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Competition–risk nexus of Taiwanese banks: from a stability–inefficiency perspective

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Abstract

Purpose – This study investigates the competition–risk nexus for Taiwan's banking industry from the stability–inefficiency perspective over the period 2002–2021.

Design/methodology/approach – This study investigates the effect of competition on bank risk from the perspective of stability inefficiency. Following Koetter *et al*. (2012), we measured bank competition levels by adjusting the Efficiency Lerner index.

Findings – This finding supports the competition–stability hypothesis for the banking sector, which states that intensified competition reduces banks' insolvency and credit risk, making the banking sector sounder. However, banks enjoy a "quiet life" environment and face less competition but still obtain high profits despite inefficiency.

Originality/value – This study considers the moderating effects of multiple factors and finds that bank size, the revenue growth rate and new business income moderate the relationship between risk and competition. In addition, compared with the Z-score, this study investigates the competition–risk relationship through stability inefficiency, which was evaluated using the stochastic frontier approach, offering more robust results than previous studies.

Keywords Stability inefficiency, Bank competition, Risk-taking, Moderating analysis

Paper type Research paper

1. Introduction

Since 1980, Taiwan has experienced rapid and continued economic growth, which economists call "Taiwan economic miracles". As financial development gradually matures, consensus on open banking competition begins. The government allows new banks to enter the market, but deregulation results in gradually rising non-performing loans (NPL). After Taiwan and China's accession to the World Trade Organization (WTO) in 2001, Taiwanese banks actively planned to enter the Chinese bank market and operate RMB businesses. The Taiwanese banking industry enjoys high profits from the high-speed Chinese economic growth. However, only qualified banks can expand their businesses to mainland China. Over the past thirty years,

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Taiwan's banking industry has developed in a process that has formed a natural oligopoly from the government's encouragement of competition to the industry's self-quitting. The relationship between competition and risk and the dynamic changes are valuable for investigating this process.

Since the 1997 Asian financial crisis, the banking industry has experienced several financial shocks; the regulator's primary supervision purpose has been to build a sound financial system and keep financial institutions operating stably for the past three decades. Previous literature argues that competition (market power) plays a crucial role in bank risk (Boyd and De Nicoló, 2005; Beck *et al.*, 2006; Martinez-Miera and Repullo, 2010). Therefore, scholars continue to debate whether bank competition boosts or reduces financial stability. The economic theory of the competition–financial stability nexus mainly includes the competition–stability and competition–fragility hypotheses. The competition–fragility hypothesis argues that banks have higher profitability from monopoly rents in a less competitive market; thus, they can absorb shock uncertainty and reduce risk-taking (Boyd and De Nicoló, 2005). By contrast, the competition-stability hypothesis argues that a higher ability and caution in monitoring borrowers when banks do not benefit from franchise value may explain the trade-off between competition and stability (Leroy and Lucotte, 2017). Therefore, the effect of competition on bank risk needs to be clarified.

The literature typically measures bank credit risk proxies as NPL. The Z-score has also been widely used to evaluate bank insolvency risk (or stability) (Leroy and Lucotte, 2017; Hussain and Bashir, 2020). However, Tabak *et al.* (2012) argued that the Z-score does not entirely indicate the potential stability that each bank can achieve. They suggested using maximum likelihood to simultaneously estimate the translog specification and dependent variables, such as Z-scores, and measure bank inefficiency in one stage. Therefore, this study constructs a Z-score translog specification function and uses stochastic frontier approach (SFA) to identify deviations from the optimal performance frontier, and demonstrates how the noise term affects efficiency, which banks do not control. This feature separates frontier deviation into random errors and inefficiency components. The latter reflects a deviation from banks' current stability, and their maximum stability must be considered [1].

This study contributes to the literature in several ways. First, unlike previous studies, which often used Z-scores, this study investigates the relationship between competition and bank risk from a stability–inefficiency perspective, offering more robust results. Second, we tested the moderating effects of multiple factors and found that bank size, revenue growth rate, and new business income moderate the relationship between risk and competition, providing insights for concerted policies. Third, we further compared the competition–risk nexus causing the dynamic change in the way banks enter the Chinese banking market (comparing signing pre- and post-ECFA) and examined whether financial cooperation in the cross-strait significantly impacts bank risk or competition and their relationship. The main findings support the competition–stability hypothesis for the banking sector in Taiwan during 2002–2021, indicating that intensified competition reduces bank risk-taking. In addition, the interaction term between competition and financial holding companies (FHCs) organisations is significantly positive, which means that greater market power decreases bank soundness when a bank is an FHC subsidiary.

The remainder of this study is organised as follows. Section 2 is the literature review and background. Section 3 describes the methodology, including the measurement of competition and risk indicators. Section 4 discusses the empirical results, and the final section presents the conclusions and outlines the policy implications.

2. Literature review and background

2.1 Literature review of competition versus risk

The literature on bank risk management focuses mainly on the determinants of bank risk-taking, such as bank efficiency, competition, and ownership structures. Previous literature confirms

that competition significantly affects bank risk; however, the competition–risk-taking nexus is ambiguous. For example, Berger and Hannan (1998) argued that a potentially more significant loss from market power reduction in cost efficiency is caused by a lack of market discipline in concentrated markets. Beck *et al*. (2006) found that the weaker the bank competition in an area, the lower the probability of a banking crisis. Figure A1 (Online Appendix) illustrates the path framework of how competition affects bank risk in the previous literature.

The main hypotheses on the relationship between competition and bank risk-taking are the competition, stability, and fragility hypotheses. The first hypothesis states that competition intensifies and incentivises banks to use lower lending rates to gain customers, thereby decreasing borrowers' probability of default and reducing bank risk. Boyd and De Nicoló (2005) derived a Cournot model with a bank market structure, assuming that banks choose the loan quantity to grant simultaneously and independently. They argued that banks' lending behaviour, based on the risk-shifting concept, tends to charge higher interest rates in less competitive markets, which, in turn, raises the probability of loan default. Goetz (2018) showed that greater competition decreases banks' failure probability and NPL share, thereby increasing profitability in the American banking industry. His findings support the competition–stability hypothesis of improving bank profitability and asset quality in competitive markets. Therefore, competition promotes bank soundness and reduces risk-taking according to the competition–stability hypothesis. Based on the preceding discussion, the following hypothesis is proposed.

H1. The competition–stability hypothesis was supported for the banking industry in Taiwan.

In contrast, the competition–fragility hypothesis states that banks must take higher risks to compensate for decreasing profits because of the fall in market power and loan rate in a more competitive market. Furthermore, greater competition may cause information asymmetry and moral hazards resulting from an imprudent screening process for borrower applications. Leroy and Lucotte (2017) investigated the relationship between competition and risk in a sample of large European listed banks and found that competition encourages banks to adopt a higher risk strategy to earn excess profits, raises individual banks' insolvency risk, and reduces European banks' soundness. Bátiz-Zuk and Lara-Sánchez (2023) showed that the Lerner index and systemic risk are negatively related at the bank level in Mexico, implying that systemic risk increases with competition. Ernaningsih *et al*. (2024) showed that a lack of competition increases systemic risk exposure from interconnection channels and bank risk contributions in a sample of 17 emerging market countries from 2000 to 2019. The main advantage of this study is that it distinguishes between different sources of bank-level risks, such as NPL, insolvency risk, and stability inefficiency. Based on the preceding discussion, the following hypothesis is proposed.

H2. The competition–fragility hypothesis was supported for the banking industry in Taiwan.

Some recent studies have tested the nonlinear relationship between competition and bank risk. A few scholars, such as Martinez-Miera and Repullo (2010), Hussain and Bashir (2020), and Borauzima and Muller (2023), showed the co-existence of the competition-stability and competition-fragility hypotheses because the relationship between competition and risk is nonlinear. Additionally, Liao (2023) stated that evidence supporting one hypothesis does not necessarily exclude evidence supporting another. Future research could further analyse whether a dynamic, nonlinear relationship exists between competition and risk.

2.2 After the millennium of Taiwanese banking industry development

The millennium has been a critical watershed for the development of Taiwan's banking industry. Financial institutions are alert to systemic risks because of the serious non-performing loan problem, especially because many regional financial institutions, such as farmers and

fisher credit unions, have faced the crisis of the inability to operate and insolvency risks. The regulator requested and implemented its first financial reform between 2001 and 2003. The wave of mergers and acquisitions (M&A) in the banking industry and the new business model of FHC have imposed significant shocks and influence [2]. Taiwan's economic scale is small and shallow, making it challenging for banks to extend their business in Taiwan and lowering profitability, and some famous enterprise groups have withdrawn from the banking industry. The number of banks in Taiwan gradually decreased from 53 in 2000 to 38 in 2021.

To improve bank profitability, the banking industry restructured to form FHCs, which provides opportunities for the integration of the banking, insurance, and securities industries and expands financial institutions' operational synergy. This enables banks to use funds more efficiently and promotes diversification in the banking industry. For consumers, FHCs provide the convenient advantage of "one-stage shopping". They provide banks with business opportunities to increase their competitiveness and expand their service businesses. In addition, after signing the Economic Cooperation Framework Agreement (ECFA), Taiwan's banking industry allowed the construction of branches in mainland China. Under the ECFA framework, banks directly enter the Chinese financial market to extend their operating scale and raise funds flexibly, especially to follow the footsteps of Taiwanese enterprises (customers) and extend services to the Chinese market to avoid customer loss to rival banks. Under the financial reform and a series of policies sustained over two decades, banks' NPL significantly decreased from 7.44% in 2001 to 0.75% in 2021. Currently, the probability of system risk in Taiwan's banking industry is lower than that in other emerging Asian countries. Therefore, this study also considers the impact of internal (FHC) and external (ECFA) factors on the relationship between competition and risk in Taiwan.

This case study is interesting because Taiwan's banking industry experience can provide a process for forming a natural oligopoly from the government's encouragement of competition to the industry's self-elimination. In this process, dominant banks attempt cross-border expansion (ECFA) to gain greater market power; further analysis is needed to determine whether the relationship between competition and risk changes dynamically.

3. Methodology

3.1 How to evaluate the competition indicators

The existing literature provides many theoretical and empirical studies that evaluate bank competition indicators (Bikker and Spierdijk, 2010) [3]. Scholars argued that both structural and nonstructural approaches are used to evaluate bank competition models. This study measured bank competition levels by modifying the traditional Lerner index. The Lerner index is the difference between the markup prices of bank products and their marginal costs. It ranges from a maximum of 1 to a minimum of 0, with higher numbers denoting greater market power, and hence, lower competition. However, Turk-Ariss (2010) stated that the conventional Lerner index assumes perfect bank efficiency and does not consider the possibility that banks may not abuse the pricing opportunities from their market power. Thus, Koetter *et al*. (2012) suggested that adjusting the Lerner index to evaluate competition is better than the original Lerner index, which is written as follows:

$$\text{Efficiency-adjusted } Lerner_{it} = \frac{\pi_{it} + TC_{it} - MC_{it} \times y_{it}}{\pi_{it} + TC_{it}} \tag{1}$$

where π_{it} is the total interest revenue and fee revenue for bank i in year t, TC is the total cost, MC_{it} is the marginal cost and y_{it} is the bank output.

Following Tan and Anchor (2017), in modelling the cost function, this study used the following translog function form because it does not require too many restrictive assumptions about the nature of technology; thus, the specification of the cost function can be written as follows:

$$ln\left(\frac{TC}{w_3}\right) = \alpha_0 + \alpha_1 lnQ + \frac{1}{2}\alpha_2 lnQ^2 + \alpha_3 ln\left(\frac{w_1}{w_3}\right) + \alpha_4 ln\left(\frac{w_2}{w_3}\right) + \frac{1}{2}\alpha_5\left(ln\left(\frac{w_1}{w_3}\right)\right)^2 + \frac{1}{2}\alpha_6\left(ln\left(\frac{w_2}{w_3}\right)\right)^2 + \alpha_7 ln\left(\frac{w_1}{w_3}\right) ln\left(\frac{w_2}{w_3}\right) + \alpha_8 lnQln\left(\frac{w_1}{w_3}\right) + \alpha_9 lnQln\left(\frac{w_2}{w_3}\right) + \varepsilon_{it} \quad (2)$$

where TC is the banks' total cost and Q is total assets, a proxy for bank output. This study used three input prices: w_1 is the wage (price of labour), w_2 is the price of capital measured by the depreciation of fixed assets, and w_3 is the price of funds measured by interest expense to total deposits.

Marginal cost is derived from Eq. (2), which uses a single output corresponding to the total assets. Considering the first derivative of the dependent variables in the cost function, the marginal cost is as follows:

$$MC_{it} = \frac{TC/w_3}{Q}\left[\alpha_1 + \alpha_2 lnQ + \alpha_8 ln\left(\frac{w_1}{w_3}\right) + \alpha_9 ln\left(\frac{w_2}{w_3}\right)\right] \quad (3)$$

3.2 How to measure the stability inefficiency

Following Tabak *et al*. (2012) and Tan and Anchor (2017), the empirical equation we considered for estimating stochastic frontier is similar to Eq. (2), estimating the translog cost function simultaneously by maximum likelihood, the dependent variables as Z-score to w_3, and measuring bank stability–inefficiency equation as follows:

$$ln\left(\frac{Z-score}{w_3}\right)_{it} = \beta_0 + \sum_{i=1}^{2}\beta_i ln\, y_{it} + \frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2}\beta_{ij} ln\, y_{ijt} lny_{jit} + \beta_1 ln\left(\frac{w_1}{w_2}\right)_{it} + \beta_{11} ln\left(\frac{w_1}{w_2}\right)_{it} ln\left(\frac{w_1}{w_2}\right)_{it} + \sum_{i}^{2}\theta_{i1} ln\, y_{it} ln\left(\frac{w_1}{w_2}\right)_{it} + \delta_1 T + \delta_2 T^2 + \varepsilon_{it} \quad (4)$$

where the input variables were similar to those in Eq. (2). The output variables (y_i) have used two outputs, including loans and operational revenue. T is the time trend and its squared team, ε_{it} is the error term and can be distinguished as $v_{it} - u_{it}$, v_{it} is the random distribution, assumed to be normal distribution, u_{it} indicates technology and allocative inefficiency under managerial control, which is assumed to be a half-normal distribution, that we call "stability inefficiency" [4].

A higher stability inefficiency value indicates higher bank risk and vice versa. This study uses a stochastic frontier model to measure each bank's stability inefficiency, estimated using the statistical software Stata 16.0 [5].

Following Borauzima and Muller (2023) and Liao (2023), we standardised the stability inefficiency to reduce the possible influence bias of the outlier value using the following standardised formula:

$$x_{ij}^{x} = 0.1 + \frac{x_{ij} - min\,(x_j)}{max(x_j) - min\,(x_j)} \times 0.9 \quad (5)$$

where $max(x_j)$ and $min(x_j)$ denote the maximum and minimum values of stability inefficiency in each year, respectively. The stability–inefficiency value ranges from 0 to 1, indicating a bank's relative risk level in a specific year.

3.3 Empirical regression design

To investigate the relationship between risk and competition for banks in Taiwan, using stability inefficiency as a proxy, banks' risk and competition levels were defined as the adjusted efficiency Lerner index, and we also considered bank-specific variables possibly affecting risk. The baseline regression is as follows:

$$SIE_{it} = \gamma_0 + \gamma_1 SIE_{it-1} + \gamma_2 ELerner_{it} + \gamma_i \sum_{i=1}^{5} X_{it} + \varepsilon_{it} \quad (6)$$

where SIE indicates bank stability–inefficiency and *ELerner* is competition levels by individual banks. Following Hussain and Bashir (2020) and Tan and Anchor (2017), this study used three control variables as proxy bank-specific variables, including equity to asset ratio (EA), diversification measured by net profit or loss other than interest to total operational revenue (DIV), and revenue volatility measured by a rolling three-year window moving each bank's return of assets (SDROA). We also considered the impact of macroeconomic variables on bank risk-taking, including inflation rate (INF) and gross domestic product (GDP) growth rates.

We considered the possible endogeneity problem in Eq. (6), Roodman (2009) suggested solving the endogeneity problem and unobserved heterogeneity using the generalised method of moments (GMM). Compared to the dynamic and static GMM methods, we estimated the regression for the panel data. The advantage of the dynamic GMM method is that it addresses endogeneity problems and produces efficient results even with the limited time dimensions. Therefore, our empirical regression is dynamic and all parameters were estimated using the GMM, as proposed by Arellano and Bover (1995) [6]. The original data source from the Taiwan Economics Journal database and the descriptive statistics of the cost function and control variables are presented in Table A1 [7].

4. Empirical results

4.1 Competition and stability inefficiency

This section reports on Taiwan's bank competition levels and stability inefficiency from 2002 to 2021 [8]. As shown in Table A2 [7], the mean stability inefficiency is only 0.0102, implying that banks operate soundly and in a lower-risk environment. After standardising the stability inefficiency value, the mean was 0.5761, implying a significant gap in bank inefficiency. Additionally, the stability inefficiency did not include grant volatility during the study period. As seen in Figure A2 [7], this finding shows that banks had high-risk values in 2003–2006, 2008, and 2020; these periods (years) were mainly affected by the financial reform period, the global financial crisis, and the COVID-19 pandemic.

On the one hand, the mean of Lerner's adjusted efficiency is 0.541, compared with previous literature showing a low competition level. Davis *et al*. (2020) showed that the Lerner index is 0.26 for the global sample, and Hussain and Bashir (2020) showed that banks' Lerner index is 0.3582 in China. Since 2000, the wave of bank mergers has increased in Taiwan, and market power has not fallen significantly; however, lower competition does not raise the banking industry's risk (from the NPL perspective).

Spearman's rank correlation coefficient results show that stability inefficiency and competition level are only 0.1, and the correlation coefficient of NPL and competition is $\rho =$ 0.374. This implies that competition does not play an important role in bank risk-taking and

that the competition–stability and competition–fragility hypotheses may not clearly support the cause of the low competition and low-risk characteristics of the banking industry in Taiwan. Therefore, this study further investigated this relationship using a dynamic GMM regression, as described in the next section.

4.2 Results of baseline regression

Table A3 [7] presents the baseline regression results. The coefficient of *ELerner* is positive and significant in all the columns, implying that banks take more risks in less competitive conditions. In other words, larger banks with the advantage of market power may render Taiwan's banking sector unsound. These results show that the competition–stability hypothesis holds for the banking sector in Taiwan, which is inconsistent with Leroy and Lucotte (2017), however, this result is consistent with Hussain and Bashir (2020). One possible reason to explain this result is that banks enjoy a "quiet life" even if they are inefficient and still have high profits; thus, managers are incentivised to more risk-taking strategies to earn excess returns. Another possible reason is that managers do not worry about losing jobs even if their performance is poor because of the family ownership structure, which makes them prefer risk (Liao, 2021).

To summarise the results for the control variables, operating volatility significantly and positively affects bank risk, implying that greater operating uncertainty increases bank stability and inefficiency, which is consistent with our expectations. Liao and Li (2022) stated that equity to assets is a proxy for external corporate governance mechanisms. This result shows that EA does not affect stability inefficiency, indicating that corporate governance may not play a positive role in bank risk-taking in Taiwan. The coefficient of DIV has contrary results in Columns 1 and 2, indicating that bank diversification does not impact stability inefficiency, but increases NPL. Yang *et al*. (2020) showed that diversification increases the banking sector's systemic risk. The effect of diversification on systemic risk is especially significant for large and medium-sized banks. This result indicates that diversification causes banks to become involved in unfamiliar products, thereby increasing their NPL. The coefficient of SDROA is significantly positive in Column 1 and insignificant in Column 2, which means that return uncertainty worsens bank stability inefficiency but does not necessarily increase NPL. One possible reason for this is that banks' NPL rates have always remained low after a series of financial reforms in Taiwan. Thus, ROA volatility does not deteriorate loan quality. In addition, these results show that macroeconomic factors are not associated with stability inefficiency. One possible reason for this is that both economic growth and inflation have been stable for the past decade (except for 2008–2009 because of the global financial crisis), and bank risk sources are mainly posed by individual corporate characteristics.

4.3 Banks' organisation effect analysis

In this section, we explain how FHCs play an important role in bank risk-taking. FHCs have the advantage of diversification, which is conducive to operational synergy and causes banks to reduce their insolvency risk. Wu (2015) indicated that a comparison of FHCs' subsidiaries and independent banks reveals that FHCs' subsidiaries' efficiency is significantly higher than that of non-group banks. Cuong's (2021) findings showed that FHCs' affiliates tend to engage more in risk-taking than subsidiaries of bank holding companies. Therefore, we used a dummy variable model in which the bank is an FHC subsidiary equal to 1, and 0 otherwise. As shown in Column 1 of Table A4 [7], the coefficient of $FHC \times ELerner$ (DVEL) is significantly positive, while it is insignificant in Column 2. This suggests that greater market power increases bank risk when the bank is an FHC subsidiary, which is consistent with Cuong (2021). This implies that the relationship between competition and risk-taking is a trade-off; however, it only provides slight evidence to support the competition stability hypothesis because DVEL is not significantly positive in all columns [9].

However, the relationship between NPL and DVEL is negative (but insignificant) in Column 3, which shows that competition intensifies the increase in loans and is probably defaulted. One possible reason for this result is that competition doubly affects bank risk-taking. Tan and Anchor (2017) argued that competition associated with various risks exists heterogeneously, implying that the effects of competition on bank risk are not always identical. In general, an FHC subsidiary has greater market power because of scale economics and platform advantage in expanding its services and production; however, although the FHC subsidiary has operational advantages, it will not induce managers to adopt less rigorous lending strategies to expand the business scale and earn excess profits. Therefore, FHC subsidiaries have low NPL. In summary, these results show that the competition-fragility hypothesis does not hold. However, the competition-stability hypothesis for Taiwan's banking industry is only partially supported.

4.4 Comparison of banks' risk-taking in pre-and post-ECFA

After signing the ECFA, Taiwanese banks entered the Chinese financial market to extend their operating scale and services to the Chinese market to avoid customer loss to rival banks. However, after 2016, the Chinese economy began to face a slowdown in growth; at the same time, this significantly raised the uncertainty risk in the financial market. Therefore, this study investigates whether the signed ECFA across the Taiwan-China strait changes banks' risk-taking and the role of competition on risk. In this section, we assumed that DV_{ECFA} is a dummy variable whose value is 1 after the signed ECFA and 0 otherwise.

As shown in Table A5 [7], the coefficient of DV_{ECFA} is significant and positive in Column 1 and significantly negative in Column 2. This finding shows that banks' stability inefficiency increased after the signed ECFA, but NPL decreased. The deceleration of China's economic growth has indeed increased the operating risk of Taiwan's banking industry and made the banking system unsound. This is caused by increasing bank RMB business risk exposure in the Chinese market. Therefore, the regulator requires banks to decline RMB business risk exposure to the equity ratio, which will remain at a higher level of 29% in 2022. This indicates that Taiwan's banking sector's RMB business risk exposure in the Chinese market remains high and concentrated on a single market.

To further explore how the ECFA affects the competition and risk nexus for banks in Taiwan, we classified the total sample into two subsamples, pre-ECFA and post-ECFA, and re-estimated them. As Table A6 [7] shows, the competition benefits in reducing bank risk are significant before the pre-ECFA sign but do not exist after signing the ECFA, which is consistent with the dummy variable function. This suggests that the expansion of Taiwan's banking industry into mainland China has resulted in higher external risk exposure, and that internal competition does not play an important role in effectively improving risks. This implies that the standard financial supervision mechanism for the banking industry across the China-Taiwan Strait needs further improvement. Taiwanese regulatory agencies cannot effectively supervise the operational risks of Taiwanese banks in mainland China, which requires further cooperation between the regulatory agencies.

4.5 The moderating effect analysis

This study further analyses the potential mechanisms through which competition influences bank risk-taking. Liao (2022) argued that large banks use their size advantage to obtain funds at lower costs, reduce their input costs, and expand their business activities. Therefore, large banks have more ways to control their risk than medium-sized banks. However, Laeven *et al.* (2016) found that systemic risk increases with bank size and decreases with bank capital independent of the impact of bank size and capital on standalone bank risk. Bank size also plays an important role in risk, profitability, and efficiency. However, the existing literature does not provide consistent commonalities.

In addition, most previous studies stated that diversification helps reduce bank risks (Li *et al.*, 2021; Liao, 2022). However, Edirisuriya *et al*. (2015) found that a bank's solvency is negatively affected by more than a certain level of diversification into non-interest businesses. Therefore, we considered two potentially moderating variables in analysing the mechanisms below, which use the proportion of new-type business revenue (NBR) as a proxy for diversification level. The revenue growth rate (REG) is another factor that potentially affects competition and bank risk.

Based on the above discussion, we considered whether bank size, revenue growth, and new business revenue catalyse the competition and risk-taking nexus and how this affects their relationship. SPSS PROCESS v4.3 was employed for the estimation. As seen in Table A7 [7], the coefficient of $ELerner \times SIZE$ is significantly negative in all columns, implying that market power affects bank stability and inefficiency, and that NPLs mainly depend on larger than medium-small banks. It is evident from this that the larger a bank is, the more it is able to reduce risk through competition. MEGA banks enjoy a quiet environment and can expand their business scale and scope. This suggests that regulators encourage banks' M&A to have a synergistic effect but need to avoid low efficiency and the "too big to fail" dilemma.

These results show that the revenue growth rate has a positive moderating effect on the relationship between stability inefficiency and market power, implying that through revenue growth, market power helps strengthen a bank's role in reducing risks ($ELerner < 0$ in column 3). The coefficient of $ELerner \times NBR$ is significant in Columns 5 and 6, indicating that NBR has a moderating effect on the stability-inefficiency nexus market power. This finding implies that new business income can help promote the impact of a bank's market power in reducing stable inefficiency. Simultaneously, new business income mitigates the NPL caused by increased market power. This suggests that revenue diversification and service innovation have improved bank risk and soundness in Taiwan.

4.6 Robustness test

Following Hussain and Bashir (2020) and Liao (2022), we verified our results in several ways. First, this study tested alternative definitions of proxy variables for competition and risk, such as the traditional Lerner index and the Z-score. As shown in Table A8 (Online Appendix), the results indicate that the main conclusions remain unchanged.

Second, we used two-stage least squares (2SLS) and a dynamic panel model with fixed effects (FM) to reestimate Eq. (6). The results of the 2SLS model are similar to those of the GMM model; however, the FM results show that the coefficient of SIF is insignificant, and NPL is significantly positive [10]. This suggests that one disadvantage of the fixed-effects model is that it is impossible to estimate the effects of variables that do not (or hardly) vary over time. Thus, our study estimated that regression using the GMM is better than that using the fixed-effects model [11].

Third, the regression results are biased if the sample has extreme values. Therefore, we omitted the banks with the largest and smallest total assets and re-estimated our empirical function [12], showing that the main results remain the same [13]. This series of robustness tests indicates that the results are very stable.

5. Conclusion

This study investigates the impact of competition on bank risk from the perspective of stability and inefficiency in Taiwan from 2002 to 2021. These findings support the competition–stability hypothesis for the banking sector, which states that intensified competition reduces bank risk-taking. In addition, the interaction term between competition and FHC is significantly positive, which means that greater market power increases bank risk when the bank is an FHC subsidiary. This implies that greater competition reduces bank risk-

taking, provides evidence to support the competition–stability hypothesis and contradicts the competition-fragility hypothesis.

The banking sector underwent a wave of mergers and acquisitions gradually toward a polarisation market after 2000; it can be classified as "too big to fail" financial holding groups (also called "MEGA" banks) and regional independent banks such as Taichung Bank and Taipei Star Bank. These MEGA banks have complete capital reserves and buffers and high saving rates in Taiwan's private sector make it easy for them to hold full and inexpensive funds. Therefore, banks are more incentivised to make adventurous investments or speculate on products, which increases their probability of instability. Based on this discussion, this study offers several suggestions from a management perspective. First, MEGA bank managers have been incentivised to increase market share and build their "empire"; however, these expansion strategies must be based on financial soundness. Second, this study shows that diversification increases bankruptcy probability. This suggests that the development of new financial products remains unclear. Therefore, before the cautious marketing survey and timely after-sale risk control, new financial products decreased insolvency risk.

The results of this study have several important implications. First, regulators should allow new business-style banks such as Internet-only banks (direct and virtual banks) to enter the banking sector. The market power of large banks must be reduced to encourage competition among banks and decrease bank risk. Second, regulators must strengthen the supervision and information disclosure of MEGA banks to avoid bank asymmetric risk-taking due to the unthinkingly expanding business scale and scope. Third, constrained by Taiwan's shallow economy, the regulator stated that it took efforts for Taiwan's banking industry to achieve economies of scale and scope. This study suggests that Taiwan's banking industry should take advantage of the ECFA framework to deepen its operations in the Chinese financial market, expand its business scale, and retain its original customers. Considering that fintech plays a moderating role in the competition-risk nexus and is conducted across China-Taiwan bank-level data, future research can also provide a more comprehensive understanding of the competition-risk nexus.

Notes

1. Compared to the Z-score and other common risk indicators, stability inefficiency is a risk indicator which provides a more robust result (Tan and Anchor, 2017).
2. The first financial reform of 2001 was called the "258 Financial Reform Plan". The regulator stated that within two years, the NPL of financial institutions would be reduced to less than 5%, and banks' capital adequacy ratio would be raised to more than 8%.
3. See Claessens (2009) and Bikker and Spierdijk (2010) for more details.
4. This study specification avoids the bias of a two-step approach; thus, we first assumed that efficiency has a half-normal distribution, while in step two, we assumed it is normally distributed and influenced by the explanatory variables. In addition, it avoids the common econometric problem associated with two-step procedures, namely, generating regressors.
5. See Tabak *et al.* (2012) for details.
6. Following Arellano and Bover (1995), explanatory variables with lags one-period were used in observational studies as instrumental variables to address problems with endogeneity.
7. Please see it on the Online Appendix.
8. For brevity, each bank's stability–inefficiency and Lerner index results are available upon request.
9. This study further considered ownership structure (state-owned and private-owned banks). However, our findings show that only privately-owned banks supported the competition-stability hypothesis. For brevity, the results are available upon request.
10. For brevity, the dynamic panel model with fixed effects' results are available upon request.
11. See Hill *et al.* (2020) for more details.

12. This study considers extreme value influence may make results biased; after deleting partial samples, the observations in this study are 600, and it re-estimated Eq (6).
13. For brevity, the re-estimated results of excluding extreme values are not listed but are available upon request.

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Supplementary material
Supplementary material for this article can be found online.

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