0.7182	0.3822	0.7467	0.6606	0.3456

NOTES Row headings are as follows: (a) mean, (b) variance, (c) test for heteroscedasticity. Computed results based on secondary data. * Significant at 1% level, ** significant at 5% level.

TABLE 3 Results of GARCH-M (1, 1) Model

Coefficients	Brazil	Russia	India	China	S. Africa
(a) μ (constant)	0.1517	−0.0043	0.0935	0.0043	−0.4330
λ (risk premium)	0.0005	0.0978	0.0329	0.0619	0.0184
(b) ω (constant)	30.6660*	0.1044	0.0982**	0.0116**	3.3361
α (ARCH effect)	0.1394*	0.1500	0.1024*	0.1206*	0.0839
β (GARCH effect)	0.7545*	0.6000*	0.8621*	0.7806*	0.8500
$\alpha + \beta$	0.8939	0.7500	0.9645	0.9012	0.9339
Log likelihood	−2137.855	−287.2466	−921.6941	−151.2896	−1694.869
Akaike Info. Crit. (AIC)	8.436437	1.1505	3.6484	0.6153	6.6923
Schwarz Info. Crit. (SIC)	8.478076	1.1922	3.6900	0.6569	6.7340
(c) ARCH-LM test stat.	0.112659	0.5063	0.2253	0.1829	0.7763
Prob. Chi-square (1)	0.7367	0.4761	0.6344	0.6683	0.3777

NOTES Row headings are as follows: (a) mean, (b) variance, (c) test for heteroscedasticity. Computed results based on secondary data. * Significant at 1% level, ** significant at 5% level.

ditional variance's coefficient (λ) in the mean equation is insignificant, which implies that returns are independent of the risk due to conditional variance in the return series. It shows that the estimated coefficient of risk premium (λ) in the mean equation is positive but insignificant for

TABLE 4 Result of EGARCH (1, 1) Model

Coefficients	Brazil	Russia	India	China	S. Africa
(a) μ (constant)	−0.1103	0.0200	0.1085	0.0074	0.1665
(b) ω (constant)	0.2650**	−0.2248*	1.0656*	−0.4680*	0.1483**
α (ARCH effect)	0.1747*	0.1516**	0.3191*	0.2582*	0.1053**
β (GARCH effect)	0.9280*	0.9466*	−0.3457**	0.8744*	0.9411*
γ (leverage effect)	−0.1326*	−0.0992*	0.2153*	−0.0243	−0.1474*
$\alpha + \beta$	1.1027	1.0982	0.0266	1.1326	1.0464
Log likelihood	−2133.955	−194.2449	−965.0866	−153.2841	−1691.511
Akaike Info. Crit. (AIC)	8.4210	0.7844	3.8192	0.6231	6.6791
Schwarz Info. Crit. (SIC)	8.4627	0.8260	3.8608	0.6648	6.7208
(c) ARCH-LM test stat.	0.4175	1.1681	4.2945	0.0737	0.7303
Prob. Chi-square (1)	0.5175	0.2794	0.1387	0.7856	0.3922

NOTES Row headings are as follows: (a) mean, (b) variance, (c) test for heteroscedasticity. Computed results based on secondary data. * Significant at 1% level, ** significant at 5% level.

the study period, indicating that higher risk, provided by the conditional variance, will not certainly lead to higher returns.

Finally, the ARCH-LM test statistics are employed to check whether the model fulfilled all the conditions of the model or not and the results prove that the p value of the ARCH-LM test is above the 5% level, so the hypothesis cannot be rejected, revealing that the LM test did not exhibit any additional ARCH in the residuals, which signifies that the variance equations are well specified.

EGARCH (1, 1) is employed for analysing the asymmetrical effect of volatility in BRICS countries and the results are reported in table 4. It reveals that the coefficient of the ARCH effect (α) and GARCH (β) are significant and positive, which indicates that volatility is present in BRICS countries. The ARCH coefficient α and coefficient of GARCH, β, are greater than one (except India), indicating that the conditional variance is volatile and unstable. The leverage coefficient γ is significantly positive at the 1% level for all countries except China, providing the presence of the leverage effect in the return during the study period. Since the coefficient of the leverage effect (γ) is significant, it reveals that there is a significant impact of the COVID-19 period on the volatility of BRICS countries.

Another model to test the asymmetric volatility in BRICS countries is

TABLE 5 Result of TGARCH Model

Coefficients	Brazil	Russia	India	China	S. Africa
(a) μ (constant)	−0.1964	0.0215	0.1215**	0.0094	0.0961
(b) ω (constant)	32.752*	0.0063**	0.1069*	0.0123**	2.4923*
α (ARCH effect)	−0.0063	−0.0012	−0.0249**	0.1135*	−0.0534*
β (GARCH effect)	0.7861*	0.8936*	0.8846*	0.7719*	0.9163*
γ (leverage effect)	0.1924*	0.1149*	0.1718*	0.0200	0.1671*
$\alpha + \beta$	0.7798	0.8942	0.8597	0.8854	0.8629
Log likelihood	−2132.091	−191.8238	−911.3339	−151.2518	−1684.186
Akaike Info. Crit. (AIC)	8.4137	0.7748	3.6076	0.6151	6.6503
Schwarz Info. Crit. (SIC)	8.4553	0.8165	3.6492	0.6568	6.6919
(c) ARCH-LM test stat.	0.0202	0.6282	0.0029	0.1074	0.377054
Prob. Chi-square (1)	0.8866	0.4274	0.9569	0.7426	0.5385

NOTES Row headings are as follows: (a) mean, (b) variance, (c) test for heteroscedasticity. Computed results based on secondary data. * Significant at 1% level, ** significant at 5% level.

TGARCH (1, 1) and the result is shown in table 5. It helps to study the presence of leverage effects in the returns of the BRICS indices during the pandemic period. In the TGARCH (1, 1) model, the coefficient γ (leverage effect) is known as the asymmetry or leverage parameter, which is positive and highly significant for Brazil, Russia, India and South Africa. It indicates that when compared to positive shocks, the negative shocks have a greater effect on the conditional variance. Hence it is proved from the TGARCH (1, 1) model that the negative shock is because of COVID-19, where the entire BRICS countries indexes have been affected. Moreover, the LM test statistic for the TGARCH (1, 1) model does not show any additional ARCH effects in the residual, which implies that the 'variance equation is well specified.'

Conclusion

The present study tested the volatility of the BRICS index using the symmetric and asymmetric GARCH models. Daily closing prices of the BRICS countries index from January 1, 2020 to December 31, 2022 have been used for the analysis. Symmetric models, GARCH (1, 1), GARCH-M (1, 1) and asymmetric models, EGARCH (1, 1), and TGARCH (1, 1) were employed in the study to identify the volatility pattern and leverage effect. From the symmetric models it was found that the risk premium is

insignificant for all BRICS countries, indicating that the daily returns are not associated with risk due to past volatility. The result of the symmetric models supports the findings of Karmakar (2005), Banumathy and Azhagaiah (2015), and Zakaria and Winker (2012), whereas the result of GARCH-M (1, 1) is opposed to the findings of Karmakar (2007), which exhibits a significant risk premium. However, from the asymmetric models, viz. EGARCH (1, 1), and TGARCH (1, 1), the study found the 'presence of leverage effect in all four countries except China' (Karmakar 2007; Zakaria and Winker 2012). Overall, the study proves that the BRICS countries indexes were more volatile during the period of COVID-19, which does not considerably provide a better return.

The implications of the present study's findings will be fruitful for individual and institutional investors as it evidences the presence of risk during the sample period. The volatility bounces enormously during the aforesaid sample period which triggered the entire financial market, and it paves the way for the investors, fund managers and portfolio managers to be more aware about the risk and to adjust their investments accordingly.

The objective of the present study is to model the volatility pattern of the return structure in emerging BRICS countries. The research tried to examine the volatility clustering and its leverage effects using univariate GARCH models and their extension. Further research can be extended to concentrating on using the multivariate GARCH model, which uses not only variances but also covariances. Moreover, other emerging countries can also be taken as a sample for the accomplishing of better results worldwide.

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Re-Examining the South African Reserve Bank's Policy Reaction Function Using the NARDL Model

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The 3–6 percent inflation target is a policy rule used by the South African Reserve Bank (SARB) to fulfil its statutory obligation of ensuring a low and stable inflation environment and its policy reaction function assesses how the Reserve Bank responds to deviations of inflation from its target. We rely on nonlinear autoregressive distributive lag (NARDL) models to estimate the asymmetric preferences which the Reserve Bank has to inflation deviations during rising and falling episodes of inflation. Using quarterly data spanning from 2002:q1 to 2021:q4, we estimate the policy reaction functions using 7 disaggregated measures of inflation to capture the heterogeneity in the formation of price expectations. We further segregate our data into two sub-periods, corresponding to the pre-crisis and post-crisis era, as a robustness exercise. Overall, our findings indicate that in the post-crisis era the SARB (i) has become more responsive to inflation, output fluctuations and exchange rates and (ii) has responded more aggressively to rising inflation than falling inflation.

Key Words: Taylor rule, nonlinear policy reaction function, nonlinear autoregressive distributive lag (NARDL) model, survey-based inflation expectations, South Africa
JEL Classification: C22, C51, E43, E52

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Introduction

The statutory mandate of the South African Reserve Bank (SARB) is to protect the (purchasing) value of currency in the interest of balanced and sustained economic growth. In 2001, the SARB intensified its commitment to these statutory obligations by abandoning its previous monetary targets/eclectic monetary policy and adopting a fully-fledged inflation targeting (IT) framework hinged on a policy rule of keeping inflation within a 3–6% target range. Essentially, the IT regime is a forward-

looking monetary policy framework, in which the Reserve Bank makes econometric projections for future inflation rates at forecast periods of 12 to 24 months in advance. If inflation is expected to exceed its upper target bound of 6 percent, then the central bank raises the repo rate in anticipation of the target breach. This, in effect, does two things. Firstly, this 'cools' the real economy by suppressing demand pressures and consequentially lowering inflation back to its target via various monetary transmission mechanisms (Botha et al. 2017). Secondly, higher interest rates protect the purchasing power of savers and investors by ensuring that the returns gained from financial institutions offset the changes in the prices of goods and services.

Ultimately, the extent to which the Reserve Bank can contain inflation within its target and smooth out business cycle fluctuations is dependent upon the central bank's response to deviations of inflation and output growth from their fundamentals. The policy reaction function, first introduced by Taylor (1993), is traditionally used to gain insight into the behaviour of an independent monetary policymaker whose prime objective is to stabilize inflation around predetermined targets. This 'rules-based' monetary policy approach is considered a 'time-consistent solution' to the dynamic optimization problem faced by monetary authorities in simultaneously stabilizing inflation at low rates and minimizing growth losses (Kydland and Prescott 1977). If the Taylor rule holds, then a central bank can be deemed to have sufficient independence and credibility to respond to positive (negative) inflation deviations from its target without driving the economy to a recession (overheating the economy).

There are some stylized facts observed from the time series plot of repo rate, inflation expectations and the output gap presented in figure 1 which provide insights into the performance of the SARB in keeping inflation within its target using a rules-based policy. We particularly observe that whilst the repo rate appears to positively track both inflation and output gap (i.e. higher (lower) repo movements are synchronized with higher (lower) inflation and output gap), the Reserve Bank has had varying success in keeping inflation within its target. For instance, during the early adoption of the framework, as well as during the build-up to the global financial crisis (GFC), when inflation was generally rising, the SARB missed its target by wide margins. However, subsequent to the post-GFC, which is generally characterized by periods of lowering inflation rates, the Reserve Bank seems to have had more success in containing inflation within its target. This, in turn, implies that the Taylor rule dy-

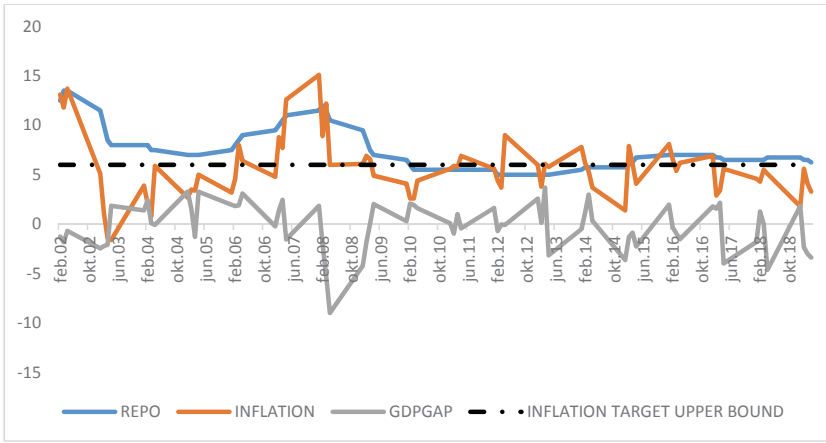

FIGURE 1 Time Series Plot of Repo Rate, Inflation and Output Gap in South Africa
The repo rate and inflation rate are specified in percentages whilst the gap variable is the cyclical component of the HP-filter of the GDP growth rate. Data collected from SARB.

namics observed during periods of rising inflation may differ from those existing during periods of falling inflation. Nonetheless, the current studies which have estimated policy reaction functions for the SARB do not take into consideration these dynamics, hence warranting further investigation into the subject (Aron and Muellbauer 2000; Ortiz and Sturzenegger 2007; Ncube and Tshuma 2010; Naraidoo and Gupta 2010; Naraidoo and Raputsoane 2010; 2011; Veller and Ellyne 2011; Klein 2012; Naraidoo and Paya 2012; Kasa and Naraidoo 2013; Baaziz, Labidi, and Lahiani 2013; Bold and Harris 2018).

We contribute to the literature by re-examining the SARB's policy reaction function for the post inflation targeting era of 2002 to 2021 and determining whether the SARB has an asymmetric policy response to rising and falling periods of inflation. This objective is achieved by estimating the Taylor-type reaction function using the nonlinear autoregressive distributive lag (NARDL) model of Shin, Yu, and Greenwood-Nimmo (2014) to decompose inflation into its partial sum processes which separate periods of increasing inflation from periods of falling inflation and hence capture different forms of asymmetric monetary policy preferences. To ensure robustness of our empirical analysis we employ an array of inflation and inflation expectations classifications in constructing the inflation gap variable used in the policy reaction function. We further perform a sensitivity analysis in which we re-estimate our empirical regressions for two sub-samples corresponding to the pre- and post-crisis periods.

Having laid out the foundation of the study, the rest of our paper is structured as follows. The next section presents the literature review and contextualizes our contribution to the literature. The third section outlines the analytical framework. The fourth section presents the empirical data as well as our empirical findings. The fifth section concludes the paper in the form of policy implications and recommendations.

Literature Review and Contribution to the Study

Since its inception, the policy reaction function has undergone numerous modifications ranging from the 'forward-looking' or 'rational-expectations-based' Taylor rule (Clarida, Gali, and Gertler 1998; 2000; Orphanides 2002) to augmentations with real exchange rates (Svensson 2003; Engel and West 2006; Wilde 2012; Chen, Yao, and Ou 2017), asset prices (Chadha, Sarno, and Valente 2004; Morley and Wei 2012; Finocchiaro and Heideken 2013) and financial conditions (Baxa, Hoorvath, and Vašíček 2013; Nair and Anand 2020; Ahmad 2020), to nonlinear policy reaction functions due to asymmetric policy preferences or asymmetries in monetary-macroeconomic relationships such as the Aggregate Supply or Phillips curve (Orphanides and Wieland 2000; Orphanides and Wilcox 2002; Nobay and Peel 2003; Schaling 2004; Dolado, Pedrero, and Ruge-Murcia 2004; Surico 2007; Cukierman and Muscatelli 2008; Castro 2011; Koustas and Lamarche 2012; Zu and Chen 2017). Notably, many of these modified Taylor policy rules have been estimated exclusively using South African data and this has resulted in a variety of empirical fits of the SARB policy reaction function (Aron and Muellbauer 2000; Klein 2012; Ncube and Tshuma 2010; Naraidoo and Gupta 2010; Naraidoo and Raputsoane 2010; Naraidoo and Paya 2012; Baaziz, Labidi, and Lahiani 2013; Bold and Harris 2018).

Whilst acknowledging the existence of previous studies which validate the Taylor rule for the SARB, we note that the magnitude of the response of the central bank to deviations of inflation from its target varies amongst the different studies. On the one hand, there are the studies of Aron and Muellbauer (2000), Ortiz and Sturzenegger (2007), Klein (2012), Veller and Ellyne (2011) and Bold and Harris (2018) which employ linear frameworks to fit the Taylor rule for the SARB. From this group, the studies of Aron and Muellbauer (2000) and Veller and Ellyne (2011) find a 'less-than-unity' response of the SARB to a percentage change in deviations of inflation from its target, whereas the studies of Ortiz and Sturzenegger (2007), Klein (2012) and Bold and Harris (2018) find a 'greater-than-unity'

response to inflation deviations. On the other hand, there exists a separate group of studies which find that nonlinear policy reaction functions are better suited for capturing the SARB policy preferences (Ncube and Tshuma 2010; Naraidoo and Gupta 2010; Naraidoo and Raputsoane 2010; 2011; Naraidoo and Paya 2012; Kasa and Naraidoo 2013; Baaziz, Labidi, and Lahiani 2013). Whereas the studies of Ncube and Tshuma (2010) and Bazziz, Labidi, and Lahiani (2013) find lower responses of the Reserve Bank when inflation is below an estimated inflation of 9%, 6% and 5.6%, respectively, the works of Naraidoo and Raputsoane (2010; 2011), Naraidoo and Paya (2012) and Kasa and Naraidoo (2013) find that the SARB responds to inflation only outside an inflation 'zone area.'

Notwithstanding the empirical developments in the South African literature, the purpose of this paper is not concerned with merely validating the existence of a Taylor rule for the SARB, but we are rather interested in examining whether the Reserve Bank has been able to fulfil its obligation of protecting the country's citizens from the corroding effects of inflation. For this to be proven true, the SARB must be found to adhere to a policy reaction function such that there exists at least a 'one-for-one' co-movement between the policy instrument and inflation during periods of rising inflation. Conversely, during periods of falling inflation the Reserve Bank may lower interest rates but must ensure at most a 'one-for-one' response to the deflation rates so that the purchasing power of money held with financial institutions does not deteriorate over time. Primarily invoked by the lack of consensus concerning the magnitude of coefficient estimates obtained for the SARB policy reaction function, our study re-evaluates the empirical evidence and in doing so, contributes to the literature in four ways.

Our first contribution to the current South African literature is the methodological approach used to estimate the policy reaction functions, in which our study makes use of the nonlinear autoregressive (NARDL) model of Shin, Yu, and Greenwood-Nimmo (2014). In the context of estimating the Taylor policy rules, we consider the NARDL framework as superior to other nonlinear econometrics frameworks, such as the threshold autoregressive (TAR), the smooth transition regression (STR) or the Markov-switching models commonly used in previous studies. For instance, the NARDL model is flexible in that it can accommodate a mixture of stationary and first difference time series, unlike other frameworks which require the series to be integrated of the same order. Furthermore, the NARDL framework reduces the chances of regression bias by accom-

modating the modelling of long-run and short-run asymmetric cointegration relations whilst remaining robust to possible endogeneity arising from the estimated regression. Courtesy of the lag design of the framework, interest rate smoothing and 'backward-looking' dynamics are also endogenously incorporated into the estimation process. Our study uses the NARDL to induce asymmetries into the SARB's policy reaction function by partitioning the inflation gap variable into negative and positive portions, such that we can discern the policymaker's preferences depending on whether inflation is on the rise or inflation is falling. Note that this differs from assumptions underlying the STR framework adopted in the previous South African studies of Ncube and Tshuma (2010), Naraidoo and Gupta (2010), Naraidoo and Raputsoane (2010; 2011), Naraidoo and Paya (2012) and Baaziz, Labidi, and Lahiani (2013), in which the policymakers' preferences differ only when inflation crosses some estimated threshold.

Our second contribution is that we estimate backward Taylor's policy rules for the SARB from a disaggregated perspective, that is, in addition to the aggregated CPI index commonly used in most of the previous South African literature, our study further employs the disaggregated price indexes for goods, on the one hand, and for services on the other. We consider this approach important since the price index used by the SARB, which is constructed based on a plutocratic weighting technique, is criticized for being an unsuitable measurement tool of inflation as it mainly reflects the consumption bundle of the top ten percent of households (Bhorat et al. 2014). As was witnessed during the 2007–2008 subprime crisis, the prices of consumer goods, which are associated with the poorest deciles, increased much more heavily compared to that of services purchased by households in the upper percentiles of the income distribution (Bhorat et al. 2014). Therefore, examining Taylor policy rules strictly using aggregated measures of inflation can be thought of as being biased, since it is possible that monetary policymakers respond differently to the varying items contained within the basket of goods and services used to calculate the aggregated consumer price index.

Our third contribution to the literature concerns our formation of the inflation expectations, which is an important component of the 'forward-looking' policy reaction function. Previous South African studies typically form inflation expectations either using a perfect foresight model with one-period ahead values of the actual inflation (Ncube and Tshuma 2010; Naraidoo and Paya 2012) or by using a simple learning rule of infla-

tion expectations (Naraidoo and Gupta 2010; Naraidoo and Paya 2012). Our study follows the works of Gorter, Jacobs, and Haan (2008), Klein (2012), Bold and Harris (2018) and Kliesen (2019a; 2019b) by making use of survey-based measures of inflation expectations in inducing 'forward-looking' policy reaction functions. As revealed in the studies of Lai (1997), Soderlind (1998) and Kaliva (2008), the use of survey-based inflation forecasts to investigate the relationship between monetary policy instrument and inflation expectations (i.e. the Fisher effect) circumvents the problems of systematic forecasting errors produced from econometric-based forecasts. Moreover, Kabundi, Schaling, and Some (2015), as well as Miyajima and Yetman (2019), have shown how the SARB has anchored the expectations of market participants differently. In our study, we account for the observed heterogeneities in survey-based expectations with respect to estimating nonlinear 'forward-looking' policy reaction functions for the SARB using expectations from different market participants, i.e. the financial sector, business sector and trade unions.

Lastly, our study performs a sensitivity analysis in which we examine whether the 2008 financial crisis has caused a change in the SARB's policy preferences with respect to its responses to inflation and output deviations. Belke and Klose (2011) note that since the financial crisis, the Taylor rule has been criticized as being an inappropriate policy tool for central banks whose policy rates are close to the zero lower bound. However, Gerlach (2011), Klose (2011) and Jung (2018) argue that the rules-based monetary policy must not be entirely dismissed, and Taylor policy rules can still be estimated within the financial crisis but with adjusted coefficients. For instance, Yellen (2012) prescribes modified policy rules with quantitative easing and forward guidance for US monetary authorities. More recently, Ahmad (2020) has proposed that the US policy reaction rule be modified such that policy rates respond 'two-for-one' with inflation deviations. However, for the case of the SARB, whose interest rates are well above the zero lower bound, such policy prescriptions may be unwarranted for the central bank.

Nevertheless, there is still a need to explore whether the coefficients on the Taylor policy rule have been altered by the global financial crisis, and we note that previous South African studies have not endeavoured to estimate policy rules strictly for the post-crisis period. In taking advantage of the fact that the NARDL framework works well with small sample sizes, our sensitivity analysis demonstrates how estimated nonlinear policy reaction for the SARB changes across two sub-sample periods corre-

sponding to the pre-crisis and post-crisis eras. The policy implications of these findings are discussed at the end of this paper.

Analytical Framework

Taylor (1993) proposes the following benchmark central bank policy reaction function:

$$i_t = r^* + \pi_t + f_\pi(\pi_t - \pi^*) + f_y(y_t - y^*). \quad (1)$$

Following Garcia, Restrepo, and Roger (2011), Baaziz, Labidi, and Lahiani (2013) and Caporale et al. (2018), we augment equation (1) with real exchange rates, particularly for emerging economies, i.e.

$$i_t = r^* + \pi_t + f_\pi(\pi_t - \pi^*) + f_y(y_t - y^*) + f_{rer}(rer), \quad (2)$$

where i_t is the Reserve Bank's policy rate, r^* is the equilibrium real interest rate, π_t is the inflation rate, π^* is the targeted rate of inflation, y_t is the actual level of output and y^* is the output trend such that $(\pi_t - \pi^*)$ is the inflation-gap, $(y_t - y^*)$ is the output-gap and *rer* is the real effective exchange rate. The dynamics in equations (1) and (2) reveal that when $(\pi_t > \pi^*)$ or $(y_t > y^*)$, then the economy is 'overheating' and the central bank's response, in this case, is to raise interest rates to induce a cooling effect on the economy. The so-called Taylor principle proposes that the central bank should ensure that interest rates should move at least 'one-for-one' with the inflation rate (i.e. $f_\pi > 1$), to ensure that the real interest rate is not falling, and consequently the real purchasing power of money is not deteriorated by inflation. A second condition for the Taylor principle to hold is that the response of the central bank to output gap deviations should be less than 'one-for-one' (i.e. $0 < f_y < 1$). Moreover, a positive coefficient is expected on the real exchange rate variable (i.e. $f_{rer} > 0$), indicating a strengthening (weakening) of real currency when interest rates are increased (decreased).

However, estimating linear policy rules such as those presented in equations (1) and (2) may not be flexible enough to capture realistic behaviour of central banks. Schaling (2004), Dolado, Pedrero, and Ruge-Murcia (2004) and Surico (2007) note that central banks may be concerned with high inflation as opposed to low inflation, hence creating a bias in the policymaker's reaction function. Moreover, Enders et al. (2010) note that, in practice, it is more difficult for the central banks to reduce inflation than to increase it, hence the response that the policy rate should be greater for positive values of the inflation-gap variable than for negative values. However, Orphanides and Wilcox (2002) and

Kim, Osborn, and Sensier (2005) note that the asymmetric policy preferences by central banks with moderate inflation rates may arise due to the opportunistic 'wait and see' approach to policy conduct. Under this setting, policymakers look for favourable external situations to induce disinflation when inflation exceeds its target, hence resisting the urge to act more aggressively and being prepared to counteract the return of inflation to its previous levels, once the 'gains' from the exogenous factors materialize.

Many studies have attempted to empirically incorporate asymmetries into the policy reaction function using formal nonlinear econometric frameworks. For instance, Perruchoud (2009) makes use of the Markov switching model to examine asymmetries in Taylor rules for the Swiss National Bank. The author finds that regime-switching behaviour in which the central bank adjusts its policy preferences in the presence of unexpected events and place more weight on stabilizing the exchange rate. Enders et al. (2010) propose the instrumental variables (IV) threshold cointegration tests to simultaneously address issues of endogeneity and asymmetries in the Taylor policy rule for the US economy and find monetary authorities to respond more aggressively when inflation is below its threshold compared to values above the threshold. Alcidi, Flamini, and Fracasso (2011) employ a smooth transition regression (STR) framework to model nonlinear policy reaction rules for the US, although the author identifies credit spread and interest rates as the transition variables responsible for regime changes. Caporale et al. (2018) apply the GMM estimators to the threshold autoregressive (TAR) model in estimating nonlinear policy rules for Indonesia, South Korea, Israel, Thailand and Turkey and segregate inflation into lower and higher regimes, although the authors observe differences in estimated inflation threshold points and responses of policymakers to deviations of inflation and output from their targets in both inflation regimes for the emerging countries.

As previously mentioned, our study deviates from the methodologies previously used in the literature and uses the more powerful and flexible NARDL model of Shin, Yu, and Greenwood-Nimmo (2014) to incorporate asymmetries in the SARB policy reaction function. To do this, we decompose the inflation gap variable, $(\pi_t - \pi^\star)$ into partial sum processes of positive and negative changes such that equation (2) can be re-specified as the following long-run asymmetric model:

$$i_t = \alpha_0 + f_\pi^+ \pi_t^+ f_\pi^- \pi_t^- + f_y(y_t - y^\star) + f_{rer}(rer) + e_t, \tag{3}$$

where π_t^+ and π_t^- are partial sum processes of positive and negative changes in $(\pi_j - \pi^\star)$, respectively, defined as:

$$\pi_t^+ = \sum_{j=1}^{i} \Delta\pi_j^+ = \sum_{j=1}^{i} \max(\Delta(\pi_t - \pi^\star), 0), \tag{4}$$

$$\pi_t^- = \sum_{j=1}^{i} \Delta\pi_j^- = \sum_{j=1}^{i} \max(\Delta(\pi_t - \pi^\star), 0). \tag{5}$$

Note that from the partial sum processes, various forms of asymmetries can be identified. For instance, if $f_\pi^+ > f_\pi^-$, then policymakers place a higher weight on rising inflation as opposed to disinflation episodes, hence reflecting a conservative central bank. Conversely, if $f_\pi^+ < f_\pi^-$, then policymakers place less weight on rising inflation and this is 'somewhat' consistent with an 'opportunistic' central bank. Moreover, the partial sum processes can identify opportunistic policymakers who satisfy the Taylor principle (i.e. $f_\pi^+ < f_\pi^-, f_\pi^+ > 1, f_\pi^- > 1$) or conservative monetary policymakers who satisfy the Taylor principle (i.e. $f_\pi^+ > f_\pi^-, f_\pi^+ > 1, f_\pi^- > 1$).

The NARDL (p, q)-in-levels transformation of regression (3) can be specified as:

$$i_t = \sum_{j=1}^{p} \phi_i i_{t-j} + \sum_{j=1}^{p} (\theta_j^+ \pi_{t-j}^+ + \theta_j^- \pi_{t-j}^-) + \sum_{j=1}^{p-1} \gamma_i \Delta y_{t-j} + \sum_{j=1}^{p-1} \lambda_i \Delta rer_{t-j} + \zeta_t, \tag{6}$$

where ϕ_i is the autoregressive parameter, θ_j^+ and θ_j^- are the asymmetric distributive-lag parameters and ζ_t is a well-behaved error with properties $N \sim (0, \sigma^2)$. From equation (6), the unrestricted error correction representation can be expressed as:

$$\Delta i_t = \sum_{j=1}^{p-1} \lambda_i \Delta i_{t-j} + \sum_{j=0}^{q-1} (\alpha_j^+ \Delta\pi_{t-j}^+ + \alpha_j^- \Delta_{t-j}^-) + \sum_{j=1}^{p-1} \sigma_i \Delta y_{t-j} + \sum_{j=1}^{p-1} \psi_i \Delta rer_{t-j} + \Omega\xi_{t-j} + \zeta_t, \tag{7}$$

where $\xi_{t-j} = i_t - \theta_j^+ \pi_{t-j}^{e+} - \theta_j^- \pi_{t-j}^{e-}$ is the asymmetric error correction term (ECT) and the asymmetric long-run parameters are computed as

$f_\pi^+ = -(\theta^+/\rho)$ and $f_\pi^- = -(\theta^-/\rho)$. Shin, Yu, and Greenwood-Nimmo (2014) note that the NARDL model encompasses four types of nonlinearity from which the authors propose various tests procedures to verify the difference forms of nonlinearities. Firstly, there is the generalized asymmetric cointegration effect which is analogous to the bounds test for cointegration presented in Pesaran, Shin, and Smith (2001). This asymmetric version of a bounds test for cointegration is an F-test of the joint null hypothesis, $\rho = \theta^+ = \theta^- = \gamma = \lambda = 0$, and the statistic used in testing this form of asymmetry is denoted F_{PSS}. Secondly, there are equilibrium adjustment asymmetries which are analogous to the test for significance of error correction mechanism found in Banerjee et al. (1998). This latter test uses a t-statistic which tests the null hypothesis $\rho = 0$ against the alternative $\rho < 0$. Thirdly, there is the Wald test evaluating the null hypotheses of long-run or reaction asymmetry, which evaluates the null hypotheses ($H_{\text{LR}}^S: f_\pi^+ = f_\pi^-$) using a test statistic denoted W_{LR}. Lastly, there is the Wald test for short-run asymmetries, which evaluates the null hypotheses ($H_{\text{SR}}^S: \alpha_j^+ = \alpha_j^-$) using a test statistic denoted as W_{SR}.

Data and Empirical Findings

DATA DESCRIPTION

The data used in the study has all been retrieved from the SARB online database, and has been captured on a quarterly frequency over the period of 2002:q1 to 2021:q4. Our main independent variable is the repo rate, which has been the SARB's official policy rate since 1998. Our main independent variable is the inflation-gap variable, which, in following Bold and Harris (2018), is constructed by subtracting inflation, π_t, from the mid-point of the SARB 3–6 target, i.e. $\pi^\star = 4.5$. Our study makes use of 7 classifications of inflation in constructing the gap variable, these being total CPI, total goods, total services, all expectations (12-month forecast), financial expectations (12-month forecast), business expectations (12-month forecast) and trade union expectations (12-month forecast). Note that the employed expectation series come courtesy of the Bureau of Economic Research quarterly survey which they have been carrying out since 2002 (see Miyajima and Yetman (2019) for a more detailed discussion on the surveys). To construct the output-gap variable we take heed of previous South African literature and extract the cyclical component of the HP filter applied to the GDP growth rate (i.e. $\lambda = 1600$). Also, following the previous studies of Naraidoo and Gupta (2010) as well as Baaziz,

Labidi, and Lahiani (2013), we include the real effective exchange rate to account for openness in the reaction function.

EMPIRICAL RESULTS

Table 1 presents the empirical findings from NARDL regression estimates, which induces long-run and short-run asymmetries by partitioning the inflation-gap variable into two components, the first measuring the deviations from the inflation target during periods of rising inflation (i.e. f_{π}^{+}) and the second measuring deviations during periods of falling inflation (i.e. f_{π}^{-}). Note that this differs from the conventional linear estimates which assume that policymakers have the same response to inflation deviations regardless of whether inflation is rising or falling. Further note, that under the NARDL set-up we can more appropriately evaluate whether the SARB has been able to protect the purchasing power of citizens by ensuring that the real interest rate remains positive (Nikolsko-Rzhevskyy, Papell, and Prodan 2019). For this to be proven true, the partitioned coefficients satisfy the condition $f_{\pi}^{+} > 1$ and $0 < f_{\pi}^{-} < 1$, such that the nominal interest rate remains higher than inflation during both periods of rising and falling inflation, respectively, and the real interest rate is never decreasing. The reported F_{SYG} statistics, which are the nonlinear counterpart of the conventional bounds test statistic of Pesaran, Shin, and Smith (2001), indicates that all regressions can be modelled using NARDL specifications.

Nonetheless, to confirm the significance of long-run NARDL effects, the computed W_{LR} statistic is required to reject the null hypothesis of

TABLE 1 Full Sample: NARDL

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lag	NARDL (1,0,0,0,0)	NARDL (3,1,4,3,3)	NARDL (3,2,1,1,3)	NARDL (3,2,1,1,3)	NARDL (2,0,0,0,2)	NARDL (2,2,1,0,2)	NARDL (2,2,0,0,2)
f_{π}^{+}	0.39***	0.97**	−0.51**	−0.65	−0.17	−0.52	−0.70
	(0.12)	(3.78)	(0.18)	(0.53)	(0.29)	(0.38)	(0.58)
f_{π}^{-}	0.44***	0.99**	−0.35*	−0.46	0.01	−0.28	−0.47
	(0.12)	(3.78)	(0.18)	(0.62)	(0.30)	(0.41)	(0.66)
f_{y}	0.64***	0.58***	0.86***	0.64***	0.66***	0.69***	0.79***
	(0.17)	(0.14)	(0.25)	(0.17)	(0.19)	(0.24)	(0.22)
f_{er}	0.001	0.51**	0.09	0.21**	0.09	0.13	0.15
	(0.07)	(0.21)	(0.21)	(0.09)	(0.12)	(0.12)	(0.13)

Continued on the next page

TABLE 1 *Continued from the previous page*

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta repo(-1)$		0.40***	0.46***	0.45***	0.52***	0.50	0.46**
		(0.11)	(0.12)	(0.07)	(0.07)	(0.08)	(0.08)
$\Delta repo(-2)$		0.28**	0.11				
		(0.10)	(0.10)				
Δf_{π}^{+}		0.03	−0.002	−0.02		−0.07	−0.005
		(0.02)	(0.03)	(0.12)		[0.11)	(0.11)
$\Delta f_{\pi}^{+}(-1)$			0.05	0.41***		0.28**	0.17
			(0.03)	(0.13)		(0.12)	(0.12)
Δf_{π}^{-}		0.06	−0.009			−0.17*	
		(002)***	(0.03)			(0.09)	
$\Delta f_{\pi}^{-}(-1)$		−0.05***					
		(0.01)					
$\Delta f_{\pi}^{-}(-2)$		−0.02					
		(0.01)					
$\Delta f_{\pi}^{-}(-3)$		0.03***					
		(0.01)					
Δf_{y}		0.02	0.09***				
		(0.02)	(0.01)				
$\Delta f_{y}(-1)$		0.06***					
		(0.02)					
$\Delta f_{y}(-2)$		0.04*					
		(0.02)					
Δf_{er}		0.02**	0.006	0.01*	−0.002	−0.007	−0.02***
		(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
$\Delta f_{er}(-1)$		-0.03***	−0.02**	−0.02***	−0.02***	−0.02***	
		(0.008)	(0.007)	(0.006)	(0.005)	(0.0006)	
$\Delta f_{er}(-2)$		−0.01*	0.002				
		(0.006)	(0.007)				
$ect(-1)$	−0.15***	−0.09***	−0.14***	−0.13***	−0.13***	−0.13***	−0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)

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$f_{\pi}^{+} = f_{\pi}^{-}$, which in our case only holds for total CPI (eq. 1), total goods (eq. 2), total services (eq. 3) and financial expectations (eq. 5). In narrowing down these findings, the NARDL long-run coefficients confirm the Taylor principle only for total goods inflation as both f_{π}^{+} and f_{π}^{-} coefficients produce statistically significant estimates of 0.97 and 0.99 respectively, which are very close to unity, whereas both estimates are greater than

TABLE 1 *Continued from the previous page*

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
F_{SYG}	15.17***	3.09***	5.33***	10.64***	9.88***	9.74***	8.34***
W_{LR}	5. 12**	4.16**	7.11***	1.23	5.90***	2.67	1.26
W_{SR}	7.60***	3.54*	2.84	1.06	3.46*	1.83	0.95
χ^2_{NOR}	2.46	39.53***	67.84***	78.59***	31.99***	61.23***	73.33***
	(0.29)	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
χ^2_{SC}	14.08***	0.31	2.97*	0.34	0.48	0.10	0.16
	[0.00]	[0.73]	[0.06]	[0.71]	[0.62]	[0.91]	[0.85]
χ^2_{HET}	1.78	0.17	0.12	0.08	0.48	0.07	0.04
	[0.29]	[0.68]	[0.73]	[0.77]	[0.49]	[0.80]	[0.85]
χ^2_{FF}	1.17	1.04	1.44***	8.88***	4.70***	2.55*	7.26***
	[0.25]	[0.30]	[0.00]	[0.00]	[0.00]	[0.08]	[0.00]

NOTES Equations: (1) total CPI, (2) total goods, (3) total services, (4) all expectations, (5) financial expectations, (6) business expectations, (7) trade unions expectations. ***, ** and * denote 1%, 5% and 10% critical values, respectively. Standard errors of the estimates are reported in parentheses. *P*-values on diagnostic tests reported in square brackets. Optimal lag length of NARDL models are determined by the modified Schwarz criterion.

the estimate on the output gap variable. We also note positive and statistically significant estimates on the partitioned inflation-gap variable for total CPI, although the estimated coefficients of 0.39 and 0.44 for negative and positive partitions, respectively, are both 'lower-than unity' and lower in value compared to the output-gap coefficient estimate. Moreover, we note that for both total CPI and total goods regressions, $f_\pi^+ < f_\pi^-$, implying that the central bank responds more (less) aggressively to decreasing (increasing) periods of inflation, and, in this instance, we conclude for the opportunistic approach of the SARB to monetary policy as advocated by Kasa and Naraidoo (2013).

However, we also observe that the NARDL methodology fails to fit appropriate nonlinear long-run Taylor rules for services inflation (eq. 3) and different categories of inflation expectations (equations 4–7). Whilst, for the case of services inflation, the WLR statistic validates long-run asymmetries, we oddly observe negative and statistically significant estimates on the partitioned inflation-gap variable, with a higher (lower) absolute value being found for positive (negative) partitions. By interpretation this implies the SARB acts in a 'pro-inflationary' manner towards the services sectors by acting more (less) aggressively during rising (falling) periods of inflation deviations. Concerning the different classes of inflation expec-

tations, both negative and positive partitions produce insignificant coefficient estimates. Altogether, the observed response of the SARB towards the services sector and the expectations of different economic agents is counterintuitive to the expected policy reaction function of inflation-targeters.

We also observe that whilst the W_{SR} statistics testing for short-run asymmetries produce significant estimates which reject the null hypothesis of no short-run nonlinearities at a 5% critical level in eq. 1 (total CPI), eq. 2 (total goods) and eq. 5 (financial expectations), the corresponding regression estimates are either insignificant or inconclusive. Moreover, the ECT produce their expected negative and statistically significant estimates, and the speed of reversion back equilibrium following a shock produces values ranging from –0.11 to –0.15, implying 11% to 15% correction of disequilibrium every quarter. Finally, the diagnostic tests fail to find evidence of serial correlation or heteroscedasticity for most estimated regressions, although we do observe instances where the regressions fail to pass the tests for incorrect functional form. As highlighted by Rudebusch (2005), Perruchoud (2009) and Huber (2017), unaccounted structural breaks in the Taylor rule renders the specification prone to the Lucas critique and hence increases the probability of specifying incorrect Taylor policy rules. Whilst previous studies have focused on different monetary policy regimes as the source of structural breaks in policy function, our study considers the global financial crisis as a more appropriate structural break, taking into account that our time-series data strictly corresponds to the singular monetary regime.

SENSITIVITY ANALYSIS

In line with Caporale et al. (2018), we identify the global financial crisis of 2007–2008 as the structural break in our times series. Therefore, in this section of the paper we perform a sensitivity analysis which entails segregating the data into pre-crisis (2002:q1–2008:q3) and post-crisis (2008:q4–2020:q4) periods.

Table 2 presents the NARDL estimates for the pre-crisis periods and, judging from the *F*-test for bounds cointegration and Wald test for long-run asymmetries, as well as the significance and sign of the coefficient estimates, we can fit significant nonlinear Taylor rules for 5 out of the 7 estimated regressions (i.e. total CPI, total services, all expectations, financial expectations, trade union expectations), although the nonlinear dynamics differ amongst the different inflation measures. For instance,

TABLE 2 Pre-Crisis: NARDL

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lag	NARDL (1,0,1,0,1)	NARDL (1,0,0,0,1)	NARDL (3,1,3,3,3)	NARDL (3,3,0,3,3)	NARDL (1,0,0,1,1)	NARDL (1,1,0,1,1)	NARDL (1,1,0,1,1)
f_{π}^{+}	0.27***	−0.05	0.45***	1.05***	−0.02	0.14	0.24
	(0.06)	(0.24)	(0.09)	(0.09)	(0.22)	(0.20)	(0.17)
f_{π}^{-}	0.33***	0.04	0.95***	1.39***	0.34	0.45**	0.49**
	(0.07)	(0.24)	(0.14)	(0.29)	(0.21)	(0.19)	(0.18)
f_{y}	0.50**	1.23*	1.04***	−0.19	0.32***	0.58***	0.51***
	(0.21)	(0.64)	(0.13)	(0.19)	(0.22)	(0.16)	(0.13)
f_{rer}	−0.35	−0.75	0.75***	−0.23*	−0.17	−0.12	−0.07
	(0.31)	(0.58)	(0.14)	(0.11)	(0.13)	(0.11)	(0.08)

Continued on the next page

we only validate the Taylor principle for all inflation expectations (eq. 4), which is the sole regression satisfying the condition $f_{\pi}^{+} > 1, f_{\pi}^{-} > 1$. Moreover, for total CPI (eq. 1), total services (eq. 3) and all expectations (eq. 4), we find that policymakers respond more (less) aggressively during periods of decreasing (increasing) inflation (i.e. $f_{\pi}^{+} < f_{\pi}^{-}$), which indicates an opportunistic approach to monetary policy. We also find positive and significant coefficient estimates on the negative partitions on the inflation expectation variable of the business sector (eq. 6) and trade unions (eq. 7) whilst the positive partitions produce insignificant estimates. This latter finding implies that during the pre-crisis, the Central Bank has only responded to inflation deviations of business and trade union expectations during periods of falling inflation, which also describes the opportunistic behaviour of the central bank.

Table 3 presents the NARDL estimates for the post-crisis period and, based on the *F*-test for bounds cointegration and Wald test for long-run asymmetries, as well as the significance and sign of the coefficient estimates, we can only fit significant nonlinear Taylor rules for 2 out of the estimated 7 regressions, i.e. total CPI (eq. 1) and business expectations (eq. 6). Out of these two regressions, only business expectations satisfies the Taylor principle during periods of rising inflation, since $f_{\pi}^{+} > 1$, although we note that during periods of disinflation, the Reserve Bank is unresponsive. These dynamics correspond to a conservative approach conduct of monetary policy. Similarly, for total CPI, we find that policymakers have responded more (less) aggressively towards inflation deviations during periods of rising (falling) inflation, which is different from

TABLE 2 *Continued from the previous page*

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta i(-1)$			−0.15	−0.70**			
			(0.12)	(0.18)			
$\Delta i(-2)$			0.77***	0.72***			
			(0.10)	(0.11)			
Δf_{π}^{+}			0.02	0.70***		−0.19*	−0.24**
			(0.02)	(0.14)		(0.09)	(0.09)
$\Delta f_{\pi}^{+}(-1)$				−1.31***			
				(0.21)			
$\Delta f_{\pi}^{+}(-2)$				−0.58**			
				(0.16)			
Δf_{π}^{-}	0.10***		−0.41***				
	(0.02)		(0.05)				
$\Delta f_{\pi}^{-}(-1)$			0.30***				
			(0.04)				
$\Delta f_{\pi}^{-}(-2)$			0.14***				
			(0.02)				
Δf_{y}			−0.05**	0.06***	0.10***	0.11***	0.10***
			(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
$\Delta f_{y}(-1)$			0.22***	0.15***			
			(0.03)	(0.02)			
$\Delta f_{y}(-2)$			0.15***	0.22***			
			(0.02)	(0.03)			
Δf_{rer}	−0.01	−0.03***	−0.15***	−0.06***	−0.01	−0.01	0.001
	(0.009)	(0.01)	(0.02)	(0.01)	(0.008)	(0.008)	(0.008)
$\Delta f_{rer}(-1)$			0.16***	0.11***			
			(0.02)	(0.02)			
$\Delta f_{rer}(-2)$			0.13***	0.08***			
			(0.02)	(0.01)			
$ect(-1)$	−0.16***	−0.10***	−0.48***	−0.80***	−0.29***	−0.35***	−0.41***
	(0.02)	(0.01)	(0.06)	(0.12)	(0.02)	(0.03)	(0.03)

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the results obtained for the pre-crisis and full sample estimates, and yet these dynamics correspond with the conservative approach to monetary policy. For the remaining classifications of inflation, the coefficient on the inflation gap variable either produces negative and significant (services inflation) or insignificant (i.e. total goods, all expectations, financial expectations, business expectations, trade union expectations) estimates.

TABLE 2 *Continued from the previous page*

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
F_{SYG}	14.04***	1186***	4.36***	3.97***	8.30***	7.34***	18.56***
W_{LR}	12.51***	5.87***	35.48***	3.71**	3.25*	1.83	1.68
W_{SR}	6.54***	4.51**	7.16***	1.85	1.56	0.98	0.56
χ^2_{NOR}	0.56	1.29	0.86	0.04	1.44	1.09	1.47
	[0.75]	[0.53]	[0.65]	[0.98]	[0.49]	[0.58]	[0.48]
χ^2_{SC}	0.48	0.23	1.64	2.57	0.13	0.02	0.23
	[0.63]	[0.80]	[0.38]	[0.22]	[0.88]	(0.98)	[0.79]
χ^2_{HET}	2.22	1.81	0.91	0.20	0.68	2.31	0.05
	[0.15]	[0.15]	[0.35]	[0.66]	[0.69]	(0.14)	[0.83]
χ^2_{FF}	0.34	1.08	2.15	1.02	0.31	0.82	1.25
	[0.74]	[0.29]	[0.12]	[0.37]	[0.76]	(0.43)	[0.23]

NOTES Equations: (1) total CPI, (2) total goods, (3) total services, (4) all expectations, (5) financial expectations, (6) business expectations, (7) trade unions expectations. ***, ** and * denote 1%, 5% and 10% critical values, respectively. Standard errors of the estimates are reported in parentheses. *P*-values on diagnostic tests reported in square brackets. Optimal lag length of NARDL models are determined by the modified Schwarz criterion.

TABLE 3 Post-Crisis: NARDL

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lag	NARDL (1,1,1,0,0)	NARDL (2,1,2,0,3)	NARDL (3,1,0,2,3)	NARDL (2,0,0,2,3)	NARDL (2,0,0,2,3)	NARDL (4,1,3,4,4)	NARDL (2,0,0,2,3)
f^+_π	0.74***	0.14	−0.61*	0.25	0.10	1.19*	0.48
	(0.17)	(0.18)	(0.29)	(0.59)	(0.50)	(0.60)	(0.73)
f^-_π	0.68***	0.12	−0.61**	−0.20	−0.13	0.48	0.03
	(0.15)	(0.18)	(0.26)	(0.53)	(0.47)	(0.43)	(0.58)
f_y	0.58**	0.89***	1.42***	1.38***	1.33***	0.82*	1.19***
	(0.23)	(0.30)	(0.24)	(0.46)	(0.48)	(0.39)	(0.34)
f_{rer}	0.08	0.40***	0.50***	0.42***	0.41***	0.40***	0.38***
	(0.06)	(0.08)	(0.11)	(0.14)	(0.14)	(0.12)	(0.09)

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Moreover, we observe that whilst the exchange rate variable has been predominantly insignificant during the pre-crisis period, the variable turns positive and statically significant for most regressions in the post-crisis.

Conclusion

The South African constitution mandates to the Reserve Bank the sole responsibility of protecting the value of the Rand currency against the

TABLE 3 *Continued from the previous page*

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta repo(-1)$		0.56***	0.39***	0.50***	0.50***	0.35**	0.50***
		(0.07)	(0.11)	(0.08)	(0.09)	(0.13)	(0.09)
$\Delta repo(-2)$			0.23*			0.21	
			(0.13)			(0.20)	
$\Delta repo(-3)$						0.51***	
						(0.21)	
Δf_{π}^{+}	0.08**	−0.02*	−0.20***			−0.09	
	(0.03)	(0.009)	(0.04)			(0.22)	
Δf_{π}^{-}	0.07***	0.02*				−0.36**	
	(0.02)	(0.01)				(0.14)	
$\Delta f_{\pi}^{-}(-1)$		−0.04***				−0.37**	
		(.001)				(0.14)	
$\Delta f_{\pi}^{-}(-2)$						−0.30**	
						(0.14)	
Δf_{y}			0.13***	0.12***	0.12***	0.13***	0.12***
			(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
$\Delta f_{y}(-1)$			−0.05**	−0.05**	−0.05**	−0.001	−0.04**
			(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
$\Delta f_{y}(-2)$						0.05*	
						(0.02)	
$\Delta f_{y}(-3)$						0.05***	
						(0.01)	
Δf_{rer}		0.02***	0.02***	0.01*	0.01*	0.02***	0.01*
		(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)
$\Delta f_{rer}(-1)$		−0.04***	−0.04***	−0.04***	−0.04***	−0.07***	−0.04***
		(0.007)	(0.007)	(0.008)	(0.008)	(0.02)	(0.008)
$\Delta f_{rer}(-2)$		−0.02***	−0.02***	−0.02**	−0.02**	−0.04**	−0.02**
		(0.006)	(0.006)	(0.007)	(0.007)	(0.01)	(0.007)
$ect(-1)$	−0.19***	−0.13***	−0.15***	−0.14***	−0.14***	−0.02*	−0.15***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.009)	(0.03)

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eroding effects of inflation in the interest of promoting financial stability and sustained growth. Our study provides a re-examination of Taylor's principle for the South African economy for the post-inflation targeting era of 2002:q1 to 2021:q4 as a means of evaluating whether the Reserve Bank has been successful in protecting the purchasing power of currency against inflation. Our empirical analysis differs from those of previous studies in three ways. Firstly, we employ an array of inflation and infla-

TABLE 3 *Continued from the previous page*

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)
F_{SYG}	10.04***	8.07***	6.09***	5.35***	5.28***	3.97***	5.37***
L_{LR}	6.14***	3.08*	3.16***	2.42	6.36***	3.48*	4.89***
L_{SR}	4.95***	1.52	2.12	0.89	3.91**	1.86	2.74
χ^2_{NOR}	3.88	2.89	4.02	4.53	1.33	1.80	1.36
	[0.16]	[0.24]	[0.13]	[0.10]	[0.52]	[0.36]	[0.53]
χ^2_{SC}	8.95***	0.83	0.58	0.43	0.52	.95	0.37
	[0.00]	[0.45]	[0.57]	[0.65]	[0.60]	[0.40]	[0.70]
χ^2_{HET}	2.48	0.001	0.05	0.12	0.13	0.41	0.15
	[0.12]	[0.97]	[0.82]	[0.73]	[0.72]	[0.53]	[0.70]
χ^2_{FF}	1.09	0.06	0.66	0.26	0.21	0.31	0.37
	[0.28]	[0.95]	[0.42]	[0.80]	[0.84]	[0.58]	[0.72]

NOTES Equations: (1) total CPI, (2) total goods, (3) total services, (4) all expectations, (5) financial expectations, (6) business expectations, (7) trade unions expectations. ***, ** and * denote 1%, 5% and 10% critical values, respectively. Standard errors of the estimates are reported in parentheses. *P*-values on diagnostic tests reported in square brackets. Optimal lag length of NARDL models are determined by the modified Schwarz criterion.

tion expectations classifications in constructing the inflation-gap variable in the policy reaction function. Secondly, we estimate the policy reaction function using the NARDL framework, which is flexible enough to capture different forms of asymmetric policy preferences. Lastly, we provide a sensitivity analysis in which we split our empirical data into two subsamples corresponding to the pre-crisis periods and post-crisis periods.

Our baseline NARDL estimates reveal that the Taylor principle is confirmed for the total goods inflation, although the observed nonlinear dynamics emulate that of an opportunistic central bank. However, in performing our sensitivity analysis, we find stark differences between the pre-crisis and post-crisis eras. For instance, the NARDL estimates show that in the pre-crisis era the Taylor principle was fulfilled when all inflation expectations are used to compute the inflation gap, hence providing evidence of a forward-looking Taylor policy rule. Conversely, in the post-crisis era, the Taylor rule is solely satisfied for business expectations, during periods when inflation is increasing. Moreover, our results show that the central bank's behaviour has changed from being opportunistic in the pre-crisis era to being conservative in the post-crisis era and only in the post-crisis period does the real exchange rate significantly enter the policy reaction.

All in all, when taking into account asymmetries and structural breaks, we find that that the Taylor principle has been fulfilled in the forward-looking Taylor specifications in both the pre-crisis and post-crisis period, with the SARB providing appropriate policy responses to all inflation expectations during periods of falling and rising inflation during the pre-crisis era and for business sector expectations during periods of rising inflation in the post-crisis era. This implies that the SARB's scope of protecting the economic units' purchasing power has narrowed in the post-crisis period, with the reaction function placing more weight on the business sector expectations.

Considering that the structural breaks were incorporated into the estimation process in an arbitrary manner, an avenue for future research would be to examine the Taylor principle, making use of econometric models which can simultaneously account for time-varying and asymmetric adjustments dynamics within the Taylor rule.

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