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Interest Rate and Bank Risk-Taking: The Role of Income Diversity

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Abstract

This research examines the impact of interest rates on the risk-taking appetite of banks in Egypt and how income diversity influences their risk-taking. Furthermore, it contributes to the literature by investigating the association between the interacting effect of interest rate and income diversity shares on bank risk-taking. The sample includes 22 banks operating in Egypt spanning from 2011 to 2020. For the analysis, the cross-sectional time-series generalized least squares regression (GLS) approach is employed. The results reveal that low-interest rates exacerbate bank risk-taking. In addition, larger income diversity restricts the risk-taking behavior of banks. Importantly, the results show that banks with higher levels of income diversity push for less risky positions during the low-interest rate period. Hence,

the results provide valuable insights into the importance of the moderating role of income diversity strategies. The results are robust to different proxies of bank risk-taking. The policy implications from this research indicate that bank managers and regulators in Egypt as well as in similar emerging economies shall promote income diversity strategies to ensure the safety and soundness of the banking system at times of low-interest rates.

Keywords: Interest rate, Bank risk-taking, Income diversity, Emerging economies

Paper type: Research paper

1. Introduction

Financial institutions play an important role in the economy through the efficient allocation of resources from savers to borrowers with profitable investment opportunities (Oino, 2018). The financial liberalization process in developed and developing nations over the recent decades has resulted in the privatization of financial institutions, removal of entry barriers in markets, and deregulation of interest rates (Sharma & Anand, 2018). The low-interest rates present a challenging environment for financial institutions (Bikker & Vervliet, 2018). This gives a motivation for academics to investigate the question of whether a low-interest rate is a blessing or a curse.

A considerable amount of literature has been published on the impact of interest rates on bank risk-taking appetite. Some prior studies find that a low-interest rate contributes to a decrease in bank risk-taking. Presumably, banks are inclined to bolster their capital positions (Bikker & Vervliet, 2018; Bongiovanni et al., 2021). However, plentiful evidence finds that low-interest rates are expected to encourage banks to undertake riskier investments, supporting the "search for yield" hypothesis (e.g., Delis & Kouretas, 2011; Hoffmann, 2014; Nguyen & Boateng, 2015; Chen et al., 2018; Majumder & Li, 2018; Moyo & Roux, 2020; Teixeira et al., 2020). Furthermore, the evidence reported by Gehrig and Iannino (2021) confirms that a low-interest rate increases banks' systemic risk exposures, which reduce the resilience and safety of the banking system.

Against that backdrop, banks started to focus on diversifying their portfolios to partially mitigate the harmful effects of loosening interest rates on profits (Claessens et al., 2018; Brei et al., 2019; Lopez et al., 2020). Over recent years, income diversity strategies have become essential sources of profits for banks besides the traditional lending-deposit activities (Lee et al., 2020). Several banks in emerging countries have recently expanded their services beyond the traditional lending and deposit-taking activities for making profits and enhancing the business cycle (Aydemir & Ovenc, 2016; Ovi et al., 2020). Literature also emphasizes the importance of income diversity for risk reduction (e.g., Majumder & Li, 2018; Moudud-Ul-Huq et al., 2018; Saunders et al., 2020; Li et al., 2021).

Existing studies for the risk effects of bank income diversity, although many, have not yet come to a consensus. The proponents argue that a shift toward non-interest income activities reduces banks' risks and the probability of failure, hence stabilizing their profitability. The premise is that banks can benefit from economies of scope (Apergis, 2014; Meslier et al., 2014; Ashraf et al., 2016; Ovi et al., 2020; Alouane et al., 2021; Nguyen et al., 2021). The

opponents, however, argue that income diversity may dilute the expertise and comparative advantages of banks' managers. In addition, income diversity exhibits greater return volatility (Delpachitra & Lester, 2013; Nguyen, 2018).

This paper contributes to the aforementioned literature in two main ways. First, we examine how the interest rate, income diversity individually and interactively impact bank risk-taking in an emerging market context. Second, we use both accounting and market-based bank risk-taking proxies. The rest of this paper is organized as follows: Section 2 reviews the existing literature and develops research hypotheses. Section 3 focuses on data and methodology. Section 4 presents the descriptive statistics and empirical results. Section 5 concludes by focusing on the policy implications of our empirical results.

2. Literature Review and Hypotheses Development

2.1 Bank Interest Rate and Bank Risk-Taking

There is extensive evidence regarding the impact of interest rates on bank risk-taking. A line of research provides no evidence of bank risk-taking behavior in response to a decline in interest rates (see e.g., Bikker & Vervliet, 2018; Brei et al., 2019; Boungou, 2020; Dang & Dang, 2020; Mahrous et al., 2020; Matthys et al., 2020). One side of the argument states that banks reduce the provision of loan losses due to lower chances of credit risks during low lending rate periods, supporting the evidence of "evergreening" (Brei et al., 2019; Boungou, 2020). In fact, Brei et al. (2019) conclude that when lending interest rates decline by 3%, the ratios of risk-weighted assets decline by 6.2%, thus reducing the likelihood of defaults. Consistent with this argument, research by Dang and Dang (2020) finds that lower lending interest rates boost banks' credit portfolios and help in sustaining the overall financial stability of the banking sector. Other studies postulate the beneficial role of a low lending interest rate policy in stimulating economic growth. Easing lending interest rates put fewer burdens on borrowers while repaying, thus reducing the shares of non-performing loans and triggering banks to expand their lending activities (Mahrous et al., 2020; Matthys et al., 2020). Contrary to this point of view, banks have been found to finance riskier projects when interest rates are eased because banks are incentivized to offset the declines in profits, consistent with the "risk-taking channel" (Delis & Kouretas, 2011; Nguyen & Boateng, 2015; Drakos et al., 2016; Chen et al., 2018; Majumder & Li, 2018; Brana et al., 2019; Teixeira et al., 2020; Whited et al., 2021). Drakos et al. (2016) observe that excessive risk-taking behavior appears mainly when banks are foreign-owned. Furthermore, several studies find the increased bank leverage, where interest rates are becoming too accommodative (e.g., Nguyen & Boateng, 2015; Moraes & Mendonça, 2019). Therefore, the low-interest rate dilemma has been argued as a key factor triggering banks to become less safe during the financial crisis period (Moyo & Roux, 2020).

Although a considerable amount of literature has been published on the association between interest rate and bank risk-taking, the findings remain inconclusive. Further, most studies have only focused on examining advanced economies. Hence, this research aims to enrich the existing literature and examine whether low-interest rates exacerbate the risk-taking of banks operating in Egypt. The first research hypothesis can be stated as follows:

H_1. *There is a negative association between lending interest rates in one year and bank risk-taking in the subsequent year.*

2.2 Income Diversity and Bank Risk-Taking

Several studies document that increased income diversity is not associated with larger bank risk-taking (e.g., Lee et al., 2014; Majumder & Li, 2018; Moudud-Ul-Huq et al., 2018; Saunders et al., 2020). Also interestingly, Ovi et al. (2020) conclude that greater diversity strategies mitigate the proportion of loans in the portfolios of banks' assets, thus lessening banks' credit risk. In addition to the achievements of higher capital savings, in line with the "diversification benefits". Their findings are consistent with the prior work of Shim (2013). Other researchers contend that banks with larger income diversity shares are more financially stabilized and can better maintain their franchise values and cash flows in the long term. Hence, bank managers shall evitably consider income diversity as a "strategic decision" and ensure an adequate level of banks' involvement in these strategies (e.g., Nguyen et al., 2012; Hsieh et al., 2013; Doumpos et al., 2016; Markoulis et al., 2021). According to Markoulis et al. (2021), the expansion of banks into these strategies enables them to better diversify risks and achieve greater profits. Moreover, banks have better opportunities to maintain good stock performance during periods of financial distress. The recent evidence reported by Li et al. (2021) also supports the notion that banks with good income diversification strategies are less exposed to risks than their counterparts during the COVID-19 pandemic. In contrast, other studies find that income diversity strategies expose banks to higher risks, in line with the "diversification-fragility hypothesis" (Mili et al., 2019; Tran et al., 2020; Hunjra et al., 2021). Risks are attributed to the fact that banks lack sufficient experiences to manage diverse strategies (Saghi-Zedek, 2016; Ghosh, 2020), hence increasing the volatility of earnings and the likelihood of default risk (Abuzayed et al., 2018; Duho et al., 2020). The findings of Kim et al. (2020) also reveal that income diversity triggers banks to experience financial instabilities at different stages of a financial crisis.

In a nutshell, the findings of prior studies examining the impact of banks' non-interest income shares on bank risk-taking are indecisive. Furthermore, most of the empirical studies are concentrated on the United States and European economies, which are characterized by unique features. In fact, the nature of the Egyptian market remains ambiguous. Therefore, the current research aims to fill the limitedness in the prior literature by examining whether highly diversified banks are less risky takers in the context of Egypt. The second research hypothesis can be established as follows:

H_2. *There is a negative association between income diversity shares in one year and bank risk-taking in the subsequent year.*

Reviewing the literature indicates a research gap in the accounting and finance field due to not investigating the association between the interacting effect of interest rate and income diversity on bank risk-taking. Therefore, this research fills this gap by investigating whether the excessive risk-taking behavior responding to the decline of interest rates can be restricted for banks with higher income diversity shares. The third research hypothesis can be developed as follows:

H_3. *The larger is the banks' income diversity shares, the less negative is the association between lending interest rates in one year and bank risk-taking in the subsequent year.*

3. Data and Methodology

We use annual consolidated accounting data for a sample of banks registered at the Central Bank of Egypt (CBE) from 2011 to 2020. Bank accounting data are collected from the Thomson Reuters database. (Note 1) **Appendix 1** summarizes the variables used in this research. Since the calculation of our market-based risk-taking measure requires stock prices, banks listed at the Egyptian Stock Exchange (EGX) are only used for this calculation. Market data on bank stock prices are also collected from the Thomson Reuters database. **Appendix 2** presents the list of banks along with their classifications.

The following regression model is used to examine the developed hypotheses (Note 2):

$$RISKTAKING_{it} = \beta_0 + \beta_1 INTERESTRATE_{it-1} + \beta_2 INCOMEDIVERSITY_{it-1} + \beta_3 INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1} + \sum_{J=1}^{N} \beta_J CONTROLS_{Jit-1} + \epsilon_{it-1}$$

3.1 Bank Risk-Taking

For a comprehensive analysis and robust results, we rely on accounting and market-based measures to proxy for bank risk-taking. Accounting risk-taking measures represent loan loss provisions to net loans, the standard deviation of annual net interest margin, and the simplified Z-score. The market-based risk-taking measure represents the annualized standard deviation of monthly stock returns.

3.1.1 Accounting-Based Measures

Following ElBannan (2015) and Abou-El-Sood (2019), loan loss provision to net loans (LLP_{it}) ratio is used as a proxy for bank risk-taking. Higher ratios are suggestive of excessive risk-taking by banks (Altunbas et al., 2007). Two additional accounting risk-taking measures are used; the volatility of annual net interest margin and the simplified Z-score. Prior studies use the volatility of the annual net interest margin of a bank as a proxy for risk-taking. Net interest margin is computed as the ratio of net interest revenue to average earning assets of bank i at year t (e.g., Moudud-Ul-Huq et al., 2018). The simplified Z-score is also employed to measure the number of standard deviations that the returns have to fall before a bank becomes insolvent (Abuzayed et al., 2018). Following the methodology of prior literature, the simplified Z-score is calculated as follows:

$$ZSCORE_{it} = \log\left(\frac{ROA_{it} + TE_{it}/TA_{it}}{\sigma\, ROA_{it}}\right)$$

Where $ZSCORE_{it}$ is the simplified Z-score of bank i at year t. ROA_{it} is the ratio of net income after taxes to average total assets, TE_{it}/TA_{it} is total equity to total assets ratio, $\sigma\, ROA_{it}$ is the standard deviation of return on assets. A high (low) Z-score means high (less) financial stability and less (high) bank risk-taking (ElBannan, 2015; Moudud-Ul-Huq et al., 2018; Abou-El-Sood, 2019; AlKhouri & Arouri, 2019; Ghosh, 2020; Kim et al., 2020;

Hunjra, et al., 2021).

3.1.2 Market-Based Measures

Bank risk-taking shall also be analyzed with market-based proxies (Abuzayed et al., 2018). Similar to the methodologies of prior literature, we rely on the volatility of stock returns as our main proxy for market-based risk-taking. The monthly closing stock prices are used to compute the monthly stock returns for each listed bank for each month over the study period. We then compute the annualized standard deviation of a bank's monthly stock returns over the 2011 to 2020 period. Higher return volatility suggests excessive risk-taking by banks and a higher possibility of default (Meslier et al., 2014; Abou-El-Sood, 2019; Tran et al., 2020).

3.2 Interest Rate

Using the interest income on loans to net loans ratio allows us to capture the average lending interest rate that bank i charges on its borrowers (Delis & Kouretas, 2011; Nguyen & Boateng, 2015; Wambari & Mwangi, 2017; Majumder & Li, 2018; Harkati et al., 2020).

3.3 Income Diversity

Income diversity takes place when banks provide larger shares of non-interest services or activities (Abuzayed et al., 2018; Bitar et al., 2018; AlKhouri & Arouri, 2019; Matthys et al. 2020). Following prior studies, we use the ratio of non-interest income to total income (interest income plus non-interest income) as a proxy for bank income diversity. Larger values indicate a higher income diversity by a bank and vice versa (Hsieh et al., 2013; Majumder & Li, 2018; Moudud-Ul-Huq et al., 2018; AlKhouri & Arouri, 2019; Kim et al., 2020; Matthys et al., 2020; Alouane et al. 2021; Hunjra et al., 2021). (Note 3)

To investigate the income diversity impact on the association between interest rate and bank risk-taking, we include in our regression model an interest rate and income diversity interaction term, where the latter is measured using a dummy variable for banks providing larger shares of non-interest income services or activities based on their income diversity size. Banks with an average diversification size of greater than 0.23 were categorized as highly income diversified banks.

3.4 Bank-Specific and Macroeconomic Variables of Bank Risk-Taking

We include several bank-specific and macroeconomic variables that may impact the risk-taking behavior of banks. These variables include: $SIZE_{it-1}$, $CASH_{it-1}$, $EFFICIENCY_{it-1}$, $MARKET_{it-1}$, $STATE_{it-1}$, and $CRISIS_{it-1}$.

$SIZE_{it-1}$ is measured by the natural logarithm of total assets (ElBannan, 2015; Tran et al., 2020; Alouane et al. 2021). Larger-sized banks pursue riskier activities since they enjoy a "comprehensive safety net" and would be bailed out by the government in case of financial distress, consistent with the "too-big-to-fail" hypothesis (Haq & Heaney, 2012; Bhagat et al., 2015; Ashraf et al., 2016). However, the evidence reported by Shim (2019) reveals that banks with larger sizes are more stable due to the disciplinary effect of bank franchise or charter values. $CASH_{it-1}$ is the natural logarithm of cash and cash equivalents. Indeed, holding

stocks of cash and their equivalents are expected to buffer against adverse shocks, hence reducing financial distress and failure risk (Palazzo, 2012). Furthermore, cash holdings allow bank managers to exploit the benefits of greater financial flexibility and competitive advantages in the market (Dimitropoulos et al., 2020). Therefore, banks operating in countries where higher cash holdings prevail are inclined to sustain higher levels of growth (Wu et al., 2021). In contrast, Garavito and Chion (2021) provide evidence that excess cash holdings are suggestive of future risky investment opportunities.

Another variable of interest is bank efficiency ($EFFICIENCY_{it-1}$) which is measured by the ratio of total expenses to total revenues, a higher value indicates a less efficient bank. It is well established in the literature that less efficient banks are less proactive in the process of credit monitoring and screening of expenses, confirming the 'bad management' hypothesis (Chortareas et al., 2011; Fiordelis et al., 2011; Silva et al., 2016). Therefore, lower efficiency is expected to increase banks' credit, market, operational, and reputational risks and diminish their financial soundness (Isshaq et al., 2012; AlKhouri & Arouri, 2019; Assaf et al., 2019). Moreover, the evidence reported by Ding and Sickles (2018) confirms that less efficient banks are more likely to extract risky opportunities due to experiencing lower charter values. This result lends support to the "moral hazard hypothesis" (Kwan & Eisenbeis, 1997).

To control for bank market power ($MARKET_{it-1}$), we employ the squared market share of bank i (relative to the total market) at year t-1 in terms of total deposits (ElBannan, 2015; Tran et al., 2020). The contribution of Danisman and Demirel (2019) confirms that greater market power in banking reduces the risky behavior by banks, in line with the "concentration-stability" view. According to prior studies, larger market power enhances banks' profits and their franchise values, which in turn lead to more prudent bank behavior to avoid making losses (e.g., Tabak et al., 2015; Trinugroho et al., 2018; Shim, 2019). In contrast, Berger et al. (2009) find that more market power in the loan market erodes banks' profits and increases loan portfolio risk, supporting the "concentration-fragility" view. Garc á-Herrero et al. (2009) contend that banks with larger market power charge higher interest rates to loan customers, hence triggering severe difficulties to customers while repaying their loan obligations.

Furthermore, we include a dummy variable ($STATE_{it-1}$), that equals one if state shareholding in a bank is 50% or more of ownership and 0 otherwise to control for the impact of bank ownership. State ownership is assessed from two different views. According to the first, state ownership is expected to reduce bank risk and preserve financial stability. This is consistent with the idea that the state can bail out their banks in the case of collapse, hence customers trust banks that are owned by the state more than other banks (Al-Khouri, 2012). According to the second point of view, state ownership induces excessive bank risk-taking in many ways (ElBannan, 2015; Ismiyanti et al., 2018; Otero et al., 2020; Ho et al., 2021; Moudud-Ul-Huq et al., 2021). First, state-owned banks enjoy the advantages of "state protection" or "state bailout guarantees" (Zhu & Yang, 2016). Indeed, state-owned banks rely on government intervention by capital injections or nationalizations during the financial turmoil (Saghi-Zedek, 2016; Moudud-Ul-Huq et al., 2021). Second, state-owned banks are likely to pursue larger volumes of "public social programs" at the expense of their

profitability and efficiency (Iannotta et al., 2013; Pak, 2020). Third, state-owned banks are controlled by politicians, and hence they are likely to follow their political goals that trigger banks to undertake risky investments with low profits (Ismiyanti et al., 2018). Fourth, state ownership encourages banks managers to take on risky investments that maximize their benefits instead of promoting business goals. For instance, managers attempted to choose riskier projects that promise higher returns and greater rewards in the form of compensations (Ho et al., 2021).

Finally, we include a crisis dummy variable ($CRISIS_{it-1}$), that takes the value of one if the year is 2011, 2012, or 2013 and zero otherwise to proxy for the political and economic instability periods that occur in Egypt. A handful of existing studies rigorously claim that crisis is associated with greater risk-taking by banks (e.g., Bhagat et al., 2015; Pino, 2022) and results in lower financial stability for both conventional and Islamic banks (e.g., AlKhouri & Arouri, 2019). Hence, the negative effects of the crisis will lead to declines in banks' profits in the longer term (Apergis, 2014). By contrast, the findings of Ovi et al. (2020) indicate that banks follow more conservative risk policies during a crisis period to reduce the chances of being victims of other crises. In a related study, Ashraf et al. (2016) report that banks expect higher losses during the crisis and make provisions to cover these losses. Subsequently, banks' risk exposures are reduced significantly in a crisis period (Ibrahim & Rizvi, 2018; Wu et al., 2021) and banks can remain resilient in the periods following a crisis (Abuzayed et al., 2018). In addition, banks can provide liquidity to the global financial markets (Ashraf et al., 2016).

4. Data Analysis and Results

Table 1. Summary statistics of the regression variables

	Mean	Median	Std Dev.	Min.	Max.
$RISKTAKING_{it}$: LLP	0.01	0.01	0.01	-0.01	0.14
$RISKTAKING_{it}$: NIMVOLATILITY	0.00	0.00	0.00	0.00	0.02
$RISKTAKING_{it}$: ZSCORE	3.13	3.04	1.24	0.00	8.24
$RISKTAKING_{it}$: STOCKVOLATILITY	0.09	0.08	0.04	0.00	0.20
$INTERESTRATE_{it-1}$	0.10	0.10	0.03	0.06	0.20
$INCOMEDIVERSITY_{it-1}$	0.23	0.23	0.07	0.03	0.47
$INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1}$	0.05	0.07	0.05	0.00	0.20
$SIZE_{it-1}$	10.56	10.52	1.03	8.41	12.99
$CASH_{it-1}$	9.15	9.03	1.21	6.23	12.60
$EFFICIENCY_{it-1}$	1.68	1.54	0.70	0.10	4.92
$MARKET_{it-1}$	0.01	0.00	0.04	0.00	0.26

Table 1 reports summary statistics of our research variables. It is evident that the average LLP_{it} is approximately 0.01 over the sample period, with a minimum of -0.01 and a maximum of 0.14. We find that $NIMVOLATILITY_{it}$ has an average of 0.00, with a minimum of 0.00 and a maximum of 0.02. Further, $ZSCORE_{it}$ has a mean (median) of 3.13 (3.04) with a standard deviation of 1.24 and (Min. = 0, Max. = 8.24). As regards the market measure of bank risk-taking, banks generate $STOCKVOLATILITY_{it}$ of 0.09, with a

minimum of 0.00 and a maximum of 0.20.

The mean $INTERESTRATE_{it-1}$ is about 0.10, with a minimum of 0.06 and a maximum of 0.20. On average, approximately 0.23 of the income in the sample comes from $INCOMEDIVERSITY_{it-1}$ sources, showing ample cross-section and time-series variability since the values ranged from a minimum of 0.03 to a maximum of 0.47. The interaction term ($INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1}$) has a mean of 0.05 with the minimum and maximum of 0.00 and 0.20, respectively. Turning to bank-specific characteristics, the mean $SIZE_{it-1}$ of our banks is LE10.56m and ranges from LE8.41m to LE12.99m. The mean of $CASH_{it-1}$ is approximately LE9.15m during the study period and varies between LE6.23m and LE12.60m. $EFFICIENCY_{it-1}$ shows a mean of 1.68, with a minimum-maximum range from 0.10 to 4.92. The $MARKET_{it-1}$ power of banks records an overall average of 0.01 with a standard deviation of 0.04.

Before the empirical analysis, we test the stationarity of research variables. According to the fisher tests for panel unit root, all the variables are stationary. Next, the panel cointegration tests are estimated to evaluate whether there is a long-term stable structural association or equilibrium phenomenon when holding a set of variables together. The panel findings do not agree with the null hypothesis of no cointegration (Gujarati, 2003). We moreover check for multicollinearity using the variance inflation factor (VIF). Baum (2006) suggests that the critical value of the VIF is 10. The result shows that the value from the VIF is generally less than 10, hence providing evidence for the absence of multicollinearity among independent research variables.

Finally, we test for heteroscedasticity using the Modified Wald test and, to address autocorrelation, we implement a Wooldridge test. Due to the evidence, in particular for heteroscedasticity and/or autocorrelation, we employ the cross-sectional time-series generalized least squares (GLS) to correct for the residuals when estimating the regression models (Gujarati, 2003).

Table 2. Main Results Using Cross-sectional Time-series Generalized Least Squares Regression – Banks (2011-2020)

Variables	$RISKTAKING_{it}$			
	LLP_{it}	$NIMVOLATILITY_{it}$	$ZSCORE_{it}$	$STOCKVOLATILITY_{it}$
$INTERESTRATE_{it-1}$	-4.37***	-1.91*	2.85***	-3.05***
	-0.096	-0.016	9.438	-0.432
$INCOMEDIVERSITY_{it-1}$	-1.87*	-4.59***	5.38***	-4.17***
	-0.017	-0.012	8.074	-0.218
$INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1}$	1.65*	2.59***	-2.70***	1.75*
	0.020	0.011	-4.668	0.149
$SIZE_{it-1}$	-0.31	-0.47	-6.48***	-2.31**
	0.000	0.000	-1.628	-0.020

$CASH_{it-1}$	0.71	0.49	6.24***	0.67
	0.001	0.000	1.101	0.004
$EFFICIENCY_{it-1}$	4.09***	0.54	-2.42**	0.91
	0.005	0.000	-0.388	0.006
$MARKET_{it-1}$	-1.86*	2.59***	2.00**	4.75***
	-0.073	0.026	7.454	5.258
$STATE_{it-1}$	-0.46**	-0.74	-7.00***	1.79*
	-0.002	-0.001	-2.088	0.017
$CRISIS_{it-1}$	2.03	0.83	4.75***	-0.15
	0.002	0.000	0.639	-0.001
CONSTANT	1.35	2.64***	5.33***	4.98***
	0.011	0.008	10.086	0.324
Year fixed effects	YES	YES	YES	NO
Firm fixed effects	YES	YES	YES	YES
P-value	0.0000	0.0000	0.0000	0.0000
Observations	181	162	169	116
Number of banks	22	20	21	12

Notes:

1. $RISKTAKING_{it} = \beta_0 + \beta_1 INTERESTRATE_{it-1} + \beta_2 INCOMEDIVERSITY_{it-1} + \beta_3 INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1} + \sum_{J=1}^{N} \beta_J CONTROLS_{Jit-1} + \epsilon_{it-1}$

   $RISKTAKING_{it}$ = the dependent variable that proxies for risk-taking for bank i at year t, measured by: LLP_{it} = the ratio of loan loss provision to net loans, $NIMVOLATILITY_{it}$ = the volatility of annual net interest margin, $ZSCORE_{it}$ = the simplified Z-score, $STOCKVOLATILITY_{it}$ = the annualized standard deviation of monthly stock returns, $INTERESTRATE_{it-1}$ = the ratio of interest income on loans to net loans of bank i at year t-1, $INCOMEDIVERSITY_{it-1}$ = the non-interest income to total income ratio, $INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1}$ = the interaction term between bank interest rate and income diversity, $SIZE_{it-1}$ = the natural logarithm of total assets, $CASH_{it-1}$ = the natural logarithm of cash and cash equivalents, $EFFICIENCY_{it-1}$ = total expenses divided by total revenues, $MARKET_{it-1}$ = the squared market share of a bank (relative to the total market) in terms of total deposits, $STATE_{it-1}$ = a dummy variable that equals one if the bank is state-owned and zero otherwise, $CRISIS_{it-1}$ = a dummy variable that equals one if the year is 2011, 2012, or 2013 and zero otherwise.

2. *, **, and *** represent significance at the 10%, 5%, and 1% level respectively.

3. A year and firm fixed effects are used to control for autocorrelation and heteroskedasticity in regression residuals respectively.

Table 2 reports a negative and significant impact of $INTERESTRATE_{it-1}$ on

$LLP_{it}, NIMVOLATILITY_{it}$, and $STOCKVOLATILITY_{it}$. Further, it shows a positive and significant impact of $INTERESTRATE_{it-1}$ on $ZSCORE_{it}$. Therefore, banks are more likely to pursue riskier activities when interest rates are too low, it is also likely that low-interest rates with consequent increased bank risk-taking, exhibit less financial stability. It is consistent with the prior findings that low-interest rates expose banks operating in emerging markets to severe risks, proving incompatibility with financial stability (Hoffmann, 2014), thus supporting our first research hypothesis. According to prior studies, banks find it optimal to undertake excessive risks to compensate the largest declines in profits and franchise values when interest rates are low (Delis & Kouretas, 2011; Nguyen & Boateng, 2015; Chen et al., 2018; Majumder & Li, 2018; Brana et al., 2019; Teixeira et al., 2020; Whited et al., 2021).

Consistent with our second research hypothesis, it has been found that $INCOMEDIVERSITY_{it-1}$ affects negatively and significantly the risk-taking of banks as measured by $LLP_{it}, NIMVOLATILITY_{it}$, and $STOCKVOLATILITY_{it}$. The results also declare that $INCOMEDIVERSITY_{it-1}$ affects positively $ZSCORE_{it}$ at the level of 1%. This is consistent with some earlier studies (e.g., Nguyen et al., 2012; Shim, 2013; Doumpos et al., 2016; Ovi et al., 2020) who agree that the expansion of banks into non-interest income strategies enable them to better diversify risks and to witness more financial stability, in line with the effect of some "diversification benefits". Moreover, the results support the argument by Markoulis et al. (2021) that diversification benefits may increase due to reduced exposure to volatile returns.

Importantly, the coefficients of the interaction terms $INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1}$ have the expected positive signs with $LLP_{it}, NIMVOLATILITY_{it}$, and $STOCKVOLATILITY_{it}$ and are generally statistically significant at conventional levels. The interaction coefficient is negative and significant in the $ZSCORE_{it}$ model. Overall, the regression results reveal that for banks with income diversity shares larger than 0.23, the low-interest rates are associated with less bank risk-taking and more financial stability. The findings are consistent with our prediction in the third research hypothesis.

Concerning the control variables, the results show that larger-sized banks are less stable, as apparent by the significant negative coefficient of $SIZE_{it-1}$ in the $ZSCORE_{it}$ model. This suggests a considerable persistence of risk-taking by larger banks. According to prior literature, larger banks increase the size of risk since they would be bailed out by the government in case of distress (e.g., Haq & Heaney, 2012; Bhagat et al., 2015; Ashraf et al., 2016). However, there is a negative and significant association between $SIZE_{it-1}$ and $STOCKVOLATILITY_{it}$. Larger-sized banks can effectively reduce the volatility of stock returns, perhaps due to economies of scale and huge investments in information (Meslier et al., 2014; Bitar et al., 2018).

The positive coefficient 1.101 of $CASH_{it-1}$ with $ZSCORE_{it}$ suggests that greater financial stability derives from improvements in banks' cash holdings, as supported by Palazzo (2012) and Dimitropoulos et al. (2020). The results also show that $EFFICIENCY_{it-1}$ seems to increase LLP_{it} and to reduce $ZSCORE_{it}$. This indicates that the less efficient the banks are

(since a greater value for the total expenses to total revenues ratio implies less efficient operation), the higher the level of their loan loss provisions and the lower their financial stability, confirming the findings of Fiordelis et al. (2011) and Assaf et al. (2019). The rationale behind higher levels of loan loss provisions and lower financial stability is that inefficient banks' managers fail to adequately monitor their loan portfolios and to reduce expenses (Chortareas et al., 2011; Isshaq et al., 2012; Silva et al., 2016; AlKhouri & Arouri, 2019).

As for $MARKET_{it-1}$, the results show that bank market power is significantly negatively associated with the LLP_{it} and is significantly positively associated with the $ZSCORE_{it}$, as the coefficients -0.073 and 7.454 indicate. It is consistent with the prior work of ElBannan (2015), who reveals that larger market power help banks operating in Egypt to reduce risks. As well as supporting the 'concentration stability' hypothesis, the results affirm evidence of a higher degree of financial stability during episodes of larger market power (Tabak et al., 2015; Trinugroho et al., 2018; Danisman & Demirel, 2019; Shim, 2019). In spite of that, $MARKET_{it-1}$ is significantly positively associated with the $NIMVOLATILITY_{it}$ and $STOCKVOLATILITY_{it}$ with a coefficient of 0.026 and 5.258. The positive associations may be attributed to the fact that banks with larger market power compete aggressively with each other for achieving greater profit margins. Increased competition has raised uncertainty, hence amplifying volatility (Crimmel & Elyasiani, 2021).

The results also suggest that $STATE_{it-1}$ is significantly negatively associated with LLP_{it} and $ZSCORE_{it}$ and positively associated with $STOCKVOLATILITY_{it}$. State-owned banks have incentives to take on excessive risks as measured by insolvency risk and return volatility. This is due to the fact that state-owned banks are likely to benefit from "government support" in case of distress (Zhu & Yang, 2016). Moreover, our empirical evidence supports the argument stating that state-owned banks are subject to political pressures (Ismiyanti et al., 2018). However, we observe that state-owned banks exhibit lower levels of credit risk. The results can be explained in light of Lassoued et al. (2016) and Sarkar et al. (2019), who find that state-owned banks hold more capital to hedge against credit risks and maintain the quality of their assets. Finally, $CRISIS_{it-1}$ is significantly positively associated with $ZSCORE_{it}$ suggesting that banks remained resilient during the financial crisis (e.g., Ashraf et al., 2016; Abuzayed et al., 2018; Ibrahim & Rizvi, 2018; Wu et al., 2021).

5. Conclusion

The issue of bank risk-taking is important to bank regulators, policymakers, and researchers and is particularly pertinent to emerging economies where the banking sector is one of the main forces affecting economic stability. In this regard, we examine the association between interest rate and bank risk-taking and between income diversity and risk-taking. Moreover, we investigate whether the association between interest rate and bank risk-taking is moderated by larger income diversity shares. Using a sample of 22 banks operating in Egypt covering the period from 2011 till 2020, we provide empirical evidence that low-interest rates drive banks to undertake risky investments. We also show that increased income diversity restricts bank risk-taking behavior and reduces returns volatility, consistent with

"diversification benefits". Therefore, banks in Egypt shall reap the advantages of investing in channels other than the traditional activities. Most importantly, we confirm the effective moderating role of income diversity in regulating excessive risk-taking behavior by banks when interest rates become too accommodative. Hence, initiatives from policymakers and regulators are needed to encourage banks managers to become more dependent on income diversity strategies within a low-interest rate environment. Future research into the double interacting impact of interest rate and income diversity on bank risk-taking is crucial to support our regression results with data from banks operating in other emerging economies. Future research may also employ other proxies of bank risk-taking.

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Appendix 1. Description of Variables

Variable	Description	Data Source
LLP_{it}	Loan loss provision to net loans	Authors' calculations
$NIMVOLATILITY_{it}$	The volatility of annual net interest margin using a rolling window approach of 3 years. Net interest margin is measured as the ratio of net interest revenue to average earning assets	Authors' calculations
$ZSCORE_{it}$	The bank-level simplified Z-score = $\log(\frac{ROA_{it} + TE_{it}/TA_{it}}{\sigma\ ROA_{it}})$, where ROA_{it} is the ratio of net income after taxes to average total assets, TE_{it}/TA_{it} is total equity to total assets ratio, $\sigma\ ROA_{it}$ is the standard deviation of return on assets which is calculated using all years rolling window	Authors' calculations
$STOCKVOLATILITY_{it}$	The annualized standard deviation of a bank's monthly stock returns	Authors' calculations
$INTERESTRATE_{it-1}$	Interest income on loans divided by net loans	Authors' calculations
$INCOMEDIVERSITY_{it-1}$	Non-interest income divided by total income	Authors' calculations
$INTERESTRATE_{it-1} \times INCOMEDIVERSITY_{it-1}$	Multiplying interest rate and a dummy that takes 1 if income diversity is greater than 0.23 and 0 otherwise	Authors' calculations
$SIZE_{it-1}$	The natural logarithm of total assets	Authors' calculations
$CASH_{it-1}$	The natural logarithm of cash and cash equivalents	Authors' calculations
$EFFICIENCY_{it-1}$	Total expenses to total revenues	Authors' calculations
$MARKET_{it-1}$	The squared market share of a bank (relative to the total market) in terms of total deposits	Authors' calculations
$STATE_{it-1}$	A dummy that takes 1 if bank i is state-owned and 0 otherwise	Banks' annual financial reports
$CRISIS_{it-1}$	A dummy that takes 1 for the 2011-2013 years and 0 otherwise	

Appendix 2. Final Sample of Banks Registered at the Central Bank of Egypt

Number of Banks	Name of Banks	Classification	
		Listed or Un-listed Banks in the EGX	Ownership Structure
1	National Bank of Egypt (NBE)	Un-listed	Governmental
2	Banque Du Caire	Listed starting from February 2017	Governmental
3	Export Development Bank of Egypt (EBE)	Listed	Governmental
4	Housing and Development Bank (HDB)	Listed	Governmental
5	Commercial International Bank (CIB)	Listed	Non-Governmental
6	Qatar National Bank (QNB) Al Ahli	Listed	Non-Governmental
7	Credit Agricole Egypt	Listed	Non-Governmental
8	National Bank of Kuwait (NBK) Egypt	Listed	Non-Governmental
9	Egyptian Gulf (EG) Bank	Listed	Non-Governmental
10	Suez Canal Bank	Listed	Non-Governmental
11	Abu Dhabi Islamic Bank (ADIB)	Listed	Non-Governmental
12	Al Barka Bank	Listed	Non-Governmental
13	Faisal Islamic Bank of Egypt	Listed	Non-Governmental
14	Societe Arabe International Du Banque (SAIB)	Listed	Non-Governmental
15	Abu Dhabi Commercial Bank (ADCB) Egypt	Un-Listed	Non-Governmental
16	Arab African International Bank (AAIB)	Un-Listed	Non-Governmental
17	Audi Bank	Un-Listed	Non-Governmental
18	Emirates National Bank of Dubai (NBD) Egypt	Un-Listed	Non-Governmental
19	Bank of Alexandria	Un-Listed	Non-Governmental
20	Blom Bank Egypt	Un-Listed	Non-Governmental
21	Al Ahli Bank of Kuwait (ABK) Egypt	Un-Listed	Non-Governmental
22	Ahli United Bank (AUB) Egypt	Un-Listed	Non-Governmental

Notes

Note 1. Data from 2010 are extracted due to the presence of lagged independent variables.

Note 2. We lag our independent variables by one period to avoid endogeneity problems (e.g., Brei et al., 2019; Danisman and Demirel, 2019; Kim et al., 2020).

Note 3. Different categories of net non-interest income according to Thomson Reuters: net commission & fees income/(expense), net foreign exchange income/(expense), gain/(loss) on trading investments, gain/(loss) on investment securities, gain/(loss) on sale of financial instruments, gain/(loss) on fair value adjustments from those derivatives transactions, trust income, net income/(expense) from insurance services, and other non-interest income.