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Income diversification and banking risk in the context of banking regulation in the WAEMU

Moussa Ismaël KONE
Department of Economics, International Polytechnic Institute for Elites, Abidjan, Côte d'Ivoire

***Abstract*---**The objective of this study is to analyze the link between income diversification and banking risk in a banking regulation context. After applying the generalized method of moments to a sample of 70 WAEMU banks over the period 2011-2018, it appears that the diversification of banks' income contributes to risk diversification. Furthermore, risk is further reduced when banks comply with capital adequacy standards. The result implies that income diversification and banking regulation are complementary in reducing banking risk.

***Keywords*---**Banking risk, Regulatory capital, Diversification, Banking regulation, WAEMU.

1. Introduction

From the 1980s to the mid-1990s, in response to the banking crisis that shook large parts of the banking system in the West African Monetary Union (WAMU) zone, banking supervision emerged as an effective solution. This crisis necessitated the implementation of major reforms, notably financial liberalization within the meaning of McKinnon (1973) and Shaw (1973), the establishment of the Banking Commission in 1990, whose primary mission was to supervise and control credit institutions. Since then, the regulatory environment has evolved towards the efficient banking supervision standards laid down by the Basel Committee. Previously based on the provisions of Basel I, the authorities have brought the prudential framework into line with the new Basel II and III rules, which came into force in January 2018[1]. This new framework aims to preserve a resilient banking system that meets the needs of the WAEMU economies and has

[1] The architecture of the new regulatory framework is built upon the following three complementary pillars: (i) minimum capital requirements aligned with key risk categories (credit, operational, and market risks), (ii) the principles of prudential supervision and the corresponding supervisory review process, and (iii) the principles of market discipline, aimed at enhancing transparency and public disclosure of institutions' risk exposures

Corresponding author: *KONE, M.I., Email: konemoussaismael@yahoo.fr*
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a controlled risk profile (BCEAO, 2017). Particular importance is given to the requirement for minimum capital holdings in this regulatory framework (Rochet, 2008). The main advantage of bank capital requirements is that they make the financial system more resilient, thereby reducing the likelihood of banking crises and the resulting production losses. In the WAEMU, the figures from BCEAO (2022) reflect compliance with these standards. The total solvency ratio stood at 12.6% in 2021, compared with 12.4% in 2015[2]. This period was marked by a decline in risk (with the gross risk deterioration rate falling from 14.2% in 2015 to 10.06% in 2021), but the risk remains significant. However, disparities are noticeable among the countries of the union.

The solvency of the banking systems in Côte d'Ivoire and Burkina Faso has improved. The respective solvency ratios rose from 11.7% and 9.4% in 2015 to 12.7% and 13.4% in 2021. In Mali, there was a decline in the portfolio deterioration rate between 2015 and 2021 (from 14.2% to 9.7%) following a relatively stable solvency ratio (from 14.2% in 2015 to 14.5% in 2021). In Senegal, the decline in the solvency ratio (from 16.4% to 12.7% between 2015 and 2021) led to an increase in the quality of banks' assets, with the portfolio deterioration rate falling from 19.5% to 11.4% between 2015 and 2021. Although there has been a decline in the deterioration rate, it remains above the union average.

In the case of Benin, the increase in bank solvency (from 9.5% to 13.6%) was accompanied by a decrease in risk (from 22.3% to 12.25%), but the rate of deterioration in the banks' portfolios remains above the union average. The banking system in Togo does not meet solvency standards (this ratio fell from 8.4% to 6.8% between 2015 and 2021). Although it has declined (from 16.7% to 11.9% between 2015 and 2021), the quality of banks' assets is lower than that of the union. A distinctive feature of the riskier banking systems in the union is the presence of systemically important banks, which account for 15.5% of the assets of WAEMU banks.

Overall, compliance with prudential standards does not seem to go hand in hand with the quality of banks' assets. A review of the literature is necessary for further insights.

The theory predicts that higher bank capital can reduce banks' risk-taking in at least two ways. First, banks will improve their selection and monitoring of borrowers (Holmstrom and Tirole 1997; Coval and Thakor 2005; Allen and al.2011). Second, greater capitalisation may encourage banks to choose less risky asset portfolios (Furlong and Keeley 1989; Rochet 1992; Freixas and Rochet 2008). However, some argue that increasing banks' capital may also lead to greater risk-taking in two potential ways. First, if higher capital means more shareholders, owners may exert less effort as their stake becomes diluted (Besanko and Kanatas 1996). Second, as increased capital reduces the return on equity, banks may invest in riskier projects as capital increases to seek higher returns (Koehn and Santomero 1980; Dell'Ariccia and al., 2014). Empirical

[2] It should be noted, however, that there has been a decline in the number of banks complying with these prudential standards. In terms of total assets, the share of banks not meeting prudential requirements increased from 7.6% to 10.7%.

studies support this theoretical controversy (Mehran and Thakor, 2011; Berger and Bouwman, 2013; Abou-El-Sood, 2016 ; Chiaramonte and Casu, 2017).

Considering this controversy, another strand of literature highlights the usefulness of certain strategies, such as diversification, which companies could undertake as a means of hedging. Bank diversification mitigates default risk through the co-insurance effect (Lewellen, 1971). This effect results from the combination of activities with imperfectly correlated revenue streams, which reduces the volatility of the company's cash flow (Borghesi and al., 2007).

By way of illustration, in WAEMU, the share of interest income in total banking income fell between 2011 and 2015 from 42.10% to 28.75% but rose between 2015 and 2021 to 48.75%. This trend goes hand in hand with regulatory capital but contrasts with risk. Regulatory capital decreased between 2011 and 2015 (from 12.6% to 12.4%) and increased between 2015 and 2021 to stabilize at around 12.6%. Over the entire period, risk decreased. The questions that arise from these findings and the literature are as follows: Is there a trade-off between the effects of diversification of banks' income, regulatory capital and banking risk? On the other hand, what is the effect of the interaction between diversification of banks' income and regulatory capital on risk?
In this study, we focus on the interaction between regulatory capital and bank diversification, as well as their ability to reduce banking risk.
The rest of the study is organized as follows: the next section presents a review of the literature, section 3 describes the methodology used, section 4 presents the results of the various analyses, and the final section presents the conclusions of the study.

2. Summary of research on the relationship between income diversification, risk and regulatory capital

2.1. Income diversification and banking risk

Markowitz's modern portfolio theory Markowitz (1952, 1959) offers a rigorous definition of the concept of diversification by showing how combining several financial assets reduces the overall risk of a portfolio. In this context, diversification consists of mitigating risk by spreading investments across different assets, so that a potential loss on one can be offset by gains on another. Markowitz formalises this logic through ‘efficient diversification’, whereby rational investors seek to optimise the risk/return ratio by combining risky assets with risk-free assets, such as government bonds or money market securities, which offer low returns but virtually no risk. The result of this approach is the efficient frontier, which represents the set of portfolios offering the best risk/return trade-off. Diversification therefore makes sense when it minimizes risk without excessively reducing expected returns. This approach is particularly relevant to the study of banking risk, as it helps to understand how asset allocation within a banking portfolio can help to stabilize returns and limit exposure to financial shocks.

Several empirical studies have analyzed the link between diversification and banking risk using different econometric methods. Velasco (2021), using a panel model and a panel of listed banks in developed countries, shows that regulatory

capital mainly influences income diversification. Yang and al., (2020) using ordinary least squares (OLS) and data from US banks, reveal that diversification increases systemic risk, particularly for medium-sized and large institutions. Wang and Lin, 2021, using the generalized method of moments (GMM), found that income diversification reduces risk in emerging Asia-Pacific economies but has no effect in developed economies. Adem (2023), combining static and dynamic panel estimates, emphasises that diversification enhances banking stability in Africa, while pointing out that excessive diversification can weaken institutions. Finally, Ammar and Boughrara (2019), also using GMM on data from the MENA region, conclude that diversification, particularly linked to transactional activities, improves the profitability and stability of banks.

2.2 Regulatory capital and banking risk

Empirical studies on the relationship between regulatory capital and banking risk reveal mixed results. Klomp and Haan (2012) use quantile regressions on more than 200 OECD banks and show that regulation and supervision increase risk. Dutra and al., (2024)., using a panel of 535 OECD banks, use panel models and reveal that the effect of regulation depends on the level of investor protection. In Europe, Meulemana and Venneta (2011) apply a dynamic panel model and conclude that certain macroprudential tools are effective, while Danisman and Demirel (2019) using the GMM method, highlight the moderating role of market power. In developing countries, Awdeh and al., (2011). use a simultaneous equation model and find that higher capital increases risk, while Ashraf and al., (2016) using LSDVC and GMM methods on Pakistani banks, conclude that strict requirements reduce risk. Other studies, notably those by Klomp and Haan (2015) and Hunjra and al., (2021) also use GMM and confirm that regulation and supervision improve stability, although their effectiveness varies depending on the structure and institutional context of banks. These contrasting results indicate that the effectiveness of diversification and regulation depends heavily on the level of economic development, the structure of banks and the quality of the institutional environment. We will therefore analyze this relationship econometrically to measure the combined effect of diversification and regulatory capital on banking risk.

3. Methodology

Here we will present the variables used in our study and the estimation techniques.

3.1. Definition of variables and data sources

The variable we seek to explain is credit risk. Credit risk arises from the non-repayment of a loan. Among the existing risk measures, we use the ratio of provisions for losses to assets as (Garr, 2013) due to the availability of data.

Table 1: Summary of variables used

Variables	Mesures	Sources
INCDIV	Diversification, as per Laeven and Levine (2007): DIVREV = $1-\left\|\frac{Interest\ income - Non\ interest\ income"}{Total\ income}\right\|$	BCEAO
CAR	Regulatory capital (CAR), calculated by dividing regulatory capital by total assets	BCEAO
CREDACT	The variable is obtained by relating customer loans to the total assets of the banks.	BCEAO
liquidity	Liquidity reflects the bank's ability to meet its commitments.	BCEAO
bank size	Size is an important variable in determining risk management policy.	BCEAO
GDP	GDP : Annual growth rate of real GDP	WDI
INF	Inflation, captured by the growth rate of the consumer price index (CPI)	WDI
CONCE	Concentration, measured by the market share of the three largest banks	BCEAO

Source: The author

The data used for this study comes mainly from the World Bank and the BCEAO. The study sample consists of 70 banks and covers the period 2011–2018.

3.2.1. Specification of the generalized method of moments (GMM)

To study the effect of income diversification on banking risk, we have opted for a dynamic panel model estimated using the generalized method of moments. This choice is based on the phenomenon under study. Each bank has its own diversification and risk management policies. As pointed out in Griliches and Mairesse (1997), the ordinary least squares estimator provides plausible parameter estimates for the share of factors in the economy and is generally consistent with the assumption of constant returns to scale. However, in the case of unobserved heterogeneity and simultaneity, this estimator becomes less effective. Similarly, the Within estimator leads to unsatisfactory and biased estimates, especially since the temporal dimension is small relative to the individual dimension, which is often the case in microeconomic panels (Anderson and Hsiao, 1981; Nickell, 1981). In this context, the first difference generalized method of moments (DGMM) estimator, which eliminates unobserved individual specific effects through first-order differentiation, should lead to more satisfactory results.

The DGMM estimator is convergent when T is fixed. However, this estimator has weak properties in finite samples. In particular, Arellano and Bond (1991), Kiviet (1995), Ziliak (1997); Blundell and Bond (1998) show that the DGMM estimator can be severely biased, based on Monte Carlo simulations.

The potential existence of significant bias in the DGMM estimates in our study led us to favour the SYSGMM estimator. Furthermore, Blundell et al., (2000) also show that the SYSGMM estimator significantly improves precision gains, but also significantly reduces sampling bias compared to the DGMM estimator when the

regressors are weakly exogenous and correlated with the individual effect. Performing the Hausman test (1978), will allow us to determine the structure of the errors (fixed effect or random effect).

In the case of highly persistent series, Arellano and Bover (1995) and Blundell and Bond (1998, 2000 show that it is preferable to use a systemized generalized method of moments (SYSGMM) estimator. This involves combining the DGMM estimator with additional conditions relating to the level equations.
The econometric specification of our study is given by:

$$RISK_{it} = \alpha_i + \alpha_1 RISK_{it-1} + \alpha_2 SIZE_{it} + \alpha_3 DIVREV_{it} + \alpha_4 CAR_{it} + \alpha_5 CREDACT_{it} + \alpha_6 LIQUID_{it} + \alpha_7 GDP_{it} + \alpha_8 CONCE_{it} + \alpha_9 INF_{it} + \varepsilon_{it} \quad (1)$$

To assess the contribution of regulatory capital in the relationship between income diversification and banking risk, we introduce a multiplicative factor into the previous equation[3]. This gives us the following equation:

$$RISK_{it} = \alpha_i + \alpha_1 RISK_{it-1} + \alpha_2 SIZE_{it} + \alpha_3 DIVREV_{it} + \alpha_4 CAR_{it} + \alpha_5 DIVREV * CAR + \alpha_6 CREDACT_{it} + \alpha_7 LIQUID_{it} + \alpha_8 GDP_{it} + \alpha_9 CONCE_{it} + \alpha_{10} INF_{it} + \varepsilon_{it} \quad (2)$$

With RISK, bank credit risk; DIVREV, income diversification; SIZE, bank size; CAR, regulatory capital; CREDACT, customer credit; LIQUID, bank liquidity; GDP, GDP growth rate; CONCE, bank concentration; INF, inflation rate.
The model is validated by instrument testing and autocorrelation testing.

4.1.2. Quantile regression
The fixed effects method of quantile regression (MMQR) was developed by Machado and Silva (2019). By specification, it addresses endogeneity and tackles the problems of heteroscedasticity and unobserved values in regressions. The MMQR estimator differs from other standard estimators such as Canay (2011) and Koenker (2004) because the time-invariant country fixed effects vary at each different quantile of the conditional distribution of the dependent variable. The empirical analysis is performed on two quantiles (Q25 is the 25th quantile and Q75 is the 75th quantile).

5. Results

5.1. Descriptive analyses
The average value of the DIVREV variable is 0.722, reflecting a significant level of income diversification among banks in the WAEMU. It appears that the level of

[3] The first condition states that the explanatory variables (excluding the lagged first-differenced dependent variable), in their first-differenced form, are uncorrelated with the individual effect. The second condition states that the lagged first-differenced dependent variable is also uncorrelated with the individual effect

income diversification shows low dispersion (standard deviation 0.23). However, the gap between the most diversified banks and the least diversified banks remains wide. The average amount of bank liquidity represents 3.6% of assets. This variable shows low dispersion around the mean.

On average, banking risk (provisions for risk) is estimated at 1.1% of banks' assets. This variable shows high dispersion (standard deviation equal to 0.025), reflecting heterogeneity in banks' risk management. The average amount of bank credit represents 57% of assets. This variable shows low dispersion around the mean (standard deviation 0.375).

Table 2: Descriptive statistics

Variables	Moyenne	Ecart-type	Minimum	Maximum	Observations
LIQUID	0.036	0.042	0.002	0.373	560
CREDACT	0.570	0.375	0.067	6.715	560
RISK	0.011	0.025	-0.001	0.215	560
CAR	0.109	0.180	0.004	1.478	560
DIVREV	0.722	0.238	0.000	0.999	560
GDP	5.481	2.719	-5.370	10.760	560
INF	1.770	2.617	-2.224	12.183	560
CONCE	65.151	16.790	41.943	100.000	560
SIZE	12.131	1.076	8.795	14.459	560

Source: Author, based on data from the BCEAO (2022) and the World Bank (2022)

Après la statistique descriptive, il convient d'examiner la corrélation entre les variables de l'étude. Les résultats de la matrice de corrélation sont contenus dans le tableau 2.

Table 2: Results of the Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) RISK	1								
(2) DIVREV	-0.2988*	1							
(3) SIZE	-0.2574*	0.2196*	1						
(4) CREDACT	-0.1307*	0.1299*	-0.0018	1					
(5) LIQUID	0.1329*	-0.1093*	0.0454	-0.0181	1				
(6) CAR	0.4940*	-0.3636*	-0.6946*	-0.0882*	0.0139	1			
(7) GDP	0.0679	0.0438	0.0762	-0.0151	0.1187*	-0.0006	1		
(8) INF	-0.0083	0.0108	-0.1290*	-0.014	-0.1325*	0.0249	-0.2293*	1	
(9) CONCE	0.0403	-0.0124	-0.3987*	0.0459	-0.2007*	0.2031*	-0.1108*	0.1354*	1

Source: Author, based on data from the BCEAO (2022) and the World Bank (2022)

The table shows that the explanatory variables are weakly correlated, unlike regulatory capital and bank size. This rules out any suspicion of multicollinearity.

5.2. Interpretations and discussions of econometric results

The summary of the estimation results is contained in Table 3.

The results indicate that diversification of banks' income reduces risk. Indeed, this variable has a significant level of 1% and negatively influences the risk

incurred by banks. Service fees, net trading profits and other non-interest income are not correlated or are imperfectly correlated with net interest income. Consequently, income diversification leads to more stable net operating income and higher risk-adjusted financial performance.

Regulatory capital increases banks' risk-taking. Strict capital regulations are likely to reduce market discipline on banks, firstly by requiring banks to maintain higher capital and lower debt, and secondly by giving debt holders greater confidence that the regulator is monitoring banks. Weaker market discipline could translate into higher banking risk. Strict capital requirements may also force banks to engage in regulatory arbitrage, thereby increasing overall risk. Furthermore, the interaction between income diversification and regulatory capital is negative. This result shows that while income diversification reduces banking risk, regulatory capital also contributes to its reduction.

Bank credit has a significant coefficient and negatively influences the risk variable. This result implies that the effectiveness of bank intermediation reduces risk. Large banks are better able to manage risk. Indeed, large banks are able to diversify. The more diversified they are, the better they manage risk. The establishment of a risk management team, the necessary equipment and transaction costs are unavoidable expenses for banks seeking to hedge their financial risks. These costs involve significant economies of scale, making risk management more accessible to larger banks. The liquidity of banks leads them to take more risks. The explanation for this can be found in the work of Vazquez and Federico (2015). The authors analyse the relationship between liquidity structure and stability during the financial crisis. They showed that banks with a weak liquidity structure (high level of liquidity risk) and high leverage before the crisis were the most exposed to the risk of bankruptcy. Furthermore, they point out that, in the context of corporate debt renewal, the deterioration in market liquidity leads to an interaction between liquidity and credit risk, resulting in an increase in both liquidity and credit risk premiums. Classical theories of banking microeconomics support this idea (Diamond and Dybvig, 1983; Holmström and Tirole, 1998).

The results show that GDP growth has a positive impact on credit risk. Economic growth increases financing needs, improves the solvency of economic agents and, as a result, should increase demand for credit. Conversely, when there is a slowdown in economic activity, the supply of credit gradually tightens. Thus, Kashyap and al., (1993) observed, based on US data, that changes in the bank credit ratio are correlated with the economic cycle. This ratio, which they call the mix ratio, declines during periods of economic slowdown and increases during periods of recovery.

Inflation has a positive impact on credit risk. This can be explained by the fact that moderate inflation helps to ensure a balance between savings and investment levels, without which interest rates would rise, thereby limiting investment projects by businesses and individuals. Similarly, when inflation is too high, it risks reducing productive investment and therefore growth potential, affecting the value of companies. This could trigger a financial accelerator process and turn into a financial crisis. According to Fofack (2005), inflationary pressures

contribute to high levels of non-performing loans in a few sub-Saharan African countries with fixed exchange rate regimes.

Table 3: Estimation Results

VARIABLES	RISK	RISK
L. RISK	0.83046***	0.82349***
	(0.00465)	(0.00626)
DIVREV	-0.00934***	-0.00611***
	(0.00073)	(0.00065)
SIZE	-0.00181***	-0.00317***
	(0.00023)	(0.00033)
CREDACT	-0.01853***	-0.01767***
	(0.00097)	(0.00110)
CAR	0.00330***	0.00836***
	(0.00091)	(0.00200)
c.CAR#c.DIVREV		-0.02905***
		(0.00408)
LIQUID	0.04963***	0.04789***
	(0.00138)	(0.00209)
GDP	0.00035***	0.00033***
	(0.00003)	(0.00002)
CONCE	0.00001	-0.00001
	(0.00001)	(0.00001)
INF	0.00088***	0.00079***
	(0.00002)	(0.00005)
Constant	0.03563***	0.05203***
	(0.00345)	(0.00499)
Observations	490	
Number of ID	70	

Standard errors in parentheses
*** p<0.01. ** p<0.05. * p<0.1

Source: Author, based on data from BCEAO (2022) and the World Bank (2022)

To assess the effect of diversification on risk, we estimate a quantile model. The results are shown in Table 4.

The results indicate that income diversification reduces risk in the lower quantiles, i.e. when the level of risk is low. When the level of risk rises, income diversification is not a good strategy for reducing risk. This is explained by the interaction between risk diversification and regulatory capital. In fact, in the presence of high risk, banking regulations help mitigate banking risk. Efficiency reduces risk in the lower quantile levels. Regulatory capital, inflation and economic activity are the main determinants of banking risk regardless of the quantile level.

Table 4: Quantile regression estimation results

VARIABLES	RISK	RISK
	Q25	Q75
QUANTILES LIQUID	0.000	0.012***
	(0.006)	(0.002)
CREDACT	-0.001*	0.000**
	(0.000)	(0.000)
CAR	0.039***	0.047***
	(0.003)	(0.003)
DIVREV	-0.001**	-0.000
	(0.001)	(0.000)
GDP	0.000	0.000***
	(0.000)	(0.000)
INF	0.000*	0.000
	(0.000)	(0.000)
SIZE	0.002***	0.002***
	(0.000)	(0.000)
CONCE	-0.000	-0.000
	(0.000)	(0.000)
Observations	560	560
Number of groups	70	70
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

Source: Author, based on data from BCEAO (2022) and the World Bank (2022)

Conclusion

Can prudential regulation curb the link between income diversification and risk? In this section, we analyzed the link between income diversification and banking risk in the context of banking regulation. To do so, we used a panel model applying the generalized method of moments to a sample of 70 WAEMU banks over the period 2011-2018. The results of our estimates showed that: diversification of banks' income contributes to risk diversification. In addition, risk is further reduced when banks comply with capital adequacy standards. Furthermore, large banks that are efficient in terms of intermediation are better able to reduce risk. On the other hand, banks that are increasingly liquid take more risk. In addition, macroeconomic instability through rising inflation encourages banks to take more risk. Optimism about economic growth increases banks' appetite for risk.

Our findings highlight the need for banks to comply with regulatory capital requirements, which ensure better risk diversification when their revenues are diversified. Bank liquidity management is necessary to reduce risk. Banks must consider the environment.

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