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Journal of Economics and International Finance

Full Length Research Paper

Do exchange rates influence US poultry exports?

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The United States is the world's largest poultry producer and exports about 18% of its total poultry production. With the global demand for poultry products projected to rise further, understanding key factors in world trade is essential for better trade. We study the influence of key demand factors, that is, exchange rate, poultry price and income of importing country on US poultry products. We focused on the top five importers namely, Mexico, Canada, China, Hong Kong, and Russia. A fixed effects model and a double-log multiple regression model are used. All three demand factors in a country were significantly associated with the quantity of poultry. Exchange rate negatively influenced US exports to the five countries. However, the magnitude, direction, and significance of these three variables varied for each country as shown in the country-level regression estimates.

Key words: Exchange rate, poultry trade, US poultry exports, poultry exports.

INTRODUCTION

The US poultry industry has been expanding over the years. Over the last ten years, the joint value of production from broilers, eggs, turkeys, and chicken has been over $40 billion in most years. In 2021, it was $46 billion, up from $35 billion in 2020. Likewise, US poultry exports have recorded considerable growth over the past two decades. Poultry exports have been above $4 billion for the last ten years and crossed $5 billion in 2021. Given the expanding market and potential growth, there is a need for more study on the key demand factors that could influence US poultry exports. The key factors focused on here are poultry price and, per capita income in the domestic market, and exchange rate.

This research focuses on countries that together account for over 60% of US poultry exports by value

(Weaver, 2014). They include Mexico, Canada, China, Hong Kong, and Russia. Being one of the world's most efficient poultry producers, poultry imports by the US are inconsequential, comprising only 0.3% of local consumption of poultry.

Foreign poultry producers are unable to compete in the US market at cost or quality. Weaver (2014) finds evidence that this is due to the high productivity and economies of scale of the US poultry industry. These characteristics, according to the United States International Trade Commission, have led to the US accounting for approximately one-quarter of global poultry production, thereby becoming the world's largest poultry producer (Weaver, 2014).

The poultry industry in the US is very competitive and

adapts to consumer preferences, making it a very successful industry. A key factor that is attributed is its vertically integrated production that gives poultry processors high control over their product, resulting in high-quality poultry processing (Vukina, 2001). Consolidation over time has led to economies of scale. Furthermore, the poultry industry continually improves and advances in all stages of the manufacturing process via in-depth research and development to upgrade all segments of production, including breeding, disease control, feed compositions, and rearing/housing systems at grow-out facilities (Weaver, 2014).

High-quality production also keeps the US industry relatively immune to disease outbreaks elsewhere in the world. Such outbreaks in other parts of the world have boosted the exports of US poultry products. For example, following the outbreak of foot-and-mouth disease, there was a considerable increase in the consumption of chicken in Korea because many consumers replaced beef and pork with chicken (Piggott and Marsh, 2004). As a result, Korea imported more poultry products from the US. Another notable trend in Korea was the increasing number of chicken franchise chains, particularly in 2010 and 2011, owing to the demand by millennials for diverse branded chicken products (Prinsloo, 2018).

Since then, the per capita chicken consumption in Korea had only risen and continues to rise (Choi and Hinkle, 2018). Similar trends around the world have increased the demand for poultry products which has been met by imports from US. Consequently, exports are becoming more relevant for US poultry manufacturers (Capps et al., 1994). Relatively speaking, studies show that the safety of food has little effect on the demand for meat when compared to the price of the item or the income of the consumers (for example, Piggott and Marsh, 2004).

In view of such marked developments in the US poultry export market, there is a need to examine important factors that influence poultry trade. The factors influencing US poultry exports were study. Important factors considered in this study are foreign exchange rate, export price, and per capita Gross Domestic Product (GDP). Below we discuss the trade of poultry products followed by a discussion on the key variable in this study, the exchange rate.

International trade of poultry products

Poultry production across the globe can be categorized into commercial large-scale poultry, traditional village scavenging, and semi-commercial systems. Other unconventional methods include free-range and organic (Kitalyi, 1997). Traditional village-scavenging poultry is peculiar to developing countries and constitutes a substantial portion of poultry in the global flock or continent flock. This is also known as "backyard" or "farmyard" poultry in Europe and North America, where the market sizes have decreased, but are still noticeable. Traditional poultry significantly aids poverty alleviation and increased food security. However, there has been insufficient research to upgrade the efficiency of traditional poultry production (Kitalyi, 1997). It is evident that traditional poultry production is not efficient and has low productivity. As stated by Aboki et al. (2013), that the efficiency of family poultry can be improved by the adoption of innovations, medicines, and the provision of capital by the government. Hence, competition with commercial poultry production is relatively less in developing countries. Scanes (2007) states that semi-commercial production, which falls in between traditional and commercial poultry, lacks the infrastructure to improve poultry. Insufficient infrastructure and lack of financial capital constrained the ability of local poultry producers to meet the rising consumer demand, which drove the demand for imports from countries that have large-scale commercialized industries, such as the US.

The past two decades has seen poultry consumption rise up to the top spot in the world among livestock commodities (Miller et al., 2022). The US poultry sector, the world's largest producer of poultry meat, exports 17% of its domestic production (Miljkovic et al., 2003).

During 2001 – 2021, the US poultry export market underwent considerable changes (Dohlman and Boussisos, 2022). US is currently the second largest exporter of poultry products with 26% of the global poultry trade. Poultry imports rose by 4% reaching 14.2 million metric tons in 2021. Consumption even in a low-income region, such as sub-Saharan Africa has increased from 0.33 million metric tons to 1.96 million metric tons. Latin American and Caribbean countries together make up the second largest importing region with 1.13 million metric tons. Russia's imports, however, dropped by 1.22 million metric tons during that period. Geopolitical issues with the US did impact trade with a few countries, such as China and Russia. For example, there was a US poultry ban by Russia in 1996 and a drastic reduction in imports by China in response to avian influenza in 2000s (Zhuang and Moore 2015).

Miljkovic et al. (2003) suggested that trade liberalization (GATT, WTO, NAFTA) paved the way for the emergence of the US as among the top two world's major meat exporter. US poultry exports took off in the 1990s when the Russian Federation became the topmost importer of US poultry, accounting for 40% of US poultry exports. In 2001, the US poultry production was 42.43 billion pounds, thereby comprising 24 percent of the world's total output. Poultry exports by the US were 6.4 billion pounds, which constitutes close to 33% of the world poultry trade, of which 60% was shipped to consumers in Asia (Awokuse and Yuan, 2006). Mexico, China, Canada, and Hong Kong are equally important poultry markets for the US. Countries like Thailand, Brazil, and a few other large exporting countries compete with US in the world

poultry markets (Miljkovic et al., 2003).

Distance, which largely determines transportation cost, is not included in this study because we do not have data on the amount of poultry exports from each port. The ports are spread across the country, making it difficult to have a precise distance estimate. Previous studies by Atkins and Bowler (2016) showed that trade barriers of various kinds tend to impact US poultry exports.

Existing research on exchange rates and exports

Exchange rate is among the most important factors determining international trade. A stronger dollar reduces the price of foreign goods to US consumers. Consumers in that foreign country, on the other hand, must pay more for US goods.

Thus, a stronger dollar boosts demand for imports and decreases the demand for exports. A weaker dollar has the reverse effect, that is, foreign consumers have to pay less, thereby, increase demand for exports. Studies have shown that exchange rates do considerably impact trade for most commodities. A study on Thailand's agricultural trade showed a significant impact of the exchange rate on rice, tapioca, poultry, and fisheries but not on natural rubber (Jatuporn et al., 2016).

Exchange rate volatility is also found to have some influence on trade. The extent of the impact depends on the nature of the response to risk, availability of capital, forward contracts, and the time horizon of the trader (McKenzie, 1999).

The general hypothesis is that high variability in the exchange rate leads to instability in the prices of US agricultural products in terms of the local currency in the importing countries abroad. In response, a risk-averse trader would consider whether to trade or not. A USDA's Economic Research Service report observed that about 25% of the adjustments in US agricultural value were due to fluctuations in exchange rates over the years. Awokuse and Yuan (2006), for example, found that the exchange rate volatility had a negative association with US poultry export, but this relationship was not statistically significant. High exchange rate volatility caused a substantial decrease in the demand for US products and local consumption in foreign countries (Shane and Leifert, 2007).

Miljkovic et al. (2003) studied the impacts of GATT and NAFTA agreements on exchange rate pass-through. The "Pass-through" relationship in this sense describes the proportional relationship between local currency import prices and exchange rates (Devereux and Engel, 2002). The results showed that incomplete exchange rate pass-through exists for many countries. They specifically quantified the impact of relative exchange rates on US poultry, beef, and pork export prices among the largest meat-importing nations. Country-specific factors such as varying demands for product quality, domestic policies, and income effects were also estimated.

DATA AND METHODS

Panel data at the country level was collected for the period 1993-2012. Mexico, Canada, Russia, Hong Kong, and China were chosen as they are the largest importers of US poultry products. All variables are monthly. Monthly quantity and value data for US poultry products for January 1993 to December 2012 for crucial export destination countries were obtained from the Food and Agriculture Organization (FAO) and used to deduce export prices (FAO, n.d.). Income level reflects purchasing power of consumers in the importing country. Quarterly per capita GDP is used as a proxy for income as has been used in the literature (for example, Awokuse and Yuan, 2006). Quarterly GDP information were obtained from International Financial Statistics, while that for China was obtained from the Federal Reserve Bank of St. Louis (FRED), which they sourced from the Organization for Economic Co-operation and Development (OECD) (2017).

Exchange rates were obtained from World Bank and the International Monetary Fund (IMF) international finance statistics data (World Bank, n.d.). The quantity of US poultry exports is the volume of US poultry products shipped to each of the five countries considered in this study. This differs across the countries, and it might be a result of varying demand and supply factors in those countries (Figure 1). Average poultry exports from US during this period increased in the order, with Canada as the highest followed by China, Mexico, Hong Kong, and the least to Russia. On average imports, China is the top importer (88 million tons) followed by Russia (51 million tons). Among these countries, Canada has the smaller share in terms of quantity. Figure 1 also shows variability in poultry imports from US by these countries. Russia showed higher variability. Canada and Mexico showed an increasing trend while Hong Kong reduced imports in the latter years of the study period.

Awokuse and Yuan (2006) described the exchange rate as the price of a currency in terms of another currency and it is probably the single most cogent variable in determining the level of trade. The exchange rate for each is reported in the local currency as obtained from the World Bank and was converted to equivalent US dollar value. All countries except Canada have a low exchange rate, ranging from 0.1211 to 0.1373 (Table 1). A Canadian dollar, in the study period, equals 0.796 US dollars. The standard deviation suggests that all countries except Russia did not vary much between 1993 and 2012.

The average exchange rate ranges from highest to lowest in the order from Canada, Russia, China, Hong Kong, and least Mexico (Figure 2). This depicts how strong the currency of the countries relative to the US dollar is. The Canadian dollar appears to be the strongest, while the Mexican peso seems to be the weakest in comparison to the US dollar. The Russian ruble has a higher standard deviation. A closer examination shows that where the exchange rate dropped in the late 1990s, and thereafter remained about the same for the next 12 years.

The mean export price to countries ranges from highest in Canada, followed by Hong Kong, China, Mexico, and least in Russia (Figure 3). Finally, the average per capita GDP across the countries ranges from highest in Canada, followed by Hong Kong, Mexico, and Russia, and the least in China. The monthly exchange rate is shown in Figure 1 for all countries, and the value is calculated as:

$$Exchange\ Rate\ (US\ dollar) = \frac{1}{Exchange\ Rate\ Local\ Currency}$$

According to the Organization for Economic Co-operation and Development, total GDP depicts the standard measure of the value added created through the production of goods and services
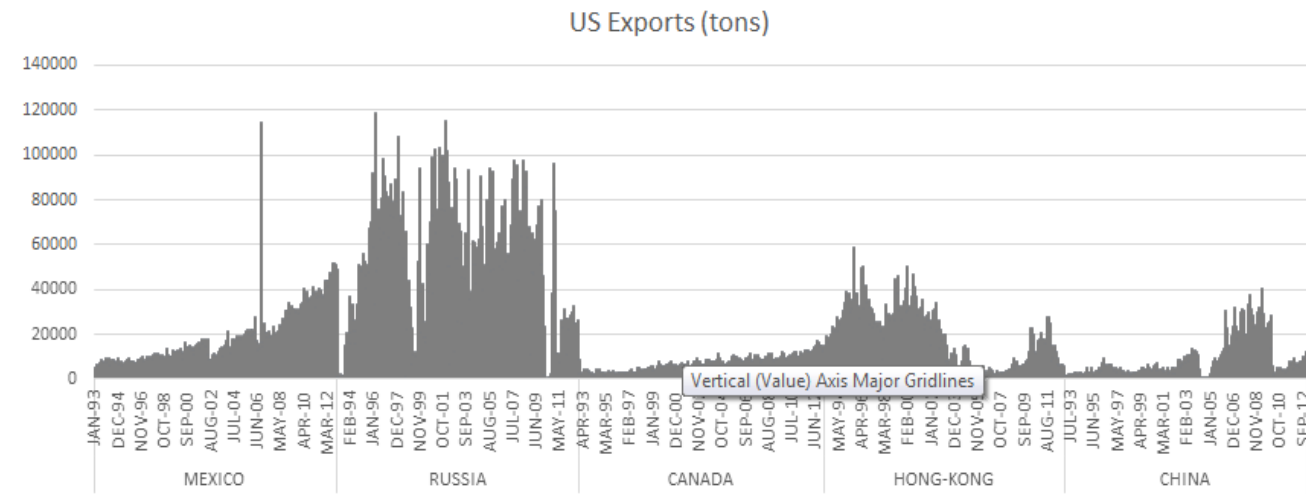
US Exports (tons)

Figure 1. Monthly US poultry exports to select countries, Jan 1993-Dec 2012.
Source: Food and Agriculture Organization (FAO) of the United Nations.

Table 1. Descriptive statistics across the 5 countries between 1993-2012.

Country	Quantity US poultry export (Mean/SD) (tons)	Exchange rate (Mean/SD) ($)	Export price (Mean/SD) ($)	Per capita GDP (Mean/SD) ($)
Canada	7,304 (3,332)	0.7966 (0.1249)	2,609 (382)	30,538 (442)
China	89,722 (8,942)	0.1313 (0.0161)	824 (146300)	515 (195267)
Hong Kong	19,005 (12,707)	0.1287 (0.0004)	934 (286)	9,644 (12,172)
Mexico	18,776 (13,004)	0.1211 (0.0661)	802 (171)	7,113 (1,899)
Russia	51,132 (28,999)	0.1373 (0.2451)	778 (289)	1,367 (1,066)

Figures in parenthesis are standard deviation.
Source: Authors.

Exchange Rate in USD ($)

Figure 2. Monthly Exchange rate of the countries in US Dollars (USD), Jan 1993- Dec 2012.
Source: World Bank (WB) and International Monetary Fund (IMF).
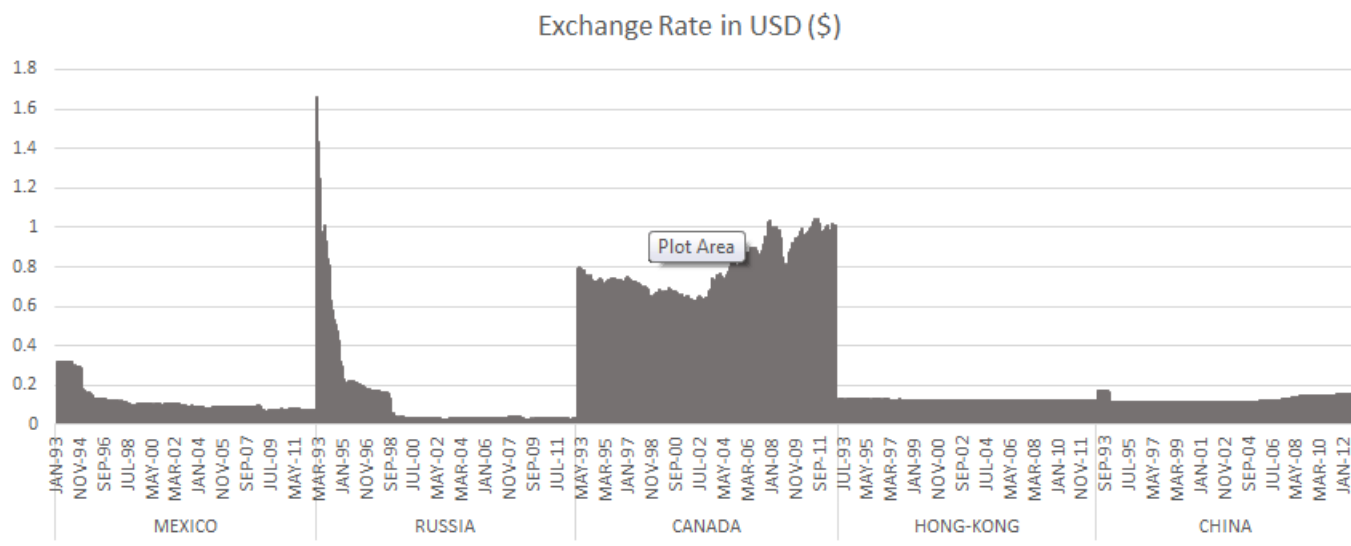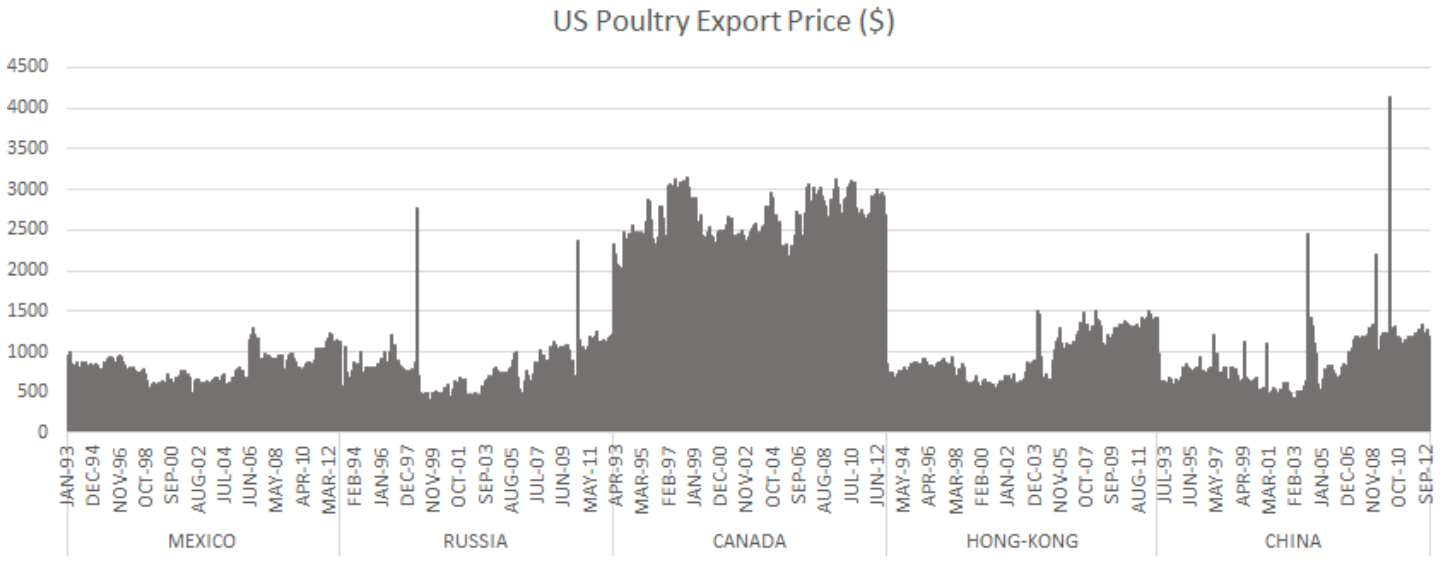
US Poultry Export Price ($)

Figure 3. Monthly export price of US Poultry to their trading partners, Jan 1993- Dec 2012.
Source: Food and Agriculture Organization (FAO) of the United Nations.

produced by a country in a period. GDP per capita is the most commonly used proxy for income. A previous study by Awokuse and Yuan (2006) found that foreign income has significant positive effects on US poultry trade. Total GDP data were recorded in local currencies.

GDP per capita was obtained by dividing the total GDP of a specific year by the population of people living in that country during that specific year. The resulting values which were in the national currency of the countries were then converted to the US dollar by using the corresponding exchange rate. Although per capita GDP only measures the economic output of a country, it does not directly depict the income level but gives a good guestimate on the aggregate productivity measure of the entire population in a country.

$$Per\ Capita\ GDP = \left(\frac{Total\ GDP}{Population}\right) Exchangerate USD$$

Export price depicts not only the price paid by the countries to US poultry exporters but also captures the transportation and associated costs between US and its trading partners. It was derived by dividing the export value by the total quantity, thereby comprising cost, insurance and freight, called c.i.f. The FAO Foreign Trade barriers report explains how these factors and others are put in place and how they affect the import and export trade between the US and different countries. Awokuse and Yuan (2006) used a similar approach to deduce export price.

Empirical model-1: Aggregate double-log model multiple regression model

Where a non-linear relationship exists between the independent and dependent variables in a multiple regression model, it is the usual practice to logarithmically transform the variables (Benoit, 2011). To address skewness and heteroskedasticity, all the variables were converted to natural logarithms. The full model is shown below, equation -1.

There are three specifications: first is a univariate regression with exchange rate variable, and second a multiple regression with

exchange rate, per capita GDP, and export price. Thirdly, country dummy variables are added to the second specification. The third specification is also a fixed-effects model at the country level.

$$\ln Q_{it} = \ln\beta_0 + \ln\beta_1 ER_{it} + \ln\beta_2 P_{it} + \ln\beta_3 G_{it} + e_i,$$

where Q_{it} = Quantity of poultry exports to a country i, where i = Canada, China, Hong Kong, Mexico, or Russia; t represents specific month and year, where t = Jan 1993, Feb 1993, ..., Dec 2012. ER_{it} = Exchange rate in country i and at time t. P_{it} = Export Price of poultry to a given country and at a given time; G_{it} = Per capita GDP of a given country and at a given time; Equation (1) is modified to include country fixed effects.

$$\ln Q_{it} = \ln\beta_0 + \ln\beta_1 ER_{it} + \ln\beta_2 P_{it} + \ln\beta_3 G_{it} + \sum(\beta_{4i} D_i) + e_i$$

D_i is a dummy variable for country i, where i = Mexico, Russia, China, or Canada.

Dummy variables for each country are included to capture time-invariant country-specific factors. To avoid linear dependency, Canada was used as the baseline because it has a similar economic and consumer environment as that in US, and as a result, was dropped out in the regression. Therefore, the estimates of the country dummy variables are to be interpreted relative to Canada. This is synonymous to Knetter's Model which was used by Miljkovic et al. (2003) to identify the potential effects of changes in relative exchange rates on meat export prices.

Empirical model-2: Double-log regression model for each country

To compare the individual country effect, a double-log regression was run for each country. This would help assess the impact of the variables specific to the country, especially to see if those are different or not. Variables in each of the country-level models were significant.

We also ran a univariate regression to examine the effect of the exchange rate on the quantity of US poultry exports to each country, without the inclusion of other control variables, such as per

Table 2. OLS estimates of double-log model on US poultry exports.

Variable (%)	Model 1	Model 2	Model 3
Exchange rate (log)	-0.481*** (0.030)	-0.582*** (0.054)	-0.226*** (0.054)
Export Price (log)	-	-0.156* (0.086)	-0.287*** (0.099)
Per capita GDP (log)	-	0.194*** (0.023)	0.252*** (0.047)
China	-	-	0.196** (0.233)
Hong Kong	-	-	0.365** (0.156)
Mexico	-	-	0.433 (0.167)
Russia	-	-	1.618** (0.225)
F-stat	255***	116***	105***

Single and double asterisks (*) denote statistical significance at the 0.10 and 0.05 levels respectively.
Source: Authors.

RESULTS AND DISCUSSION

Double-log model regression provides elasticities making it easier to interpret the coefficient estimates. It's worth reemphasizing that the data is monthly and hence the estimates represent monthly changes. Since all the variables were converted to natural log, they will be interpreted in percentages. Firstly, we discuss the estimates of equation-1 mentioned above presented in Table 2. Note that the sign of the exchange rate is consistently negative in all three models, which is consistent with a previous study by Awokuse and Yuan (2006). Including country-level fixed effects more than halve the exchange rate estimate, probably, because other variables now capture the variation in the export amounts. Estimates for the country dummy variables represent the difference in the dependent variable between the country and the omitted one, i.e., Canada. In other words, it needs to be interpreted relative to Canada. In terms of magnitude, in response to a 1 percent increase in a country's exchange rate, there will be a decrease of 0.22 percent in the quantity of US poultry exports. Consistent with results found by Eenoo and Purcell (2000), the price of US poultry has a negative impact on the quantity of US poultry exports. That is, for every percentage increase in the US poultry price, the quantity of US poultry exports will decline by 0.287%.

As expected, and in line with research by the FAO (2009), per capita GDP was found to have a positive impact on poultry exports, implying that for a one percent rise in per capita GDP, poultry exports will also rise by 0.252%. The quantity of US poultry exports to Mexico is 0.030 tons higher than that of Hong Kong. The quantity of US poultry exports to Russia is also 0.544 tons higher than that of Hong Kong, while US poultry exports to China are 0.073 tons lower compared to that of Hong Kong. Finally, the quantity of US poultry exports to Canada is 0.159 tons higher than to Hong Kong. Overall significance test revealed a high F-statistic of 105 suggesting model significance in explaining the variations in the quantity of US poultry exports.

The exchange rate is statistically significant and, thereby, influences US poultry exports. Per capita GDP has a significant impact on the quantity of US export as well. The price of US poultry has a statistically significant effect on the quantity of US poultry exports. The dummy variables showed that the quantity of US poultry exports to Russia and Canada are statistically significant, and thus, their quantity of poultry imports from US differs from Hong Kong's poultry imports from the US. Meanwhile, the quantity of US poultry exports to Mexico and China are not statistically different from the quantity of US poultry exports to Hong Kong.

When comparing all three specifications in Table 2, the results are similar in direction of the relationship but vary in magnitude, particularly for exchange rate and export price. Including country-level dummy variables considerably changed the estimates of the other variables which indicates that the relationship among these important trade variables vary by country.

Double-log multiple regression model for individual countries

Running regressions on individual countries showed different relationships between exchange rates and US exports (Table 3). Notably, the exchange rate and per capita GDP variable has a statistically significant association with the quantity of US poultry exports to each of the five countries analyzed here. The exchange rate variable is significant for all countries and the magnitude varies from -0.35 for Russia to a high +75.9 for Hong Kong. The magnitude is below 2 for all countries except Hong Kong. Furthermore, the relationship

Table 3. OLS estimates of double-log model on US poultry exports for individual countries.

Variable (in log)	Canada	China	Hong Kong	Mexico	Russia
Exchange rate	1.672*** (0.222)	-1.052* (0.634)	75.886*** (11.894)	-0.658*** (0.053)	-0.347*** (0.097)
Export Price	0.255 (0.255)	0.186 (0.179)	-1.788*** (0.131)	0.586*** (0.084)	0.044 (0.346)
Per capita GDP	0.123** (0.053)	0.614*** (0.098)	-0.296*** (0.081)	1.058*** (0.075)	-0.291* (0.159)
F-stat	45***	22***	94***	337***	5.3***

Single and double asterisks (*) denote statistical significance at the 0.10 and 0.05 levels respectively.
Source: Authors.

Table 4. OLS estimates of double-log model on US poultry exports controlling for trend.

Variable (%)	Model 1	Model 2	Model 3
Exchange rate (log)	-0.460*** (0.031)	-0.560*** (0.052)	-0.109* (0.059)
Export Price (log)	-	-0.188** (0.096)	-0.440*** (0.103)
Per capita GDP (log)	-	0.189*** (0.024)	0.088 (0.047)
China	-	-	0.196** (0.233)
Hong Kong	-	-	0.365** (0.156)
Mexico	-	-	0.433 (0.167)
Russia	-	-	1.618** (0.225)
Year	-0.460*** (0.018)	0.0046 (0.0062)	0.033*** (0.007)
F-stat	255***	116***	105***

Single and double asterisks (*) denote statistical significance at the 0.10 and 0.05 levels respectively.
Source: Authors.

between the exchange rate and US exports is negative for China, Mexico and Russia, whereas it's positive for Canada and Hong Kong. The variables are in logs as in the earlier models, hence a percentage change in exchange rate decreases trade by less than a percent for Mexico and Russia but just about a percent decrease for China. Those with an increase in US exports in response to, however, Hong Kong showed a 75% increase in response to a percentage change in the exchange rate.

Export prices

Export prices had a significant association only for select countries, namely Hong Kong and Mexico. In contrast, the coefficient was significant in the general regression that included all the major importers of US poultry products. A percentage increase in the export price of Mexico increased the quantity of US poultry exports by 0.59 percent whereas it decreased US exports to Russia by 1.79%.

Similar to the Exchange rate variable, the per capita GDP was significant for all countries. The estimated size ranged from -0.29 for Russia to +1.06 for Mexico. Hong Kong and Russia showed decrease in receiving US exports when per capita GDP increased, whereas Canada, China, and Mexico increased US exports. R-

square does show considerable variability in how much the quantity of US poultry exports is explained by per capita GDP, exchange rate, and the poultry price.

CONCLUSION AND IMPLICATIONS

This study investigated if the exchange rate impacts poultry exports from US to the top five trading countries. All the models employed in this study (except that involving China) confirm our hypothesis that the exchange rate might significantly impact the quantity of poultry exports (Table 4). We also find that the exchange rate has an inverse impact on the quantity of US poultry exports, although the magnitude is not large. Previous studies found similar results. For example, on a panel of 186 bilateral trading partners, Rose et al. (2000) observed a small indirect impact of exchange rate on poultry exports. DeGrauwe and Skudelny (2000) also found a statistically significant indirect effect of exchange rate on trade in the European Union, as did Dell'Ariccia (1999).

Individual country models showed that Canada and Hong Kong stood out as the only two countries whose exchange rates had a positive relationship with poultry exports. This is consistent with Langley et al. (2000), who found that exchange rates had a positive impact on

Thailand's exports of poultry, but not on the overall agricultural exports. However, this is contradicted by a few other studies (Anderson and Garcia, 1989; Awokuse and Yuan, 2006) that found a negative effect of the exchange rate on US poultry exports.

This study sheds more light on the relationship among poultry trade variables. Overall, the exchange rate shows mixed results. However, a closer look suggests that the relationship is negative with middle-income countries and positive with higher-income countries. The export price in equivalent dollars also shows mixed results, however, the significant price coefficients show the opposite sign of that of the exchange rate coefficient. The exchange rate coefficient for Hong Kong is +76 but the export price is -1.8, whereas, for Mexico, the exchange rate is -1.7 and the price is +0.6.

The negative association between exchange rate and poultry exports holds even in a country-level fixed effects model. The significance of country-level dummy variables could be because of some country-specific factors, such as varying demand for product quality or domestic policies (Miljkovic et al., 2003). It is also likely that policies, such as special status owing to trade agreements could have created an environment for price discrimination (Miljkovic et al., 2003).

This sounds logical because trading partners offer special trade deals either through NAFTA or GATT to favored nations. These special trade deals may provide greater incentives to trade with those favored nations. These policies could impact the coefficient of exchange rate in the model. Miljkovic et al. (2003) argued that the US became one of the world's crucial meat exporters in the era of trade liberalization.

The inverse relationship observed in this case depicts that the export market responds to lower prices. Rising promotion and customer awareness during an era of low prices might help maximize poultry exports. Eenoo and Purcell (2000) stressed the impact of the periodic low US poultry prices of the 1990s in the export market, during which time the export market responded sharply to the low prices. They argued that increased consumption can be induced only if there is a price decline.

In most models per capita, GDP had a direct impact on poultry exports. Thus, per capita GDP, a common proxy for individual income used in the literature, can be said to be an important demand driver of poultry exports. Therefore, US poultry exporters should focus more on trading partners whose economies where incomes are rising. US poultry exporters could also focus on higher quality US poultry meat. A strategy like this may also favor the domestic poultry producers in developing countries with low per capita GDP and income because they will have less competition. This might not be true for all developing economies, because competition has been argued to drive efficiency.

Currency devaluation policies could also impact the quantity of US poultry exports. It could be that some of the countries evaluated in this study are expanding domestic poultry production. Coleman and Payne (2003) found that between 1990 and 2001, Mexico's poultry industry was the fastest growing sector of the country's livestock production, with production rising to a yearly average of about 9 percent. Findings like these are vital for exporter pricing schemes, export market expansion, and estimating the impact of currency devaluation on US poultry exports (Miljkovic et al., 2003). The R-square of the above model revealed that exchange rate, export price, and per capita GDP can only explain 38.2 percent of the variability in the quantity of US poultry exports. This implies that there might be other variables that need to be considered in future research.

It must be noted that the variables were in dollars or made dollar equivalent. The implication is that the relationships among variables in currencies would also be impacted by monetary policies or currency devaluation. For example, currency devaluation took place in Mexico during the 1990s (Eenoo and Purcell, 2000). Due to growing population, sub–Saharan Africa is expected to be the highest importer of poultry accounting for 19% of the global trade.

According to an ERS study, the regions exhibiting the strongest projected increases in population are developing countries and emerging markets, including sub-Saharan Africa (up 27%), the other Middle East region (up 18%), Mexico (up 21%), Latin America and the Caribbean (up 36%), and China and Hong Kong (up 37%).

CONFLICTS OF INTERESTS

The authors have not declared any conflicts of interests.

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The determinants of public debt in the Gambia: Estimates using the autoregressive redistributed lag (ARDL) bound cointegration technique

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The main objective of this paper is to examine the key determinants of public debt in the Gambia. To achieve this objective, the Autoregressive Distributed Lag (ARD) method was employed to examine the impact of short-run and long-run selected macroeconomic variables as well as a government effectiveness variable in determining the public debt level of The Gambia during the period 2000 to 2019. The results reveal that trade openness and gross fixed capital formation have an increasing impact on the Gambia's public debt in the long-run. On the other hand, GDP growth, official exchange rate, and the government effectiveness variables have been found to have decreasing effects on public debt levels in the long-run. However, none of the variables show a significant relationship with public debt of levels of The Gambia in the short-run. Given these findings, it is recommended for the Government of the Gambia to improve the country's governance effectiveness, in particular, as weak government institutions was found to be one of the main drivers of the country's public debt in the long-run.

Key words: Public debt, debt sustainability, Auto Regressive Distributive Lag (ARDL), GDP growth.

INTRODUCTION AND LITERATURE REVIEW

Public debt, which is also referred to as government debt, pertains to the total amount of money that a government owes to its creditors. However, although the accumulation of public debt is a global phenomenon, with many countries having high levels of public debt, the debate in both the academic and policy-making circles on the determinants of public debt accumulation, particularly in developing countries remains both on-going and intense. Some, including Berensmann (2019) cite internal factors, including poor debt management and low government revenues, while others found other economic factors such as interest rate, economic growth, inflation, debt stock, budget deficit, public expenditure, openness, and monetary policy credibility as determinants of public debt (Drazen, 2000; Imbeau and Pétry, 2004; Swaray, 2005 as cited in Ekouala (2022:12-13). For Ekouala

(2022), socio-political factors such as the system (both presidential and legislative), corruption, electoral openness and competitiveness for legislative election as well as fraud have all been found to be key determinants of public debt accumulation, particularly in countries of the Central African Economic and Monetary Community region.

Similarly, research focusing on topics such as the sustainability and the optimality of the public debt levels, as well as the corresponding sustainable trajectory of fiscal balance has also been voluminous and growing (See for example Forslund et al., 2011; IMF, 2019; Calderón and Zeufack, 2020).

Other studies have also earlier examined the elements that determine the evolution of public debt (Reinhart and Rogoff, 2010; Sinha et al., 2011; Swamy, 2015; Lau and Lee (2016). Swamy (2015) in particular revealed that economic growth, population, FDI, and inflation all had a diminishing impact on debt using the Panel Granger causality methodology. He argued that investment, government spending, and openness to trade, on the other hand, had an increasing impact on public debt. Sinha et al. (2011) used panel regression to confirm that growth in GDP, interest rate changes; inflation rate, current account, and foreign direct investment are the primary factors that influence the magnitude of public debt. However, Reinhart and Rogoff (2010) examined GDP growth and public debt nexus, concluding that if the percentage of debt-to-GDP is less than 90%, the link between them becomes weak.

Sinha et al. (2011) used panel regression to confirm that growth in GDP, interest rate changes; inflation rate, current account, and foreign direct investment are the primary factors that influence the magnitude of public debt. However, these findings were refuted by the study of Reinhart and Rogoff (2010) who examined GDP growth and public debt nexus concluding that if the percentage of debt-to-GDP is less than 90%, the link between them becomes weak.   These conclusions spurred a lot of debate that led a distinct body of research to explore whether the arguments are robust enough to account for non-arbitrary debt levels (Krugman and Eggertsson, 2011; Cecchetti et al., 2011; Bittencourt, 2015).

In a study that used multiple econometric methodologies, Lau and Lee (2016) explored main factors driving public debt in The Philippines and Thailand. Their findings suggest inflation and interest cost to have been the most important elements in determining Thailand's external debt. However, no proof of relationship could be established between the aforementioned variables and public debt in the case of The Philippines. This finding conforms to an early study by Rangarajan and Srivastava (2003) who established that primary deficits and the difference between interest rates and growth significantly influences the change in debt-to-GDP ratios.

A parallel strand of literature focuses on debt sustainability and a country's debt carrying capacity is said to be determined by numerous factors, including primary deficits, interest payments, exchange rate, inflation, and GDP growth, as well as the macroeconomic environment and debt management capacities (Mahmood et al., 2009; Greenidge et al., 2010; Wyplosz, 2011; Kiptoo, 2012).

Greenidge et al. (2010) conducted a study on the drivers of foreign debt in the Caribbean countries and the results show that there is decreasing impact export and effective exchange rate (REER) on external debt. This finding conforms with the conclusion of a study by Kiptoo (2012), who looked at the factors that influence Kenya's external debt sustainability and found that the country's level of export and economic growth were both directly related to debt sustainability.

In groundbreaking study, Eisl (2017) evaluated the impact of government effectiveness on public debt. The results from this study showed that political stability, the rule of law, the control of corruption, government effectiveness, and regulatory quality promote lower public debt accumulation because these minimizes the incentives for governments to "borrow from the future," by increasing state capacity to collect taxes and effectively use public funds, and by providing more security and equity to private investment, inducing higher economic growth and tax revenues.

Other studies that focused on examining the nexus between public debt and these governance indicators include North (1991), Acemoglu et al. (2002), Acemoglu et al. (2005), Oatley (2010) and Gunduz (2017).

According to Gunduz (2017), institutions that control government operations in managing economic resources play a significant role in designing well-formulated policies that boost economic efficiency and lower the risk of negative shocks. In this sense, governments that have better and higher-quality institutions are more likely to stimulate performance and increase production, resulting in more job opportunities for their citizens. This according to Gunduz (2017) will convince consumers to spend more, thus enabling the government to mobilize more revenue through taxes and thereby help avoiding budget deficit in the future.

In a seminal study, Acemoglu et al. (2002) provided outstanding arguments as to why the quality of institutions is the drivers that explain the differences in economic performance between countries. These differences in the quality of institutions, according to Acemoglu et al. (2002), helps explain why some countries are wealthy, while others are impoverished, with countries having strong institutions growing faster than those without. South and North Korea, for example, were the same country in 1944, with the same people, cultures, history, languages, and geography. However, when they split in 1945, each adopted a different economic path. North Korea adopted a centrally planned

economy with no private property rights, no free press. South Korea, on the other hand, adopted a capitalist system of economy that includes property rights, democracy, an open economy, and a reliable legal system. Their institutional differences reflect their divergent economic paths and, as a result, debt bearing capacity.

Strong institutions are believed to uphold and ensure effective ownership rights, which encourage investors to spend, develop, and participate in economic activities. Expectations are important in an economy and as such, if individuals believe their property rights will be retained and safeguarded, they will become more ready to invest in the country, all of which play a role in a country's debt carrying capacity and long-term debt sustainability (Acemoglu et al., 2005).

As can be seen from the foregoing brief survey of the recent literature, both theoretical and empirical findings on the determinants of public debt remain inconclusive, particularly in the context of developing countries. Hence, it is important to investigate the key determinants of public debt in the context of a small developing economy like the Gambia, given that the value of the country's public debt has risen sharply in recent years and as of September 2022, it stood at D90.7 billion (https://www.voicegambia.com/2022/12/05/gambias-debt-stood-at-d90-7billion-finance-minister/).

This represents a significant burden on the country's economy and poses risks to its financial stability and long-term growth prospects. Therefore, it is important to understand the factors that contribute to the country's public debt and assess their significance in shaping its trajectory.

Overall, the literature suggests that the determinants of public debt vary across countries and regions. In the case of The Gambia, no specific studies have however identified the different determinants of the country's public debt levels.

The paper thus attempts to fill this apparent gap in the literature by addressing the main research questions of the study: do the selected variables such as trade openness, gross fixed capital formation, GDP growth, official exchange rate, and the government effectiveness manifest a causal relationship on the evolution of public debt in The Gambia, and if such a nexus exists, what are the policy implications of this link?

The paper addresses these questions by using an Autoregressive Redistributed Lag (ARDL) bound cointegration technique to analyze the determinants of public debt in the Gambia. The ARDL model is a popular econometric technique that allows for the estimation of both long-run and short-run relationships between variables, making it well-suited for analyzing the determinants of public debt.

Through this analysis, the paper makes a significant contribution to the growing body of literature on public debt in developing countries, and provides insights into the factors that contribute to the high levels of public debt, particularly in the Gambia. By analyzing the role of economic and political factors in shaping the country's debt dynamics, the paper provides a more comprehensive understanding of the determinants of the Gambia's public debt and offers practical recommendations for improving debt management, not only in the Gambia, but in other developing and emerging economies, as well.

The rest of the paper is structured as follows. Section II describes the research methodology used in the study, including a description of the data, variables, and econometric techniques. Section III provides an analysis of The Gambia's public debt portfolio in order to give the discussion more meaning.

Section IV presents the empirical results of the ARDL model, including a discussion of the significance of the determinants of public debt in the Gambia, while Section V concludes the study by summarizing the main findings of the paper, highlighting its contribution to the literature, and provides recommendations for the country's policymakers and other stakeholders.

DATA AND METHODOLOGY

The study is based on secondary time series data and focuses on both short-run and long-run analysis to check the determinants of public debt in the Gambia.

Data

This study uses a time series data on DEBT (public debt to GDP ratio), GROWTH (GDP growth), OPEN (trade openness), GFCF (gross fixed capital formation as a percentage of GDP), RIR (real interest rate), EX_RATE (official exchange rate), and GOV_EFF (Government Effectiveness) all extending over the period from 2000 to 2019. The data was extracted from the World Development Indicators (WDI) database, and from the Central Bank of the Gambia (CBG) data warehouse.

Similar variables have also been used in previous studies on the determinants of public debt (Ekouala, 2022; Bittencourt, 2015).

To determine the influence of economic growth on public debt, the model includes GDP growth (GROWTH) over the period of the study. Higher economic growth raises domestically generated revenue, which reduces the need for debt. Hence, the expected sign of the GROWTH coefficient in this paper is negative.

Trade Openness in this paper measures the degree to which a country is engaged in trade with the rest of the world. It is determined as the summation of exports plus imports in a year divided by Gross Domestic Product (GDP). Despite the fact that openness of an economy does manifest a direct link with public debt, they are widely established to have manifested an inverse relationship. Least developed economies are typically characterized by restrictions on trade.

According to Auboin and Meier-Ewert (2003), the elimination of trade barriers can lead to greater growth in an economy and an increase in export, thus, reducing dependence on external debt. The expected sign of openness in this paper is negative, implying that the more the open an economy is, the lower its public debt levels.

Exchange rate fluctuations have been widely argued in most of

the literatures to have impacted the debt levels in many least developed countries. When the value of a country's currency appreciates its debt level reduces, vice versa. The study expects to manifest a positive relationship between EX_RATE (official exchange rate and public) and DEBT (public debt as percentage of GDP). A control variable, Gross Fixed Capital Formation (GFCF) is expected to have a positive coefficient as the more investments are undertaken by the Government; the more they borrow more from the external sources to finance these investment projects thus increasing public debt levels.

Another potential influencing element on public debt levels which has been generally overlooked is government efficacy. Only Asiedu and Lien (2011) evaluate, at least implicitly, the impact of government effectiveness on public debt.

Taking example on FDI inflow, findings have established too much of unnecessary levels of bureaucracy in a government obstruct such flows.

We may infer this finding to the postulated causal relationship that link governance indicators to the government debt levels. Government effectiveness has both restricting and enabling impact on both public and private players.

Firstly, effective governments have viable, cogent, and result-oriented policies that allow them to better and prudently allocate its meagre funds. This helps in reducing the dependence on the issuance of new debt to support the government's budget.

Secondly, because an effective government delivers a steady and relatively beneficial economic environment, the quality of public services helps increase the amount of revenue generated in an economy. As a result, higher tax revenues are generated, reducing budget deficit, which necessitates borrowing.

Government effectiveness variable in this paper is part of the World Governance Indicators from the World Bank database that are calculated from 31 diverse sources which are based on hundreds of different factors (Kaufmann et al., 2010). The data exclusively focuses on perception data reported by commercial information providers, public sector organizations worldwide, survey respondents, and NGOs. The aggregate indicator of a country's score is expressed in standard normal distribution units (-2.5 to 2.5).

The explanatory variables described above were selected based on the review of the empirical and theoretical literature on the determinants of public debt.

Model specification

As argued by Njie and Badjie (2021), the preferable model for the assessment of the determinants of public debt is the vector error correction model (VECM) because the time series vary and are not stationary at the level term. However, the data are mostly stationary.

Vector Error Correction (VEC) model

A Vector Error Correction Model (VEC) as in (1) is a restricted VAR designed for use with non-stationary series that are known to be integrated. The VEC has cointegration relations built into the specification so that it restricts the long run behavior of the endogenous variables to converge to their cointegration relationships while allowing for short run adjustment dynamics.

This study uses a time series data on DEBT (public debt to GDP ratio), GROWTH (GDP growth), OPEN (trade openness), GFCF (gross fixed capital formation as a percentage of GDP), RIR (real interest rate), EX_RATE (official exchange rate), and GOV_EFF (Government Effectiveness). The analysis of the determinants of public debt in the Gambia is based on the following model:

$$\text{DEBT}_t^j = \hat{\beta}\, X_t^j + \mu_j + \vartheta_j + \varepsilon_{jt} \qquad (1)$$

X_t^j is a vector of regressors including lagged GDP growth (GROWTH), openness (OPEN), Gross fixed capital formation (GFCF), real interest rate (RIR), official exchange rate (EX_RATE), government effectiveness (GOV_EFF). The dependent variable in the analysis below is the public debt to GDP rate. It also includes the constant. μ_j is country-specific fixed effects, ϑ_j is time fixed effects, ε_{jt} is the unobservable error term. The final equation estimated in the model is given as:

$$DEBT_t^j = GROWTH_{t-1}^j + OPEN_t^j + GFCF_t^j + RIR_t^j + EX\_RATE_t^j + GOV\_EFF_t^j + \mu_j + \vartheta_j + \varepsilon_{jt} \qquad (2)$$

Table 1 provide the description of variables and data sources.

Descriptive statistics

Analysis of the Gambia's public debt portfolio

In this part of the study, a brief description of the nature and pattern of growth of the Gambia's public debt portfolio was provided.

One of the most worrying and challenging economic issues faced by the policy makers in The Gambia is the high risk of debt distress on the public debt portfolio. From the recent debt sustainability analysis conducted, the results have shown that the country has breached most of the indicative debt sustainability thresholds by substantial margins, signalling major liquidity pressures (MoFEA, 2020a).

Since the country received debt forgiveness through the Highly Indebted Poor Countries (HIPC) initiatives, the debt levels have been rapidly increasing; this continues to pose threatening macroeconomic implications. According to an IMF (2018) Second Staff Monitoring Program Review, The Gambia's public debt risks have worsened, with the ratio of debt to GDP approximately 130% at end 2017. Debt service to revenue threshold registered significant breach in the recent periods showing a liquidity challenge of the government as huge chunk of the domestically generated revenue predominantly from taxes goes into servicing debt consequently restraining government spending in other pressing sectors like agriculture, education, health etc.

This situation propelled the government to reduce the cost-risk factors embedded in the public debt portfolio over the medium to long term by pursuing various policies aimed at addressing these problems such as seeking only concessional external financing and lengthening the maturity profile of the domestic debt to reduce roll-over risk. One of the major objectives of these policies was to reduce the government's net domestic borrowing, which would relieve yield pressure and allow for a progressive extension of the maturity profile thus, help avoid locking in excessive costs upfront by extending the maturity too quickly (MoFEA, 2020 b).

The Gambia's public debt can be traced back to the 1970s when the country began borrowing from external sources to finance its development projects. By the 1980s, The Gambia's public debt had already reached alarming levels, and the government had to resort to borrowing from the International Monetary Fund (IMF) to meet its debt obligations.

In the 1990s, The Gambia's public debt continued to increase, mainly due to external borrowing to finance infrastructure projects. By 2000, the country's public debt had reached $539 million, representing about 93% of GDP. This high level of debt led to a debt crisis in The Gambia, which prompted the government to seek debt relief from international creditors.

In 2007, The Gambia's external debt was reduced by 87% under the Highly Indebted Poor Countries (HIPC) initiative, which was a

Table 1. Descriptive statistics.

Variable	N	Mean	Std. Dev.	Min	Max
DEBT	20	101.22	31.48	60.91	156.01
GROWTH	20	3.18	4.22	-8.13	7.23
OPEN	20	0.51	0.08	0.39	0.69
GFCF	20	15.18	5.45	4.56	24.92
RIR	20	19.21	12.12	-29.71	29.59
EX_RATE	20	31.76	10.69	12.79	50.06
GOV'T_EFF	20	-0.64	0.11	-0.90	-0.47

Source: Authors.
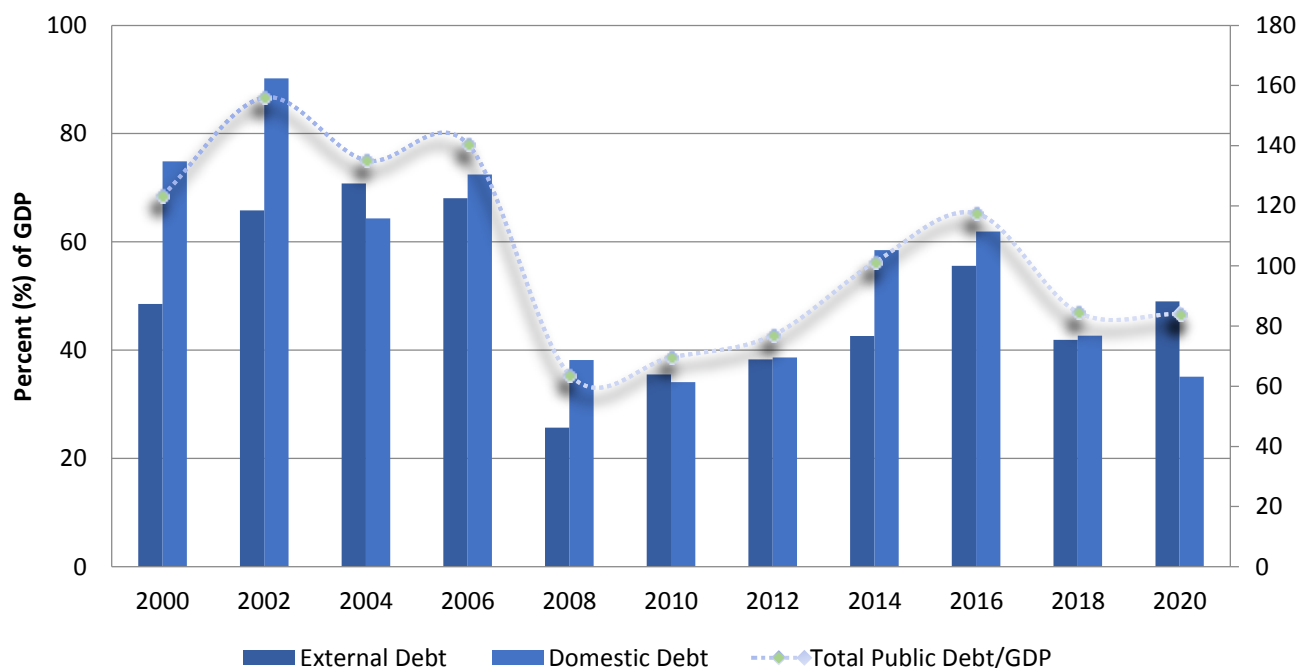
Figure 1. Evolution of public debt outstanding as a percentage of GDP.
Source: Authors.

joint program between the IMF and the World Bank aimed at reducing the debt burden of the world's poorest countries. This debt relief helped to reduce the Gambia's debt-to-GDP ratio to 45% in 2010.

Despite the debt relief, The Gambia's public debt continued to rise in the following years, mainly due to domestic borrowing to finance recurrent expenditure. By 2017, the country's public debt had reached $1.2 billion, representing about 120% of GDP. This high level of debt has put a strain on the country's economy and has made it difficult for the government to finance its development projects.

In recent years, the government of The Gambia has taken steps to address the issue of public debt. In 2018, the government launched a debt sustainability analysis to assess the country's debt position and develop a strategy for managing its debt (International Monetary Fund, 2018). The analysis found that The Gambia's debt was sustainable in the medium term, but it was still vulnerable to external shocks.

Notwithstanding, no specific research has examined the drivers of Gambia's debt levels to the best of my knowledge. As a result, this research intends to add to the current body of knowledge on

the relationship between specified variables and public debt levels with focus on The Gambia. The Government, particularly the Ministry of Finance and Economic Affairs will be interested in this paper's findings which can be used to make policy decisions.

To achieve this goal, this paper will attempt to address the following central research question: What are the key determinants of public debt accumulation in the Gambia?

In finding answer (s) to the aforementioned question, the paper uses the Autoregressive Distributive Lags Mechanism (ARDL) as proposed by Pesaran et al. (2001) to test whether the selected variables manifest a short run or long run impact on the public debt levels in The Gambia.

Public debt evolution in the Gambia

The graph in Figure 1 illustrates the historical trend in the evolution of public and publicly guaranteed debt for the past twenty years. The Gambia's public debt levels have ever been in an increase before the receipt of the HIPC and MDRI debt reliefs mainly as a result of persistent budget deficits, fiscal slippages, and an increase

Table 2. Unit root test.

Dickey-Fuller Unit-Root-Test (DFURT) using AIC			
Variables	P-value at level	P-value at 1st difference	Judgment
DEBT	-1.624	-4.782***	1(1)
GROWTH	-4.680***	-	1(0)
OPEN	-2.536	-5.194***	1(1)
GFCF	-1.988	-6.566***	1(1)
RIR	-4.179***	-	1(0)
EXC	-0.700	-2.784*	1(1)
GOV_EFF	-2.955**	-	1(0)

*, **, and *** represent 10, 5 and 1% significance levels, respectively.
Source: Authors.

in guarantees to the State Own Enterprises (SOEs). Before the receipt of the HIPC debt relief, the county's debt levels reached 140 per cent to GDP.

In 2007 the country reached the HIPC completion point and benefited from assistance worth 66.6 million USD which was meant to reduce the country's debt as a percentage of export below the 150 per cent HIPC threshold. In terms of net present value, World Bank and IMF contributions to this debt relief were US$22.3 million and US$2.3 million, respectively. As of November 2007, US$8.0 million and US$0.6 million of these total promises had already been delivered as interim assistance. In Net Present Value (NPV) terms, the total debt relief provided between 2001 and 2007 was US$17.5 million. In addition, The Gambia also benefitted from Multilateral Debt Relief Initiative (MDRI) that was initiated by the G8 countries to eliminate debts of most indebted countries with the aim to further reduce HIPCs debt and offer more resources to assist in achieving the Millennium Development Goals. This relief has helped to reduce the Debt to GDP ratio down from 140.5% to 60.9% as shown in Figure 1.

Even though the relief was on the external debt portfolio, the impact of the relief has trickled down on the domestic debt portfolio too as the relief has created a breathing space for the budget which eventually reduced the issuance of T-bills from the domestic debt market to finance the budget deficit.

Despite the receipt of these debt reliefs, the country soon started to breached most of the indicative debt thresholds in less than a decade which can be attributed to the uncontrollable growth in the budget deficit. This has forced the government to restructure its external debt with most of the bilateral and multilateral creditors in 2020 by deferring principal payments up to 2024.

According to the Debt Sustainability Analysis (DSA) report (2020), exchange rate, economic growth, primary balance, nominal interest rates, and foreign direct investments, as well as current account balance have been the driving factors on the growth of public debt in The Gambia. Historical data have shown that the combination of current account deficit and FDI are established to have been the most significant cause of the increase in debt in The Gambia. Other inexplicable factors (residuals) could have contributed to debt accumulation in the past, some of which will be assessed in this paper.

EMPIRICAL RESULTS AND DISCUSSION

The major objective of this paper is to examine the determinants of public debt in the Gambia. Therefore, in this section, we will discuss the results from the ARDL

model used to estimate determinants of the country's public debt by presenting and discussing the results of the Dickey-Fuller Unit-Root-Test, the lags selection using AIC, the ARDL bound test and the stability check that was used to test the long run stability and reliability of the ARDL model.

Dickey-fuller unit-root-test

Unlike most of the other co-integration techniques, the ARDL has important properties that make it appropriate for this study. For example, it does not impose a limiting condition that all variables for the research must be integrated using the same order. Furthermore, the ARDL methodology produces precise estimates even if the sample size is small, but other co-integration methods are sensitive to sample size, so doing bounds testing will indeed be consistent with this study. Read Srinivasan et al. (2012) for additional information on the ARDL approach.

Pesaran et al. (2001) suggested the ARDL technique that is premised upon its estimation of an Unrestricted Error Correction Model (UECM), which has significant advantages over traditional cointegration methods.

Moreover, all the variables in this paper are time-series data, which means they could be non-stationary having unit roots. A simple regression model using non-stationary variables might generate erroneous results.

ARDL model is deemed ineffective when series are integrated to order 1(2) or above. As a result I first run a unit root test on the time-series variables. The test results are shown in Table 2, which indicates that variables are integrated to a series of 1(1) or 1(0), indicating that the ARDL model is suitable to use.

Lags selection using AIC

Unrestricted ECM was used in order to check the long-run co-integration of the variables in the model. To be

Table 3. AIC lag lengths.

LAG level	Variable						
	DEBT	GROWTH	OPEN	GFCF	RIR	EX_RATE	GOV_EFF
0	9.47249		6.69022	5.89173		7.31769	
1		5.91796			8.21932		-1.71521
2	9.13928	5.90838	6.68267	5.43455	8.34429	4.83351	-1.64514
3	9.24051	6.0286	6.73295	5.50353	8.46097	4.88081	-1.5246
4	9.27908	6.04665	6.72456	5.62239	8.57502	5.00578	-1.4259

Source: Authors.

Table 4. ARDL bounds test result.

H_θ: no levels relationship	F = 11.475						
	t= -6.356						

Critical Values (0.1 -0.01), F-Statistic, Case 3

	[I_0]	[I_1]	[I_0]	[I_1]	[I_0]	[I_1]	[I_0]	[I_1]
	L_1	L_1	L_05	L_05	L_025	L_025	L_01	L_01
K_7	2.03	3.13	2.32	3.5	2.6	3.84	2.96	4.26

Accept if F < critical value for I(0) regressors
Reject if F > critical value for I(1) regressors

Source: Authors.

able to do that, the number of lags must be established first before executing UECM which I did using the Akaike Info Criteria (AIC).

The lag lengths (1 0 1 1 0 1 0) established in Table 3 using the AIC are included in the Error Correction Model in order to establish the short run impact of the independent variables on public debt.

ARDL bound test

The ARDL bound test is used to check the co-integration and long-run connection between DEBT, GROWTH, GFCF, OPEN, RIR, EX_RATE, and GOV_EFF. The empirical findings of the ARDL bound test are presented in Table 4. The results show that the F - value is higher than the upper bound value, indicating that there is a long-run relationship and co-integration between public and the explanatory variables.

Stability check

The CUSUM SQUARE was used to test the long run stability and reliability of the ARDL model as proposed by Brown et al. (1975). As seen in Figure 2, the CUSUM of SQUARES test falls within the significant threshold of 5% range. This indicates that all of the parameters utilized in

the ARDL regression analysis have remained steady throughout time.

Long Run ARDL model using AIC criteria

According to the output of the estimated long run ARDL (1, 1, 1, 0, 0, 0, 0, 1) shown in Table 5, trade openness, investment, GDP growth, government effectiveness and official exchange rate are the main determinants of the Gambia's public debt in the long run with some degree of statistical significance.

The results show that trade openness and investment are positively associated with public debt accumulation in the Gambia and are significant at 1% and 10% significant levels respectively. This is in line with our theoretical preposition and findings in earlier literature. On the other hand, GDP growth, government effectiveness, and official exchange rate are inversely related the public debt in the Gambia. This is consistent with their significance levels at 5, 5, and 10% respectively.

The negative relationship between GDP growth and public debt levels manifested by the results of this paper is supported by the findings of Hall and Sargent (2010). This is in line with the assertion that higher economic growth enhances a country's domestic revenue generation, which in turn helps in lowering a country's budget deficit, thus reducing the pressure to contract
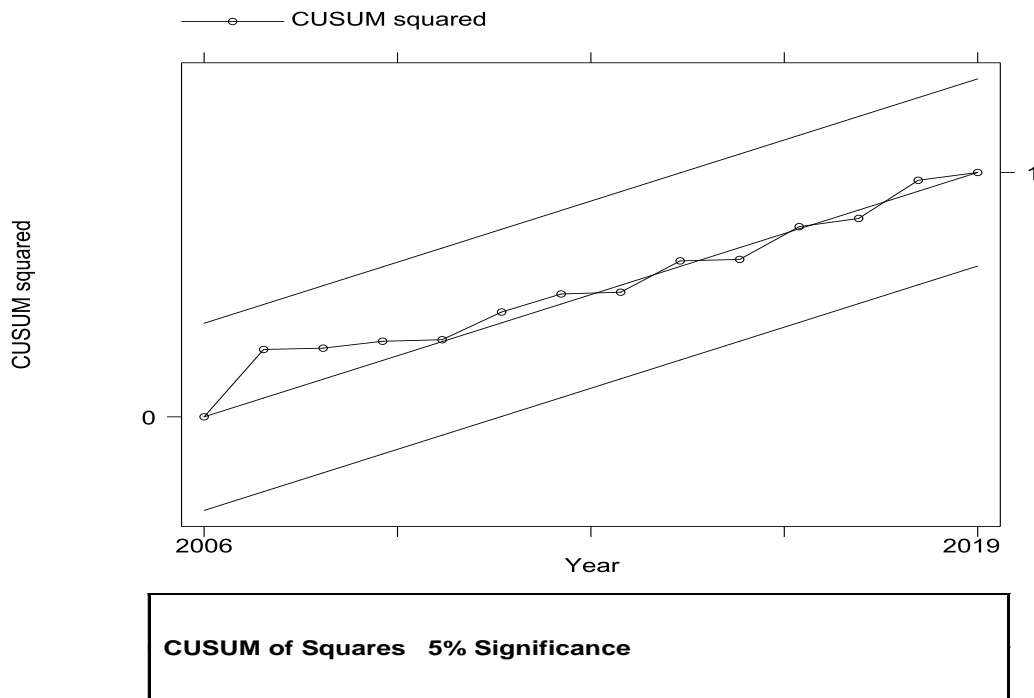
Figure 2. CUSUM squared.
Source: Authors.

Table 5. ARDL model regression output.

ARDL(1,1,1,0,0,0,1) regression
Sample: 2000 - 2019
Number of obs   =   20
R-squared   =   0.7966
Adj R-squared   =   0.5424
Root MSE   =   15.7573
Log likelihood = -71.131157

D.DEBT	Coef.	Std. Err.	t	P>t	[95%Conf.	Interval]
ADJ						
DEBT						
L1.	-0.836**	0.238	-3.510	0.008	-1.386	-0.286
GROWTH	-3.169*	1.303	-2.432	0.041	-6.172	-0.165
OPEN	4.834**	0.942	5.131	0.001	2.661	7.006
GFCF	7.820*	3.493	2.240	0.056	-0.234	15.874
RIR	-0.528	0.523	-1.010	0.342	-1.734	0.678
EX_RATE	-5.851**	1.818	-3.220	0.012	-10.043	-1.658
GOV_EFF	-13.346*	6.301	-2.118	0.085	-29.056	23.363
SR						
OPEN						
D1.	-1.415	1.018	-1.390	0.202	-3.762	0.932
GFCF						
D1.	-1.402	1.975	-0.710	0.498	-5.958	3.153
EX_RATE						
D1.	3.869	2.205	1.750	0.117	-1.216	8.955
_cons	-124.885*	52.942	-2.360	0.046	-246.970	-2.801

*, **, and *** represent 10, 5, and 1% significance levels, respectively.
Source: Authors.

loans to finance the budget deficit.

In the same vein, the decreasing effect of government effectiveness on public debt can be supported by the findings of Melecky (2012) who posits that countries with effective governments have good public debt management strategies and policies that help in mitigating financial risk and lower cost of borrowing, thus keep the debt at a sustainable level.

Gross fixed capital formation shows a significant positive relationship which is in line with most of the findings in the literature. As governments embark on more investment ventures, they tend to borrow more to finance these investment activities.

In the short run, the model shows that none of the selected variables affect public debt in The Gambia as they are all statistically insignificant.

The Error Correction Model (ECM) measures the rate of adjustment back to equilibrium in an ARDL model. If the adjustment speed or error correction term is inside the (0, -1) boundary; it shows that there is a long term convergence of the model. However if the adjustment speed does not lie within the (0, -1) boundary, then projected debt accumulation will be regarded to be growing out of hand. Therefore, the above results show that the evolution of Gambia debt level will not aggressively grow in the long run. This is supported by the ECM coefficient (-0.898) which is statically significant at 5% significant level. The estimate, -0.898, implies that 89.9% of the deviation from the long-run relation is adjusted in a year, which can be interpreted as indicating that the short-run dynamics is not really important.

Conclusion

The aim of this research is to empirically investigate the drivers of public debt levels in The Gambia, using the ARDL model.

The Gambia's efforts to attain higher and sustainable economic growth are significantly hampered by the country's huge and expanding public debt and its servicing. This paper contributes to the body of literature on the determinants of public debt with specific focus on the Gambia by using the Autoregressive Redistributive Lags (ARDL) technique. In order to achieve this aim, time series data from 2000 to 2019 was used on the selected variables that impact debt accumulation both in the short run and in the long run.

The results show that the effectiveness of a government has a decreasing effect on the public debt levels in The Gambia in the long run. This suggests that an effective government which is characterized with quality policy formulation, implementation, and a well functional debt management office may help in keeping the public debt at a sustainable level. Similarly, the appreciation of The Gambian Dalasi is found to reduce the public debt burden, however, this might eventually be a problem as the appreciation of the currency may lead to an expansion of the current account deficit and hence the external debt. Therefore, policy makers should ensure to have a stable currency in order to mitigate the exposure of external debt to foreign exchange risk.

Trade openness and gross fixed capital formation on the other hand are both associated with an increase in the public debt levels in The Gambia. However, the result of the error correction model shows that none of these variables are significant in determining the public debt levels in the short run. This implies that the short run dynamics of the public debt may not be that significant, and thus, policy makers should pay more attention to the factors that have a long run influence on the public debt levels.

Our findings have some implications for policy-making in the Gambia because the results show that an increase in economic growth is associated with a decrease in public debt in the long run. As a result, the government should pursue programs and policies that will enhance economic growth in order to keep the debt at an optimal and sustainable level.

Finally, the Government of the Gambia, particularly the Ministry of Finance, may find the results of this study useful in making economic policy decisions such as whether to increase the country's public debt and the implications such decisions for the Gambia's long-term economic growth prospects.

CONFLICTS OF INTERESTS

The authors have not declared any conflicts of interests.

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Capital, risk and efficiency tradeoffs in Cameroonian banking

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This paper analyzes the relationship between capital, risk and efficiency for a sample of 10 Cameroonian banks between 2014 and 2020. To reach the authors' target, they specify a system of equations and estimate it using the two stage least squares panel data estimator technique. The empirical analysis shows that increases of bank capital do not reduce risk taking in Cameroonian commercial banks. Moreover, cost efficiency does not explain risk taking in the Cameroonian commercial banks. There is however a negative impact of change in risk taking on the bank cost efficiency. Finally, changes in bank capital contribute positively to the yearly change in bank efficiency. Hence, policies aiming at ensuring that bankers are not tempted to play by the rules or inducing commercial banks behavior towards injection of more capital might help to improve bank efficiency and stability in this country.

Key words: Financial reforms in banking, bank capital, risk, efficiency, Cameroonian banks.

INTRODUCTION

Cameroon is an African country belonging to the Community of Central African States (CEMAC). Following the economic and banking crisis at the end of the 1980s and as a component of the structural adjustment program (SAP) implemented mostly in response to the external pressure of the International monetary fund (IMF), this country underwent financial reforms during the 1990s. These reforms were considered as a means to build more efficient, robust and deeper financial systems. Indeed, for their proponents, such reforms would bring about significant economic benefits through improved bank efficiency and effectiveness to guarantee a more effective mobilization and efficient allocation of resources among various economic activities. Consequently,

implemented measures aimed at addressing governance, risk management and more efficiency in banking and were around financial deregulation, banks restructuring and firming up capitalization to improve soundness in banking. As a result, over the last decades, banking industry in Cameroon has experienced major structural and institutional transformations that alter governance of banks operating on this country.

Domestic mergers, acquisitions and increase in foreign capital participation were among major observed structural changes in this country. The last state-owned bank in Cameroon was sold in January 2000 and this was the last step in a Structural Adjustment Programmed (SAP) recommended by the Bretton Woods Institutions

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for the country to reach the completion of the Highly Indebted Poor Countries Initiative (HIPC).This initiative was recommended to re-launch the country's economy after a decade of economic crisis that seriously affected its banks. This crisis also led to liquidation of giants such as Cameroon Bank, Banque Meridien, Rural Development Fund and the split- winding of the Bank of Credit and Commerce of Cameroon (BCCC), with transfers of its good assets to Standard Chartered Bank of Cameroon (SCBC).

Relative to institutional changes going with financial reforms, an attention was given to strengthening the regulatory and supervisory institution. The power to supervise the banking system initially carried out by the Cameroonian Loans National Council (CNC) was transferred to a community institution: The Banking Commission of Central African States (COBAC) created in 1992. As a result of this institutional change, observed failure of banks during this period was followed by a raising of the initial capital requirement of commercial banks from CFAF 300 million to CFAF 1 billion and later by an increase of the bank's minimum capital requirement vis a vis their risk- weighted assets, 8 per cent as prescribed by the Basle committee of banking in 1995.

Moreover since the early 1990s, financial liberalization implementation in Cameroon, driven by financial deregulation and technological change, has made Cameroonian banking markets increasingly more competitive. As a result, there has been tremendous emphasis on the importance of improved efficiency in the banking sector. But at the same time, this increase in competition could lead to incentives for greater bank risk-taking implying potential risk- efficiency tradeoffs in Cameroonian banking. To address this potential threat to the bank system stability, the banking commission of Central African states gave capital adequacy a more preeminent role in the prudential regulatory process. The question then arises of whether or not the level of bank capital has a significant impact on risk-efficiency tradeoffs in Cameroonian banking?

This question is of real importance in Cameroon for at least two reasons: Firstly, despite the great number of papers dealing with the issue of whether or not higher capital ratios reduces or increases overall banking risk, this issue remains largely unsolved. Moreover, the recent streams of the literature introducing the efficiency of banks into the debate just led to conflicting theoretical hypothesis. For a significant part of researchers convinced by the bad luck hypothesis, increase in risk determined by exogenous factors negatively affects bank efficiency. Conversely, for the proponents of the bad management hypothesis, bank efficiency is determined by internal behavior in banks. Therefore, it is the reduction of efficiency caused by bad management that induces increase in bank risk taking. In the third hypothesis (the skimping hypothesis), if this negative relationship between efficiency and bank risk taking

exists in the short term, it turns into a positive one in the long term. As the empirical evidence remains contradictory, this paper will therefore add empirical evidence in the Cameroonian context and allow comparisons with what is observed in other countries. Furthermore, despite the importance of this topic, with regard to financial instability and systemic bank crises observed in this country during the 90s and recent reported cases of bank distress (IMF, 2018), there is a lack of subsequent research to guide bank authorities' interventions.

Secondly, despite underwent reforms, if the excess liquidity of banks is a striking feature of the Cameroonian banking system at the end of the restructuring process as pointed by Avom and Eyeffa Ekomo (2007), in recent years the question of loan quality and of its implicit risk consequences still occupy a prominent place. In the Cameroonian context, the level of non-performing loans first declined from an average of 405 of total credit in 1995 to around 12% at the end of 2006 following the restructuring of the banking sector and the transfer of impaired loans to a loan recovery agency in the late 1990s.

But, Cameroon's structurally high ratio of non-performing loans was later aggravated in the first quarter of 2018 to 15 percent far from observed averages in North America (0.07%), Europe and Central Asia (3.8%) or even Sub-Saharan Africa (11.7%) (IMF, 2018). In more recent years and according to COBAC statistics, non-performing loans have increased by 45 billion between 2020 and 2021.

This observed increase in bad loans might not rely on the bad luck hypothesis of Berger and DeYoung (2007) in Cameroon. As IMF (2018) noted, the Cameroonian banking system has proven its resilience to exogeneous shocks even resulting from foreign economic behavior. Face to the twin recent oil price and security shocks, bank reaction was an improvement of prudential ratios. More specifically, after a declining to 9 per cent at the end of 2016, the system wide capital adequacy ratio increased to 10.7% at the end of March 2018 (IMF, 2018). Indeed, there are variations across banks on meeting the prudential ratios. In 2015 seven banks did not have enough capital to meet capital requirement of the bank Commission of Central Africa states (COBAC), and four banks (13% of banks' total assets) were in distress in 2018 with 3 of them having negative capital. This seems to be in relation with bank ownership. Following the restructuring process in the Cameroonian banking system, the capital ownership structure was modified in favor of foreign participation. Table 1 illustrates the selected banks in Cameroon, and the ownerships structure of capital in 2019.

This preeminence of foreign capital in banking can potentially expose the country to external shocks, as investors might at any time move their funds to correct imbalances in their domestic economies. But this was not

Table 1. Ownership structure of capital in selected Cameroonian banks (2019).

Banks	Government	Foreign capital	Domestic capital	Others
BICEC	17,50	70	7.5	5
SGBC	25,60	58,06	16,32	
AFRILAND		74	4	22
CBC	98,09		1,91	
BGFI BANK	20	70,69		9,31
ECOBANK		79,80	9,35	10,85
UBC		54	37	9
UBA	17.5	70	7.5	5
SCBC		100		
SCB	2.49	97.51		
CITIBANK		99,98%	0,02%	

Source: COBAC.

the case in Cameroon even during the international financial crisis of subprime. Indeed, despite the importance of foreign banks with parents that have been hit, the reaction of commercial banks in Cameroon to this external shock was to increase collateral requirements, to widen their spread and refocus their portfolios on blue chip companies and high network clients, making access to credit even more difficult for SMEs.

Overall, faced with exogeneous shocks, the reaction of banking authorities is, in many cases, to increase capital adequacy ratios to cope with bank risk taking. This shows their adhesion is not only to the idea of a negative relationship between bank capital and risk-taking behavior of banks in accordance with traditional theoretical banking models, but also to the idea that such an action can help reaching at the same time more efficiency as required by the reforms. Furthermore, by arguing that non-performing loans are not linked to external shocks, IMF (2018) implicitly suggests a determining role of the dynamics observed at the very level of Cameroonian commercial banks as described by the bad management hypothesis.

The following hypotheses can therefore be formulated;

H1: Increase in bank capital reduces commercial banks' risk taking in Cameroonian banking system
H2: There are tradeoffs between bank efficiency and bank risk taking in Cameroonian banking system
H3: Inefficient banks run with higher level of capital in Cameroonian banking system.

THEORETICAL ARGUMENTS

For a great number of researchers, risk-taking behavior and cost efficiency are adversely related in banking. At least, two alternative theoretical arguments allow the rationality of such a position to be established.

Firstly, the Berger and DeYoung (1997)'s bad luck hypothesis in which, an external event increasing the amount of problem loans may result in efforts to service these loans. This implies higher incurred costs. According to this argumentation, such exogenously determined increase in risk therefore impacts negatively the observed cost efficiency of banks: hence the idea of efficiency-risks tradeoffs in banking. Thereby, the causality runs from increase in bank risk due to external shocks to cost efficiency decrease.

Secondly, the bad management hypothesis in this alternative argument is an increase in the amount of problem loans caused by unwished internal bank behaviors. In such a case, the lower cost efficiency is a signal of poorly performing management, which has also poor control over its loan portfolio. Moreover, decrease in efficiency can motivate the bank to boost its risk in order to offset the lost levels of efficiency (Nguyen and Nghiem, 2015). Bank risk taking and efficiency relationships are therefore negative. Finally, as noted by Tan and Floros (2013), a part from credit, poor managerial practice can tarnish banks' reputation and cause market problems. Therefore, and unlike the bad luck hypothesis, in the bad management hypothesis, internal lower cost efficiency leads to an increase in problem loans.

Unlike the arguments developed so far, let us now differentiate short term from long term consequences. Monitoring of loans has an impact on both the amount of non-performing loans and cost efficiency, and this would imply possible intertemporal tradeoff between the quality of loans and the cost efficiency of the bank. In fact, bank may skimp on the resources devoted to underwriting and monitoring loans, reducing operating cost and increasing cost efficiency in the short run. But such a behavior may have an impact on the riskiness of the portfolio in the long run because non-performing loans increase as poorly monitored borrowers fall behind in loan repayment. Hence, banks that do not spend resources for instance in problem loans monitoring appear to be more efficient in

Table 2. Theoretical bank capital, risk taking and efficiency interlinks.

Risk-Capital - Risk-efficiency	Negative relationship (hazard moral hypothesis)	positive relationship (Regulatory theory)	No relationship
Trade offs			
Bad management hypothesis Bad luck hypothesis	Lower efficiency	Higher efficiency	No effect
No trade offs			
Skimping hypothesis	Higher efficiency	Lower efficiency	No effect
No relationship	No effect	No effect	No effect

Source: Authors.

the short term (Bashir and Hassan, 2017; Kolia and Papadopoulos (2020). But in the long term, they take on higher risk as this management behavior affects the quality of future loans. This theoretical position called skimping hypothesis in the literature implies a positive relationship between the considered variables and consequently a rejection of the idea of tradeoffs between efficiency and bank risk taking in banking.

The mediating effect of risk taking in the capital-efficiency relationship

Seminal researches to test the alternatives theoretical predictions in any US (Berger and DeYoung, 1997; Kwan and Eisenbeis, 1997) or European countries (Williams, 2004; Altunbas et al., 2007; Fiordelisi et al., 2011) yield contradicting results most explained by the differences in econometric methods. An alternative explanation in this paper is that the rationality of capital, risk and efficiency relationships builds both on the long-lasting bank capital-bank risk controversy in the banking literature, and in the more recent idea of bank risk-efficiency tradeoffs.

Two dominant and opposed hypotheses characterize the capital-risk relationships in the banking literature. For the proponents of negative relationship or proponents of moral hazard hypothesis (Lee and Hsieh, 2013), banks may have the incentives to increase their portfolio risk and leverage due to moral hazard because financial contracts are incomplete. In fact, bank managers usually exploit the rights of depositors that they primarily favor their interest in managerial compensation and support the benefit of shareholders for their wealth maximization. On the contrary, proponents of the regulatory approach suggest that banks are required to increase their capital in increased risk taking. Regulators therefore suggest the positive bank capital- risk relationship to reduce the problem of bankruptcy owing to higher risk and lower capital.

Hence, linking these two strands of the banking literature might help to establish the mediating effect of risk in the capital efficiency relationships, connecting definitively the three variables. We clearly distinguish the

case tradeoffs hold from the case tradeoffs is rejected.

If the tradeoffs hold and bank capital and risk are related negatively, an increase in capital requirements will result in a deterioration of bank risk taking behavior. The higher level of bank risk will in turn decrease bank cost efficiency. Let us now suppose in the same case, a positive capital-risk relationship. An increase in capital requirements in this case improves the bank risk-taking behavior (decrease of risk) and hence, leads to higher bank cost efficiency in the long term.

Let us now suppose that the bank efficiency-bank risk tradeoffs do not hold. If bank capital and risk are related negatively, an increase in capital requirements improves bank risk behavior. The lowering of risk deteriorates in this case bank cost efficiency. On the contrary, if there is a positive capital-risk relationship, changes in capital requirements affect in the same direction bank risk. Therefore, increase in capital requirements results in higher bank cost efficiency. Table 2 summarizes the theoretical relationships between the three variables in the banking literature.

Empirical review

Bank capital and risk taking

Empirical evidence on the relationship between capital requirement and risk taking is far from being conclusive. In the case of USA, Calem and Rob (1999) quantified the effect of capital-based regulation and find that an increased capital requirement, whether flat or risk based, tends to induce more risk taking by ex-ante well capitalized banks that comply with the new standard. In fact, undercapitalized banks took higher risk because the cost of bankruptcy is shifted to deposit insurance. But well capitalized banks also took higher risk because it is more profitable and there is low probability of bankruptcy. Koehn and Santomero (1980) and Kahane (1977) concluded that risk-based capital boosts risk-taking. Shrieves and Dahl (1992) and Jokipii and Milne (2011) confirm the positive relationship between capital and risk changes while studying the USA banking data. Blum

(1999) advocates that capital adequacy requirements increase the riskiness of banks. Matajesak et al (2009) favor a positive association between risk-taking and capital ratio in the case of US and 15 European countries. This is also the conclusion of Ugwuanyi (2015), who examined the relationship between risk and capital in the post-crisis setting. In contrast, Jacques and Nigro (1997) and Aggarwal and Jacques (1998) applied a similar methodology and concluded on an inverse relationship between risk and capital. Lee and Hsieh (2013) examined the effect of capital ratio on risk-taking of Asian commercial banks covering 1994 and 2008. They documented an inverse relationship between risk and capital ratio in support of the moral hazard hypothesis. Tan and Floros (2013) found an inverse relationship between capital and risk. Recent empirical contributions also favor the negative relationship between risk-taking and bank capital (Ding and Sickles, 2018; Jiang et al., 2020).

Bank efficiency and bank risk

If the aforementioned empirical contributions were mainly interested in the relation between risk and capital, for Hughes and Mester (1998), the stress should also be on the analysis of the tradeoff between risk and efficiency. The result of their empirical test shows a negative relationship between the two variables. More generally, empirical test of the efficiency-risk trade off yields conflicting results in the banking literature. For instance, in examining the same link in a large sample of European banks between 1992 and 2000, Altunbas et al. (2007) noted that inefficient European banks seem to undertake less risk. William (2004), Le (2018) and Tan and Floros (2013), in their empirical contributions, confirm this result and suggest that efficiency and risk are adversely related. Deelchand and Padgett (2009) using a sample of 263 Japanese cooperative banks over the period 2003 through 2006, confirm the belief that risk, capital and efficiency are simultaneously determined, but suggest a positive relationship between efficiency and risk in banking as argued in the hazard moral hypothesis. In fact, the results of their research show that inefficient Japanese cooperative banks take more risk, contrasting with evidence in Europe. This result is also in line with that of Kwan and Eisenbeis (1997) in the case of US commercial banks. For Bashir and Hassan (2017) or Nguyen and Nghiem (2015) the relation is also positive. They argue that banks not spending resources on risk monitoring seem to be more efficient in the short term, but, they take higher risks in medium and long term.

Bank capital and bank efficiency

The empirical evidence on bank efficiency and bank capital also remains mixed even in recent contributions of literature. Berger and Di Patti (2006), in their study of the relationships between capital ratio and profit efficiency in US banking industry over the period 1990-1995, find that higher capital has negative effect on efficiency. Also interested by profit efficiency, Fiordelisi et al. (2011), using granger tests of causality in a GMM dynamic panel framework, examine the reverse causality between the two variables. Their findings emphasize that the less efficient banks tend to take more risk and better capitalized banks perform better in terms of efficiency.

However, Barth et al. (2013), in their study of whether or not bank supervision, regulation and monitoring enhances or impedes bank operating efficiency in a sample of 72 countries over the period 1992-2007, find that a more stringent capital requirement is marginally and positively associated with bank efficiency. This was also the result of Haque and Brown (2017)'s study while Triki et al. (2017) find this true only for large banks. Pasouiras (2008) also states that capital stringency improves efficiency but their result was not robust over all specifications. Sufian (2016), in the case of Malaysian banks for the period 199-2008 or Banker et al. (2010) in the case of Korean banking institutions, suggest that efficiency is positively related to capital. Pasouira et al. (2009) discuss the impact of capital stringency not only on cost efficiency, but also on profit efficiency. As a result, capital stringency increases cost efficiency and decreases profit efficiency. Onio (2017) seems to confirm Berger and Di Patti (2006)'s findings of a negative association between capital and financial performance in the case of European banks. Bashir and Hassan (2017) state that an increase in capital increases agency costs and the free cash at the disposal of managers, leading to a decrease of efficiency. More recently, Djalilov and Piesse (2019), in their study of the impact of bank regulation on bank efficiency, consider 04 regulations: activity restrictions, capital requirements, market discipline and supervisory power. The paper finds bank activity restrictions to be the only regulation improving banking efficiency, using a sample of 21 transition countries for the period 2002-2014.

Finally, Miah and Sharmeen (2015) using a sample of banks from year 2001 to 2011 in the case of Bangladesh concluded that, capital, risk and efficiency are interrelated. One explanation of such a situation is that, the tree variables could depend on other factors such as moral hazard, asymmetric information, ownership structure and agency problems.

MATERIALS AND METHODS

Research design and sample size

At the end of 2020, 15 commercial banks operated in Cameroun. As the bank population is not large enough, the authors are constraint to test their hypotheses using a small sample. Small

Table 3. Sample representativeness.

Banks	Capital	Assets	Deposits	Loans
BICEC	49.1	726,5	602,7	320,9
SGBC	12,5	1055,4	830,2	621,1
AFRILAND	20	1260,1	997,6	603,7
CBC	12	458,1	336,6	311
BGFI BANK	20	376,5	250	273,5
ECOBANK	10	466	369,2	191,7
UBC	20	118,1	57,8	2,8
UBA	10	480,6	376,3	136,9
SCBC	10	224,3	168,8	93,1
SCB	10,5	624	509,5	324,1
Sample	174,1	4733,6	4498,7	2878,7
All banks	260,9	7010,7	5398,8	3443,7
Percentage	66,84	67,51	83,32	83,59

Source: Authors calculations.

samples are generally associated with low statistical power and increased margin of errors that can render the study meaningless.

Furthermore, there is also a possibility of vibration effects with small samples. Vibration effects refer to a situation of change of results as a consequence of even minor analytical manipulation. In the case of Cameroonian commercial banks, the authors expect a very low sampling variability as commercial banks share the same regulatory environment imposed by the Banking Commission of Central African States (COBAC). A major challenge raised notably by Van de Schoot and Miocević (2020) remains however to increase information in data by using reliable measures and a smart sampling approach. In this study, they use a non-probabilistic sampling approach. They therefore excluded five banks because of unavailability of information and data on key variables included in the model. Their panel is therefore constituted of 10 banks with yearly data in millions of Fcfa from 2014 to 2020 on all the variables included in their econometric model. The authors therefore have enough observations to obtain reliable results when estimating their econometric model. COBAC database is used to obtain banks' balance sheets data and income statements. The financial statements published on the website of each bank are also used to have reliable data on included variables. In this case, data are first converted in Fcfa when needed, and then presented in millions of Fcfa. In 2020, four of the banks considered in the sample (Afriland First Bank, SGBC, BICEC and SCB) remain the most important banks in the Cameroonian banking system in terms of activity. These four institutions account for 52% of the banking system's consolidated balance sheet, 54.3% of total loans and 54.5% of total customer deposits. As shown in Table 3, taken together, the sample banks represent 83.3% of deposits 83.59% of loans and almost 68% of assets of the whole banking industry.

Measurement of variables

The measure of endogenous variables was discussed briefly (Bank risk, capital and efficiency) and included control variables.

Bank risk measure

There is until now no consensus on how to measure bank risk in the literature. If some recent papers are based on insolvency risk

(Moyo, 2018), (Barra and Zotti, 2018), others still rely on more traditional measures. Insolvency risk is measured by distance to default indicator as follows: $Risk = log(\frac{eq_{it}+roa_{it}}{\sigma roa_{it}})$ where $eq = \frac{equity}{total\ assets}$ and σroa *the* Standard deviation of ROA. Concerning more traditional approaches, the most widely used indicator is portfolio risk. Bank risk measure is hereby given by the ratio of risk-weighted assets to total assets (Jacques and Nigro, 1997; Rime, 2001; Aggarwal and Jacques, 2001). The standardized approach to calculating risk-weighted assets consists in multiplying the amount of an asset by the standardized risk weight associated with that type of asset. A high proportion of RWA indicates a higher share of riskier assets. However, a limit generally reported of the risk weighting methodology is that it can be manipulated.

Liquidity risk is generally measured by the loans to deposits ratio (LDEP). Banks with higher loans to deposits are usually viewed as riskier due to potential shortage of liquidity. In the Cameroonian case, bank excess liquidity observed in recent years does not comply with the use of such indicator. Moreover this over-liquidity goes with credit rationing accentuated by the risk aversion of bankers, suggesting that bank risk indicator based on credit risk might be more appropriate in Cameroonian banking. This last option includes among others, as in Abedifar et al. (2013), Tan and Floros (2013) or Bitar et al. (2018), the possibility to use loan loss reserves as a fraction to total assets as a proxy of credit quality. Higher values of this ratio can be a sign of a precautionary reserve policy in the bank or an anticipation high non performing revenues (Anginer and Demirguc-Kunt, 2014). The problem with this ratio in the Cameroonian case is that its variations between banks may be related to different banking policies regarding non-performing loans, reserves and write-offs.

Following Bashir and Hassan (2017) and Kabir and Worthington (2017), non-performing loan ratio was used in this paper that is, the non-performing loans as a fraction of total loans as a risk indicator. The advantage of this ratio in Cameroonian banking is that it might contain information on risk differences between banks not caught notably by RWA.

Non-performing loans are measured by loans past due 90 days or more and non-accrual loans and reflect the ex-post outcome of lending decisions. As noted by Ding and Sickles (2018), higher values of the NPL ratio indicate that banks ex-ante took higher lending risk and, as a result, have accumulated ex-post higher bad loans.

The measure of capital

Capital ratio is generally measured in three ways. Tier1 risk based - ratio based (proportion of total capital to risk-weighted assets), total risk-based ratio (proportionoftier1 and tier2 capital of risk weighted assets) and tier 1 leverage ratio (ratio of tier1 capital on total assets). Following Nguyen and Nghiem (2015) and Zheng et al. (2017), the authors calculated capital as the ratio of core capital to total assets (capital adequacy ratio).

Efficiency scores

The authors further computed Individual bank efficiency (EFF) as the distance of a firm's observed operating costs to the minimum or 'best-practice' efficient cost frontier. Efficiency scores are derived using the stochastic frontier approach. Based on Aigner et al. (1977), the cost function of a firm is as follows:

$$CT_i = c(Y_i; P_j, \epsilon_j) \tag{1}$$

Where CTi represents the bank i total operational costs, Yi the vector of quantity of bank output variables and Pj the vector of

$$\text{Ln}(CT_{it}) = \beta_0 + \beta_y \ln(Yit) + \frac{1}{2}\beta_{yy}[\ln(Yit)][\ln(Yit)] + \sum_j \beta iyln(P_{jit}) + \frac{1}{2}\sum_j \quad \sum_k \beta_{jk}\ln(P_{jit})\ln(P_{kit}) + V_{it} + U_{it} \tag{3}$$

In this relation, *i* stands for banks and *CTit* is the total cost of bank i at the year t *where t* represents years. As *j* is an index for labor (lab), physical capital (cap) or financial capital (fin), *Plabit denotes* labor price in bank at the year t, *Pcapit* the price of physical capital of bank at year t and *Pfinit* the remuneration of financial capital of bank i at time t. The authors further noted *Yit* the output of bank *i* at the year *t*, v the random error term that incorporates measurements errors and luck and *u* a firm effect representing the bank inefficiency level, that is the distance of an individual to the efficient cost frontier. Indeed, cost efficiency measures the distance of a bank relative to the cost of the best practice bank when both banks produce the same output under the same conditions. The cost efficiency scores are therefore computed as: $CostEFF^b = \frac{exp[u^{min}]}{exp[u^b]}$

$Where\ U^{min}$ denotes the lower value taken by U^b among sample banks. Table 4 recapitulates variables included in the cost function and their measure. Table 5 presents the cost frontier estimated efficiency scores in the Cameroonian banking.

The level of estimated efficiency scores varies all along the study period and between banks. The highest level is attained in 2017. Concerning bank analysis, Commercial Bank Cameroon (CBC) with more than 98% state participation in the capital, that was not regulatory compliant in 2009 and goes into a restructuring process and a temporarily management until 2018 is also the less efficient bank of the studied sample.

Control variables

For the explanatory variables the authors used a broad range of bank-specific and country - specific variables that are believed to be important in explaining performance and risk. These include loans growth (loang) as rapid loan growth may increase risk and impact adversely on capital and bank efficiency. Bank size, through economies of scale, may influence the relationship between capital, risk and efficiency so we control for the assets size of banks (size). Big banks, typically hold less capital than smaller banks; they may also be more diversified and gain from other size advantages so it is important to control for this factor. Table 6 provides a synthetized description of the variables includes in the system of equation to be estimated.

prices of bank input variables. ϵ_j hereby denotes the compound random error. This error is divided into endogenous (u_b) and exogenous factors (e_b) that influence bank production costs. Endogenous factors or inefficiency factors are therefore related to an increase of bank production cost because of an error of management that causes inefficiency. Exogenous factors represent an increase or a decrease of bank cost due to random factors (mistakes on data's, on measurement of unexpected or uncontrolled factors). u_b and e_b are supposed separable. Taking the logarithmic form of the relation (2), we then have:

$$LnCT_i = f(Y_i, P_j) + Lnu_b + Lne_b \tag{2}$$

One remaining problem to solve to estimate this relation is that of the functional form of the production function.

To measure cost efficiency in Cameroonian banking, the authors specify a cost frontier model with two outputs and three inputs. In fact, they suppose that, in this country, bank's production function uses labor and physical capital to attract deposits. The collected deposits are used to fund loans and other earning assets. Inputs and outputs are therefore specified using the intermediation model presented by Sealey and Lindley (1977). The translog specification of the used cost frontier model (relation 3) is as follows:

Modelling framework

The modelling framework adopted to test the hypotheses in this study is based on the various approaches suggested by the strand of the literature aiming to criticize the earlier causality approach proposed by Berger and DeYoung (1997) in their seminal contribution and implemented by several researchers. As a response to causality approach and taken all together, a significant part of proposed approaches in this empirical literature implicitly suggest that, as bank capital risk and efficiency are determined simultaneously, examining the investigated relationships should best be evaluated in an appropriate system of simultaneous equations, further estimated by efficient estimators (Tan and Floros, 2013), Altunbas et al. (2007), Moudud-Ul-Huq (2019), Moudud-Ul-Huq (2020). The authors therefore specify a system of equations and estimate these using the three stage least squares panel data estimator technique. This allows for simultaneity between banks' risk, capital and efficiency while also controlling for important other bank specific factors and endogeneity. The system of equations estimated is as follows:

$$\Delta risk_{i,t} = \alpha_0 + \alpha_1 risk_{i,t-1} + \alpha_2 \Delta eff_{i,t} + \alpha_3 \Delta cap_{i,t} + \alpha_4 size_{i,t} + \alpha_5 loang_{i,t} + \varepsilon_{it} \tag{4}$$

$$\Delta eff_{i,t} = \beta_0 + \beta_1 eff_{i,t-1} + \beta_2 \Delta risk_{i,t} + \beta_3 \Delta cap_{i,t} + \beta_4 size_{i,t + \varepsilon_t} + v_{it} \tag{5}$$

$$\Delta cap_{i,t} = \gamma_0 + \gamma_1 cap_{i,t-1} + \gamma_2 \Delta risk_{i,t} + \gamma_3 \Delta eff_{i,t} + \gamma_4 size_{i,t} + \gamma_5 ROA_{i,t} + w_{it} \tag{6}$$

The relations (4), (5), and (6) satisfy the order conditions required for the identification in simultaneous equations system.

RESULTS AND DISCUSSION

Bank risk equation results

In this equation, the authors are interested by the sign of

Table 4. Cost frontier inputs and output description.

Variable	Notation	Description
Total cost	CT	Total of interest and non interest cost
Output		
Total loans	Y	Gross loans-reserves for loan loss provisions
Inputs prices		
Price of physical capital	Pcap	Expenditures on premises and fixed assets/premises and fixed assets
Price of labor	Plab	Salaries on full time equivalent employees
Price of borrowed funds	Pfin	Interest expenses paid on deposits/total deposits

Source: authors.

Table 5. Cost frontier efficiency scores in Cameroonian banking (%**).

Year	Mean	Med	Sd	Min	Max
2014	0.595	0.634	0.114	0.356	0.754
2015	0.660	0.650	0.145	0.448	0.857
2016	0.746	0.749	0.126	0.514	0.897
2017	0.791	0.810	0.075	0.672	0.881
2018	0.727	0.757	0.149	0.420	0.872
2019	0.718	0.759	0.172	0.351	0.859
2020	0.773	0.759	0.095	0.620	0.937

Source: Author's calculations based on Frontier 4.1.

Table 6. Variables included in the model.

Variable	Description
Eff	Estimated efficiency scores
risk	Non-performing Loans ratio
cap	Capital adequacy Ratio
size	natural logarithm of total assets
NIM	Net interest margin
ROA	Return on assets
loang	Loans annual's growth rate

Source: Authors.

the capital variable coefficient. If this coefficient is significant and negative, they will assert that Hypothesis H1 is validated. The estimated coefficient of bank capital variable (∆CAPt) is however significantly positive on 5% level, suggesting that the changes in risk and capital are positively related. The hypothesis H1 is therefore not validated. This result is consistent with Abbas et al. (2021), but do not confirm the findings of Ding and Sickles (2018) or Jiang et al. (2020). Therefore, faced with more stringent capital requirements in difficult times as noted during the 2007 crisis or Covid 19 pandemic, commercial banks in Cameroon seem to structure their activities in a way to reduce the regulation burden without

a corresponding reduction in the underlying risk. This can explain the high level of non-performing loans observed in this country in recent years despite measures taken by COBAC.

The authors are also interested by the sign and of the coefficient of the efficiency variable. A negative and significant coefficient would indicate that there is a tradeoff between the efficiency and risk and that this is explained by the bad management hypothesis. The results of the risk equation presented in Table 7 do not support any relationship between the changes in bank's efficiency and bank risk position in Cameroonian commercial banking. The coefficient is not statistically

Table 7. Risk equation results.

Variable	Coef.	SE	t-stat	Prob
C	-1.194***	0.409	-2.917	0.004
ΔCAP	0.256**	0.105	2.441	0.016
ΔEFFIC	-0.067	0.183	-0.365	0.715
Risk (-1)	0.153***	0.031	4.852	0.000
Size	0.044**	0.018	2.418	0.017
Loang	1.001***	0.085	11.725	0.000

Source: Authors calculations based on EViews 12 software.

Table 8. Efficiency equation results.

Variable	Coef	SE	t-stat	Prob
C	0.926***	0.241	3.839	0.000
Δcap	0.127**	0.056	2.262	0.025
ΔRisk	0.063*	0.037	1.675	0.096
Effic (-1)	-0.972***	0.134	-7.220	0.000
Size	-0.009	0.009	-0.969	0.334

Source: Authors calculations based on EViews 12 software.

significant, albeit negative.

This suggests that changes in bank's efficiency do not lead to changes in bank risk-taking behavior in Cameroonian commercial banks.

Moving to control variables, the change in the bank risk behavior is positively dependent on the net interest margin of a given year. When facing favorable interest rate environment, commercial banks in Cameroon might be tempted to increase the amount of loans provided at the expense of decreased quality of such loans. The results also imply that the change in RISK variable is determined by the loan growth (significant at 1% level) and bank size (significant at 5% level). Large banks are therefore less averse to risk in Cameroon.

Bank efficiency equation results

Table 8 presents the results of the second equation in the authors' system, where the change in the bank's cost efficiency is the dependent variable. They are interested in the estimated coefficient of the risk variable ($\Delta RISK_t$) since this estimate is related to the bad luck explanation of the tradeoff's hypothesis between bank efficiency and bank risk-taking behavior. For H2 to be validated, the estimated coefficient of the bank risk variable should be negative. This is the case in Table 8. This coefficient is negative with a value of -0.063 and significant at 10% level. They may infer from this that change in bank's cost efficiency is negatively affected by any change in bank risk taking behavior in Cameroon.

Hypothesis H2 is therefore validated. As IMF (2018) suggests that exogeneous shocks are not linked to commercial bank risk taking in Cameroon, this might be explained by unskilled management that is losing control over both the cost structure of the bank and the administration of its loan portfolio.

From the table, it can be seen that the coefficient of bank capital (ΔCAP_t) is significant at 5% level and presents a positive sign with a value of 0.012. This result suggests that commercial banks with higher capital operate more efficiently in Cameroon. This finding seems consistent with Shrieves and Dahl (1992), Berger and DeYoung (1997) Altunbar et al. (2007) or more recently Haque and Brown (2017), but do not support Bashir and Hassan (2017).

Based on the estimate of size variable ($SIZE_t$) coefficient, we might observe that the changes in the cost efficiency are not related to the size of the bank. This might suggest that behavior of the banks with respect to cost efficiency does not vary with increasing balance sheet size. This result is not consistent with the findings of Wheelock and Wilson (2012) or Hughes and Mester (2013).

Capital equation results

Let us move to the results of the capital equation presented in Table 9. The results show a negative and significant relationship between change in capital and change in bank efficiency. Inefficient banks run therefore

Table 9. Capital equation results.

Variable	Coef	SE	t-stat	Prob
C	0.642	0.504	1.273	0.205
ΔEffic	-0.551**	0.212	-2.591	0.010
ΔRisk	-0.525***	0.047	-11.047	0.000
CAP (-1)	-0.182***	0.055	-3.274	0.001
Size	-0.026	0.022	-1.153	0.251
ROA	0.028	0.017	1.629	0.105

Source: Authors calculations based on EViews 12 software.

Table 10. Capability of the model.

Equation	OBS	PARMS	RMSE	R-SQ	F-STAT	P
Efficiency	54	5	0.131	0.479	12.59	0.000
Risk	54	6	0.116	0.535	11.19	0.000
Capital	54	5	0.472	0.513	14.27	0.000

Parms=parameters RMSE=Root mean square error
Source: Authors calculations.

with higher level of capital in Cameroonian banking. H3 is validated. The authors also have a negative one with risk taking meaning that capital regulation is not binding strictly in Cameroon. In fact, there is a possibility that banks escape from COBAC's measures. Banks with significant amount of non-performing loans are forced to provide more provisions leading to consequent evolution of their capital. Similarly, as observed in the risk equation, results of the estimation of the capital equation suggest a negative and significant relation with the size of the bank as generally found in the literature and notably by Aggrawal et al. (1998) or Rime (2001). The change in the bank capital is however not related to the bank's return on assets in a given year. This last result is not consistent with Altunbas et al. (2007) who found that ROA and bank capital are sharply and positively related. It therefore seems that banks in Cameroon do no rely on earnings in order to increase their capital.

Table 10 presents the capability of our model to link efficiency, capital and risk in Cameroonian commercial banks. All X^2 are significant at 1% level. This means that at least one instrumental variable (IV) has non zero relationship with endogenous variables (Efficiency, Risk and Capital).

Conclusion

In the aftermath of the financial deregulation aiming to improve bank efficiency in Cameroon, to address the potential implicit threat to the banking system stability, the Central African States banking commission (COBAC) placed a more emphasis on bank governance considerations and notably on a more preeminent role of capital adequacy ratios in the implementation of prudential regulation. However, neither theoretical studies nor empirical papers are until now conclusive on the effect of more stringent capital requirements on bank efficiency and risk behavior.

In this paper, the interrelationships between risk-taking, capital regulation and efficiency In Cameroonian commercial banks were examined. To reach target, based on theoretical contributions and an analysis of the Cameroonian context, three hypotheses are formulated:

H1: Increase in bank capital reduces commercial banks risk taking in Cameroonian banking.
H2: There are tradeoffs between bank efficiency and bank risk taking in Cameroonian banking.
H3: Inefficient banks run with higher level of capital in Cameroonian banking.

These hypotheses are tested on a sample of representative Cameroonian commercial banks from 2014 to 2020 in a system of simultaneous equations approach. Estimation of the system relies on the use of the two stages panel data estimator technique to account for potential endogeneity and simultaneity and small samples approaches. Cost technical inefficiency is derived using the computer program named Frontier Version 4.1 developed by Coelli (1996). The authors also use proxy risk taking by a credit risk measure, capital by the capital adequacy ratio and control for bank-level variables that affect the relationship between the three considered variables.

As a result, their empirical analysis shows that bank

capital does not lead to bank risk taking behavior in Cameroonian banking. In fact, there is a positive and significant relationship between the two variables (H1 is not validated). Moreover, there is a trade -off between bank risk and bank efficiency in Cameroonian banking explained by the bad luck hypothesis (H2 is validated). Finally, there is a negative impact of change in efficiency on the yearly change in bank capital meaning that inefficient banks run with higher level of capital in Cameroonian banking (H3 is validated).

Therefore, for a better contribution of bank policy to efficiency improvements, banking authorities in Cameroon might create conditions of bankers' regulation arbitrage mitigation. In this sense measures aiming to ensure that no risk spill over from non-regulated financial institutions to the banking system might be privileged. Specially, COBAC should look at the link between banks and insurance companies and address step-in risk. Furthermore, COBAC should also develop policies aiming to scrutinize more deeply what bankers do and examine individual transactions to see whether they might be an attempt to play by the rule.

There are some limitations of this paper that need to be improved in future research. First, the analysis period is too short; it should be extended. Also the sample is limited. It can be extended to CEMAC countries. Secondly, an analysis at the macro-level might help taking into account many economic environmental variables not considered in this study. Finally, future researches might take into consideration bank capital structure as the literature suggests significant relationships with bank efficiency or bank risk.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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