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Analyzing the Effects of Bank Digitalization on Bank Competition and Profitability in Central Asia: Insights from Kyrgyzstan and Kazakhstan

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Abstract

This research investigates how bank digitalization influences competition and profitability within the banking industries of Kyrgyzstan and Kazakhstan over the period from 2012 to 2023. The bank digitalization index is estimated following the System Dynamics Approach. The assessment of banking competition is conducted using the Lerner Index and the Boone Indicator. The relationships between bank digitalization, competition, and profitability are analyzed through a two-step Generalized Method of Moments analysis. Findings reveal that in Kyrgyzstan, digital transformation enhances bank competition and efficiency, advocating local banks to accelerate digital adoption to leverage favorable market conditions. Conversely, in Kazakhstan, despite higher levels of digitalization, the impact on competition and profitability remains insignificant. This highlights the need for banks to persistently expand their digital capabilities beyond current innovations to stay competitive and improve financial results. The study recommends that policymakers foster an environment that nurtures innovation and sustains competitive equilibrium in the banking industry.

Keywords: *Digitalization, bank competition, profitability, Kyrgyzstan, Kazakhstan.*

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1. Introduction

The banking sector has always been a cornerstone of economic stability and growth. Today, it stands at the forefront of a technological revolution that is dramatically reshaping its landscape. Driven by rapid technological advancements, competitive dynamics within the sector are undergoing significant transformations (Theiri & Hadoussa, 2024). Fintech companies are emerging with innovative financial and payment solutions, posing robust competition to traditional banks. In response, a growing number of banks are adopting technologies to boost operational performance (Versal et al., 2022). Particularly in Central Asia, this digital shift is gaining momentum, with the digital banking market expected to expand at a rate of 8% from 2024 to 2028, indicating a substantial move towards digitalization among banks of the region (Statista, 2023).

After gaining independence, Kyrgyzstan and Kazakhstan have undertaken extensive economic reforms, including banking sectors. These reforms aimed to establish functional banking systems capable of supporting domestic economies and integrating into global competitive markets. Consequently, the banking industries in these nations have experienced heightened market concentration and low competition. For example, in Kazakhstan, the three largest banks hold over 60.32% of total banking assets, while in Kyrgyzstan, the top three banks account for 49.56% of the assets. This contrasts with the neighboring economies, such as China and Vietnam, which exhibit lower levels of banking concentration, at 38.32% and 25.08%, respectively (the Global Economy, 2022).

Competition in the banking sector, much like in other fields, can yield significant benefits for consumers and the broader economy through improved quality and pricing of services (Jia & Liu, 2024). Nonetheless, bank competition possesses distinct characteristics that set it apart from other industries. Several studies suggest that heightened competition could lead banks to take on more risks (López-Penabad et al., 2021). Conversely, some contend that restricted competition adds to the vulnerability among banks (Clark et al., 2018). Based on these viewpoints, the influence of bank competition on profitability can range from beneficial to detrimental outcomes (Khattak et al., 2023). In light of these considerations, the topic of competition within the banking industry has attracted growing scrutiny from researchers and industry experts over the past decade. While theoretical research has concentrated on the methodological aspects of measuring competition, empirical studies have examined the links between bank market concentration and factors such as stability (Clark et al., 2018), profitability (Tan, 2016), and overall economies (Rakshit & Bardhan, 2019). Nevertheless, research specifically addressing the relationship between bank digitalization and competition remains sparse (Chao et al., 2024; Jia & Liu, 2024). Meanwhile even with the extensive digitalization among banks globally, studies in this area are surprisingly scarce (Begimkulov, 2023). Similar to that of competition, the majority of the identified studies focus on several critical areas such as bank stability (Ben Ali, 2022; Carbó-Valverde, 2017), marketing

(Moraru & Duhnea, 2018; Utami & Supriadi, 2023) and broader macroeconomic impacts (Yang et al., 2024). However, the current literature shows insufficient representation of digital transformation's impact on bank performance (Chao et al., 2024; Nguyen et al., 2023; Theiri & Hadoussa, 2024).

Within this background, the present study aims to enhance the existing body of knowledge by targeting several crucial goals. Firstly, the research evaluates the degree of digitalization within the banking sectors of Kyrgyzstan and Kazakhstan. Secondly, it aims to determine the levels of bank competition and concentration levels in Kyrgyzstan and Kazakhstan. There is a notable scarcity of studies that have explored these topics within the specific geographical context of Kyrgyzstan and Kazakhstan despite the ongoing development of banking systems in the region. Lastly, this study performs a comparative analysis to investigate the effects of bank digitalization on banking institutions, evaluating and contrasting its effects on competition and profitability among banks in Kyrgyzstan and Kazakhstan.

2. Literature Review

2.1. Competition

Empirical studies on assessing bank competition predominantly rely on two principal frameworks: the Structure-Conduct-Performance (SCP) Paradigm and the New Empirical Industrial Organization (NEIO) model. The SCP paradigm analyzes market structure by measuring characteristics like the number of institutions, their size, assets, and capital, which influence organizational conduct variables such as pricing and product quality. This conduct impacts performance metrics like sales and profits (Mason, 1939; Bain, 1956). SCP paradigm is based on such methods as the total count of companies, the concentration ratio (Hall & Tideman, 1967), and the Herfindahl-Hirschman Index (Hirschman, 1964). While SCP offers benefits such as low data requirements and easy interpretability (Leon, 2014), it also faces conceptual and practical challenges, as noted in the literature (Claessens, 2009). For example, it fails to account for dynamic market changes due to its static analysis, presumes a one-way causality that overlooks possible reverse effects, simplifies the complexities of competition, and neglects external factors such as regulatory influences (Leon, 2014).

The NEIO framework assesses competition without explicitly accounting for market structure. NEIO emphasizes the evaluation of direct business metrics such as profits, pricing, and costs (Leon, 2014). The framework is based on more data-intensive methods, including the Lerner Index (Lerner, 1934), the Panzar-Rosse Model (Panzar & Rosse, 1987), and the Boone Indicator (Boone, 2008). Despite the challenges associated with their complexity in calculations, the NEIO methods are highly valued in economic research for their accuracy and depth of insight (Leon, 2014). This makes them particularly effective for studying sectors like banking, where market structures

are complex, and the effects of competition are critical to understanding overall performance (Leon, 2014).

2.2. Bank Competition

The unique characteristics of banking activities, along with rigorous regulatory conditions, necessitate commercial banks to maintain a balance between stability and competitiveness. The "competition-stability" theory posits that greater competition enhances the robustness of banks (Clark et al., 2018; Shijaku, 2017). In contrast, the "competition-fragility" perspective suggests that increased competition might lead banks to engage in riskier behaviors (Khattak et al., 2022; López-Penabad et al., 2021). In addition to stability concerns, several studies have found an inverse relationship between intense bank competition and profitability, supporting the competition-fragility hypothesis (Khattak et al., 2023). Other studies suggest a strong positive link of heightened competition among banks and better profitability metrics (Zoghlami & Bouchemia, 2021).

2.3. Bank Digitalization

Digitalization has profoundly altered the financial industry, including payments, deposits, and loans (Khattak et al., 2023). Technological innovations also enhance data collection and processing, facilitate accurate consumer segmentation and targeting, and improve risk management practices, leading to increased performance and profitability (Guo & Liang, 2016). Incorporating digital solutions is an integral part of an effective diversification strategy (Lestari et al., 2023). Bank digital adoption improves efficiency by reducing and optimizing operational expenses (Carbó-Valverde, 2017). Digital finance facilitates market transparency and accelerates the processing of borrower applications, thereby enhancing lending efficiency (Gao & Wang, 2023). Consequently, adopting bank innovations leads to improved bank profits (Versal et al., 2022). Bank digitalization has also been found to affect bank competitiveness positively (Gao & Wang, 2023). Yet, some scholars have revealed that bank digitalization may provide a competitive advantage only in the early stages of its adoption. However, as technology becomes more accessible and affordable across the industry, the advantages may diminish for all competitors (Carr, 2003). Consequently, digitalization may not always lead to increased profitability, the phenomenon known as the "IT profitability paradox." Scholars have revealed that the effects of bank digital transformation may take up to several years to fully materialize (Kriebel & Debener, 2019).

3. Methodology

3.1. Estimating Competition

To estimate bank competition, the study utilizes two prominent measures - the Lerner Index and the Boone Indicator. The Lerner Index is a traditional approach for assessing bank competition and a widely used indicator of market power in banking

research (Leon, 2014). The method measures the difference between a bank's total revenues and marginal cost relative to the revenues (Lerner, 1934). As a result, the index ranges from zero, indicating a competitive market, to one, denoting a monopoly. For a specific bank *b* at time *t* the Lerner Index (LI_{bt}) is defined as:

$$LI_{bt} = \frac{P_{bt} - MC_{bt}}{P_{bt}} \quad (1)$$

where P_{bt} represents the output price approximated as total revenues (including both interest and non-interest income) divided to total assets and MC_{bt} represents marginal cost.

Next, the study utilizes the Boone Indicator, which serves as an established and robust metric for assessing competitiveness in banking. The Boone Indicator suggests that firms with higher efficiency will increase their market share, especially under more intense competitive conditions (Boone, 2008). To estimate the indicator, this research adopts marginal cost rather than average cost, as the former is typically seen as a more reliable indicator of efficiency (van Leuvensteijn et al., 2011). The Boone Indicator is estimated as:

$$ln\,\pi_{bt} = \alpha + \beta ln MC_{bt} \quad (2)$$

in this formula, π_{bt} indicates bank profitability estimated via return on assets, and β represents the Boone Indicator. As the competitive environment strengthens, the value of β tends to become more negative, indicating greater competitiveness (van Leuvensteijn et al., 2011).

To compute the above measures, it is necessary to determine the marginal cost (MC). Studies in banking use the translog cost function (TLCF) to estimate MC due to the fact that it cannot be estimated straightforwardly (Gilligan et al., 1984). TLCF aggregates costs of the key banking operations and expressed as:

$$\ln(TC_{bt}) = \beta_0 + \beta_1 \ln Q_{bt} + \frac{1}{2}\beta_2 ln Q_{bt}^2 + \sum_{k=1}^{3} \gamma_{kt} ln W_{k,bt} + \sum_{k=1}^{3} \phi_k ln Q_{bt} ln W_{k,bt} + \frac{1}{2}\sum_{k=1}^{3}\sum_{j=1}^{3} ln W_{k,bt} ln W_{j,bt} + \varepsilon_{bt} \quad (3)$$

TC_{bt} denotes total costs incurred by bank *b* at time *t*. Total costs comprise bank operational expenses (interest, fees and commissions), salaries, and other administrative and operational expenditures. Next, Q_{bt} reflects the bank's outputs, approximated by total assets. $W_{k,bt}$ signifies the prices of three key inputs: labor (personnel expenses/total assets), deposits (interest expenses/deposits), and capital (other administrative expenses/total assets).

Next, the results obtained in Equation 3 are employed to determine the marginal cost:

$$MC_{bt} = \frac{\partial TC_{bt}}{\partial Q_{bt}} = \frac{TC_{bt}}{Q_{bt}}(\beta_1 + \beta_2 lnQ_{bt} + \sum_{k=1}^{3} \phi_k lnW_{k,bt}) \quad (4)$$

3.2. Bank Digitalization

Although researchers commonly employ proxies like text screening techniques and analysis of published reports to assess bank digitalization, these approaches could be inappropriate in regions like Central Asia, where access to detailed and reliable information can be scarce. In such contexts, conventional methods may not fully capture the nuances of digital transformation due to the variability in data availability and the differing levels of technological adoption across banks.

In light of these challenges, this study has adopted a more region-specific methodology to evaluate the level of bank digitalization in Kyrgyzstan and Kazakhstan. Since bank digital services encompass banking activities, including managing deposits, processing transactions including debit and credit cards, and providing loans, which are provided digitally (Agur et al., 2020). Therefore, the study relies on primary data sourced directly from the officially published reports and financial statements of banks. The approach involves categorizing digital banking services into four main groups: i) Digital Financial Services, ii) E-wallets, iii) Electronic Facilities, and iv) Online Platforms, following the method of Versal et al. (2022). Digital Financial Services and E-wallets, the metrics included the number of issued cards and e-wallets, along with transaction volumes divided by population and GDP (Table 1). Electronic Facilities were evaluated based on the distribution of bank digital infrastructure, such as ATMs and POS terminals per 100,000 people. Online Platforms were analyzed through user engagement metrics such as the percentage of mobile application users and website visits, with additional qualitative assessments of digital interface complexity based on WebIX indicators. These indicators, derived according to Hornyák's (2017) method, evaluate both Web 1.0 technologies based on speed, complexity, and design and Web 2.0 technologies that incorporate tools for communication and feedback. As the methodological instrument for constructing the bank digitalization index, the study employs the System Dynamics Approach (Lafuente et al., 2016). At the initial stage, the parameters are standardized between zero and one:

$$x_{i,t}^{*} = \frac{x_{i,t}}{\max(x_{i,t})} \quad (5)$$

where $x_{i,j}$ denotes is parameter *i* at time *t*, and $x_{i,j}^{*}$ is the normalized parameter.

Next, the index of bank digitalization (BD_t) index is computed by summing all the metrics used in the estimation:

$$BD_t = \sum_{i} x_{i,t}^{*} \quad (6)$$

Table 1. Composition of Bank Digital Index

Parameter (*j*)	Indicator (*i*)	Indicator and Estimation
Digital financial services[1] (DFS)	Payment cards[2]	$Cards = \frac{payment\ cards}{population}$
	Card payments	$Pcards = \frac{volume\ of\ cards\ payments}{GDP}$
	Card transactions	$Tcards = \frac{card\ transactions}{population}$
E-wallets (EW)	E-wallets	$Ew = \frac{Ewallets}{population}$
	E-wallet payments	$VEw = \frac{volume\ of\ Ewallets\ payments}{GDP}$
	E-wallet transactions	$NEw = \frac{Ewallet\ transactions}{population}$
Electronic Facilities (EF)	ATMs[3]	$QATM = \frac{Quantity\ of\ ATMs}{(population * 100{,}000)}$
	POS Terminals[3]	$QPOS = \frac{POS\ terminals}{(population * 100{,}000)}$
Online Platforms[4] (OP)	Mobile Application	$APP = \frac{Application\ users}{Total\ users}$
	Website	Number of visits
		Complexity of website and server[5]

Notes: [1]According to the provided data, information about loans is unavailable; [2]Inlcuding deposit and credit cards; [3]Based on the World Bank methodology; [4]Due to the absence of historical records, these metrics were omitted from the BD index calculation; [5]According to Lányi et al. (2021)
Source: Authors' elaborations based on Versal et al. (2022) and Lafuente et al. (2016)

3.3. Bank-Specific Variables

Building on prior studies, this research utilizes return on assets (ROA) and net interest margin (NIM) as the primary metrics to assess bank performance profitability (Nguyen et al., 2023). Next, the study includes bank diversification, considering that bank digitalization is assumed to affect bank profits from non-interest sources of income (Lestari et al., 2023). The study also incorporates the size variable, estimated as the natural logarithm of total assets, acknowledging that larger banks may benefit from cost reductions through economies of scale (Tan, 2016). Additionally, given that loans are a significant component of bank assets, this study includes the ratio of loan loss provisions to total loans as a key indicator of bank stability, following the methodology outlined by Clark et al. (2018). Lastly, the growth of GDP is incorporated as the principal macroeconomic measure to account for the cross-country economic differences (Rakshit & Bardhan, 2019). Table 2 provides a summary of the variables employed in the study.

Table 2. Variables Employed in Research

Variable	Estimation	Source
Lerner Index	Equation 1	Own estimation
Boone Indicator	Equation 2	
Bank digitalization	Equation 7	
Return on Assets	$\frac{Net\ income}{Total\ Assets}$	
Net Interest Margin	$\frac{Interest\ revene - interest\ expenses}{Average\ earning\ assets}$	
Diversification	$\frac{Non - interest\ income}{Gross\ revenue}$	
Size	$\ln(Total\ Assets)$	
Loan loss provisions to total loans	$\frac{Loan\ loss\ provisions}{Total\ loans}$	
GDP growth	Yearly increase	World Bank

Source: Authors' elaborations

3.4. Regression

Given the research objectives and the small data set, using standard panel estimators would not produce dependable results. Key issues include endogeneity, serial correlation, the dynamic nature of the dependent variable, and unobserved heterogeneity in the data (Khattak et al., 2023).

Introducing a lagged dependent variable can help address autocorrelation in the dependent variable. However, this method may introduce bias if the lagged variable correlates with the error term (Akande et al., 2018). Using instrumental variables could improve estimation. However, identifying suitable variables uncorrelated with the error term is challenging (Khattak et al., 2023).

These complexities and the possibility of varying standard errors have made Dynamic Panel Data (DPD) methods increasingly favored in finance and economic research (Khattak et al., 2023). DPD techniques allow for the exploration of individual and cross-sectional dynamics. Thus, the current study adopts the two-step Generalized Method of Moments (GMM) approach, as originally proposed by Arellano & Bond (1991) and Arellano & Bover 1995).

The GMM estimator is well-suited for the structure of our research data. It addresses endogeneity through instruments derived from lagged variables and manages autocorrelation and unobserved heterogeneity (Akande et al., 2018). More efficient than traditional DPD estimators, GMM excels in models with lagged endogenous variables and individual effects (Akande et al., 2018). The advantage of GMM, especially in dynamic panel data models (like those implemented using the Arellano-Bond estimator), is that it uses lagged values of the variables as instruments. The

logic is that past values of the variables are likely not correlated with the current error term, thus satisfying one of the key requirements for a valid instrument (Roodman, 2009).

Additionally, it is advantageous when unobservable factors influence dependent and explanatory variables. This makes GMM ideal for our data structure, which requires handling dynamic relationships and individual-specific variability (Akande et al., 2018).

The regression models to estimate the effect of bank digitalization on bank competition and profitability have the following forms:

$$BC_{bt} = \alpha_0 + \alpha_1 BC_{bt-1} + \alpha_2 BD_{bt} + \alpha_3 BS_{bt} + \alpha_4 GDP_t + \varepsilon_t \quad (7)$$

$$BP_{bt} = \alpha_0 + \alpha_1 BP_{bt-1} + \alpha_2 BD_{bt} + \alpha_3 BS_{bt} + \alpha_4 GDP_t + \varepsilon_t \quad (8)$$

where BC_{bt} – bank competition, BP_{bt}– bank profitability indicators, BS_{bt} - bank-specific indicators for bank *b* at time *t* and GDP is GDP growth, BC_{bt-1}, BD_{bt-1} and BS_{bt-1} – one period lags of competition, digitalization and profitability.

3.5. Data and Summary Statistics

The data utilized in this study were derived from the financial statements of commercial banks in Kyrgyzstan and Kazakhstan, available on their official websites, covering the years 2012 to 2023. The extraction involved using character recognition software to transfer data into an Excel spreadsheet, followed by a manual verification of each data point. The sample includes 23 commercial banks from Kyrgyzstan and 20 from Kazakhstan, capturing a substantial portion of the banking industry in these countries. In total, 473 observations were collected during the study period. Descriptive statistics across both countries are displayed in Table 3.

Table 3. Descriptive Statistics

	Kyrgyzstan				Kazakhstan			
Variable	**Mean**	**St. dev.**	**Min**	**Max**	**Mean**	**St. dev.**	**Min**	**Max**
BI	0.15	0.14	0.01	0.38	0.42	0.15	0.27	0.75
LI	-0.66	0.51	-1.56	0.14	-0.16	0.41	-1.12	0.66
BD	11.67	7.25	4.42	25.29	29.33	10.52	18.73	45.32
ROA	0.02	0.02	0.01	0.06	0.02	0.01	0.01	0.03
NIM	0.11	0.01	0.10	0.14	0.21	0.21	0.09	0.79
Div.	0.29	0.07	0.22	0.45	0.31	0.04	0.26	0.37
Size	15.22	0.37	14.70	15.89	19.47	0.64	18.54	20.41
LLPTL	0.004	0.00	0.00	0.01	0.07	0.10	0.01	0.34
GDP	3.71	4.44	-7.15	10.92	3.02	2,45	-2.5	5.99

Source: Authors' computations

In Kazakhstan, the banking sector displays relatively limited competition, characterized by an average Lerner Index of 0.42 and a moderate Boone Indicator of

-0.16. Conversely, the banking sector in Kyrgyzstan exhibits a more competitive environment, as indicated by a lower average Lerner Index of 0.15 and a more negative Boone Indicator of -0.66. The mean values leaning more towards the minimums suggest a robust competition among banks of Kyrgyzstan and Kazakhstan. This structure is consistent with traits of monopolistic competition commonly observed in other similar developing countries (Akande et al., 2018; Bishnoi & Mallik, 2024).

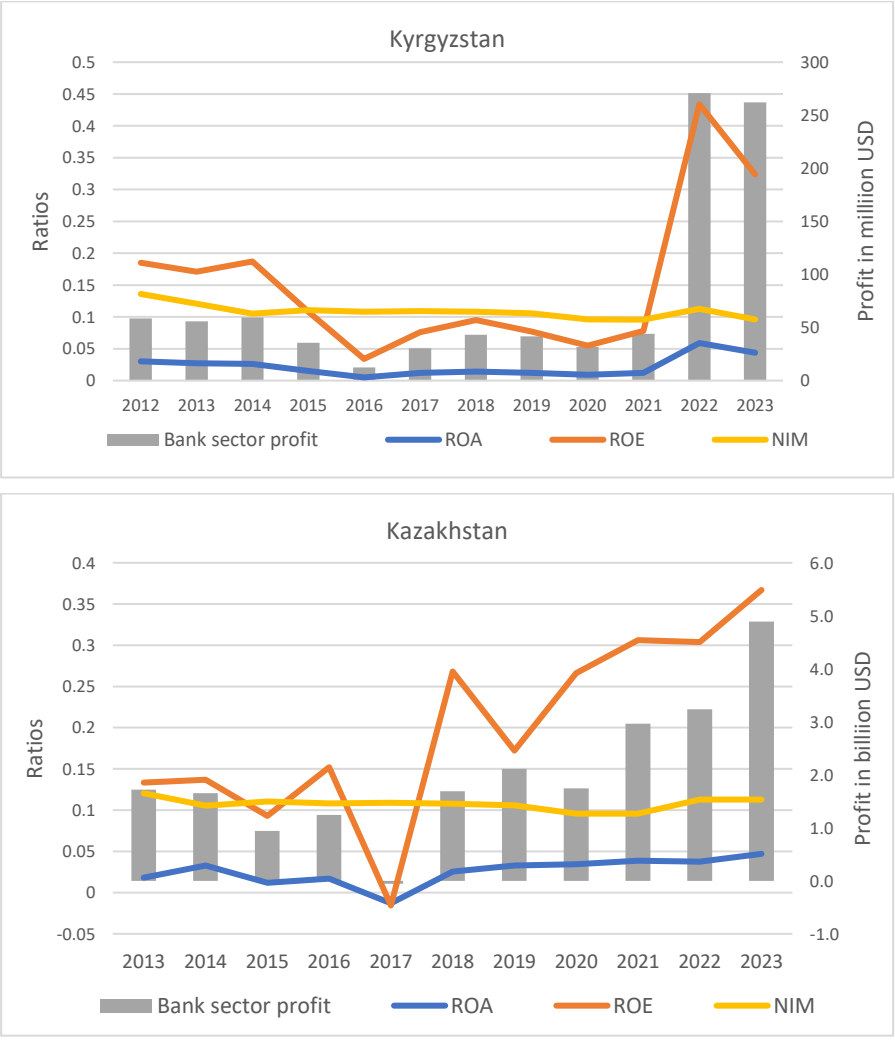

Figure 1. Bank Profitability Indicators

Source: Authors' computations

Regarding profitability, Kyrgyzstan's banking system has shown stable performance, as depicted in Figure 1, with an average return on assets of 0.02 and a net interest margin of 0.11. In contrast, Kazakhstan's banking sector leads with an average return on equity of 0.69 and a net interest margin of 0.21. However, it faced a significant net loss of 56.1 million USD (18.7 billion Tenge) in 2017, primarily due to the underperformance of the two banks. Excluding these two banks, the sector's net profit would have been 480.06 billion Tenge (1.44 billion USD), highlighting substantial concentration in Kazakhstan's banking sector. This accounts for the positive maximum Boone Indicator values observed in Table 3. Typically, the Boone Indicator suggests that banks with lower marginal costs are expected to see an increase in profits, leading to a negative β (Boone Indicator). However, the values in our study became positive, indicating unexpected competitive dynamics during these specific periods. In 2022, the banking sectors of Kyrgyzstan and Kazakhstan experienced increased profits, achieved mainly via operating income, including commissions on bank cards, cashing out, currency conversion, and bank transfers, rather than interest income, against the background overall sector development in Central Asia and Russian Ukrainian war.

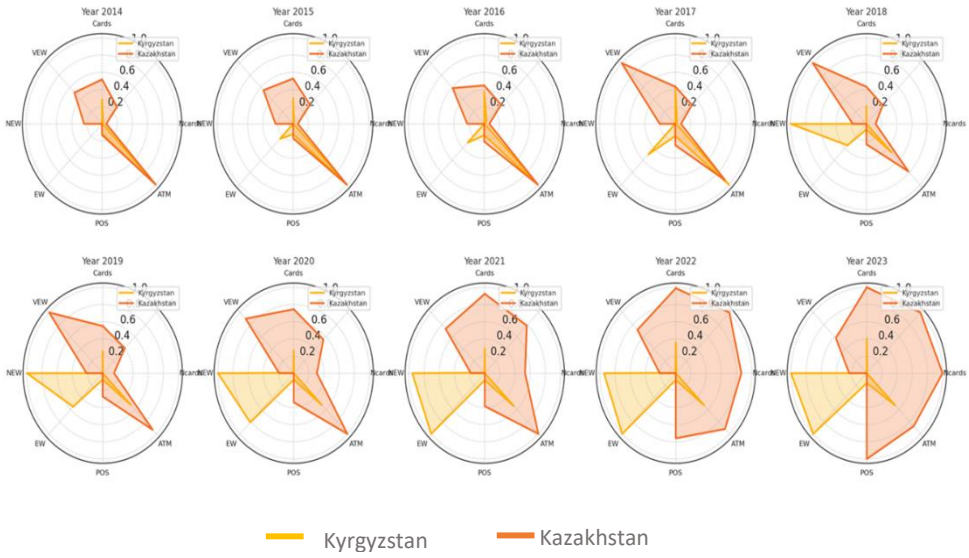

Figure 2. Bank Digitalization Index: Kyrgyzstan and Kazakhstan.

Source: Authors' computations

Kazakhstan demonstrates a higher bank digitalization level, with a mean index of 29.33, compared to Kyrgyzstan, with a mean value of 11.67. The charts presented in Figure 2 show that Kazakhstan is leading in almost all parameters except Electronic Wallets. The high adoption of Electronic Wallets in Kyrgyzstan highlights the low level of financial inclusion, especially in the regions where the penetration of banking is

low. Table 4 showcases the correlation matrix for Central Asia, indicating no multicollinearity, as all correlation coefficients remain below 0.8 (Kennedy, 2008).

Table 4. Correlation Matrix

	LI	BI	BD	ROA	NIM	Div.	Size	LLPTL	GDP
LI	1								
BI	0.03	1							
BD	-0.04	0.39***	1						
ROA	0.45***	0.04	0.02	1					
NIM	0.34*	0.24	0.38	-0.07**	1				
Div.	0.09	-0.04	-0.09	0.14*	-0.29**	1			
Size	0.35	0.38*	0.35**	-0.07	0.09	-0.11	1		
LLPTL	0.61***	0.52*	0.70*	-0.02***	0.45	0.02	0.61	1	
GDP	0.11	-0.04	0.12*	0.14*	-0.36*	0.15*	0.27	-0.20	1

Source: Authors' computations

4. Results and Analyses

This section discusses the results of GMM regressions investigating the effects of bank digitalization on bank competition and profitability. Initially, sub-sample regressions were conducted separately for Kyrgyzstan and Kazakhstan, followed by pooled regressions for joined data. Finally, the robustness tests were performed to ensure consistency and reliability.

4.1. Baseline Results

In executing the GMM regression, significant attention was dedicated to verifying the reliability of the estimates. In sub-sample regression, the Hansen J-Test for overidentifying restrictions demonstrates insignificant p-values, confirming the appropriateness of the variables and the effect of their lagged values as instruments employed in the models. Additionally, the findings from the Arellano-Bond test validate the lack of first- and second-order correlations. Finally, the significant Wald test (F-statistic) indicates an overall model fit. It shows that the variables included in the regressions provide a robust explanation of the variability in the dependent variable.

The analysis of lagged dependent variables for the Lerner Index and Boone Indicator in Kyrgyzstan and Kazakhstan reveals contrasting patterns of bank competition. In Kazakhstan, the positive lag coefficient of the Lerner Index and Boone Indicator demonstrate a persistent increase in bank market power and a decrease in bank competition. Conversely, negative but minimal lag coefficients in Kyrgyzstan suggest a slight trend toward decreasing market power and increasing competition. However, the effects are mostly unchanged, suggesting a stable competitive landscape in Kyrgyzstan's banking sector.

Table 5. GMM Regression: Bank Competition

Variables	Kyrgyzstan		Kazakhstan	
	Lerner Index	Boone Indicator	Lerner Index	Boone Indicator
Lag	-0.001*	0.003*	0.157***	0.322***
BD	-0.004***	0.011*	-0.002	0.010
Diversification	-0.001***	-0.002***	0.077***	-1.260***
Size	0.005***	-0.013***	-0.010	-0.018*
LLPTL	0.001	-0.003	0.001	2.258
GDP growth	0.011	-0.001	0.005**	-0.106***
Instruments	28	28	28	28
J-test (p-value)	0.889	0.773	0.542	0.974
AR1 (p-value)	0.7377	0.4196	0.8662	0.2301
AR2 (p-value)	0.1853	0.5419	0.2496	0.6884
Wald Test	146.46***	135.4***	696.59***	10392***

Notes: BD - bank digitalization, Size - bank size, LLPTL – loan loss provisions to total loans, J-test is the Hansen test for overidentifying restrictions of instruments, AR1 and AR2 are Arellano–Bond tests for first- and second-order serial correlations, Wald test evaluates the significance of individual coefficients in the model. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1" 1
Source: Authors' computations

The GMM analysis reveals the transformative effect of bank digitalization on bank competition in Kyrgyzstan. Specifically, a negative impact of bank digitalization on the Lerner Index suggests that bank digitalization intensifies market competition in Kyrgyzstan while diminishing the market power of individual banks. Furthermore, the analysis indicated a positive effect of bank digitalization on the Boone Indicator. This shows that bank digitalization in Kyrgyzstan leads to higher Boone Indicators, reflecting enhanced efficiency. Overall, the findings align with other research in emerging economies, indicating that digitalization increases efficiency by reducing operational costs (Verdier, 2024) and enhancing market transparency (Gao & Wang, 2023).

In contrast, the influence of bank digitalization on competition in Kazakhstan remains non-significant despite a higher level of technological integration compared to Kyrgyzstan. This observation aligns with other scientists who revealed that the competitive advantage derived from technological advancements may diminish as these technologies become more accessible and affordable to all market participants (Beccalli, 2007; Carr, 2003; Kriebel & Debener, 2019). Also, the analysis reveals that bank size, used as a control variable, is positively correlated with increased market power and decreased competition. This should signal the local governments about the negative influence of state interventions on overall bank competition.

GMM regression analyses of bank profitability metrics present a contrasting scenario between Kyrgyzstan and Kazakhstan (Table 6). Notably, lag-dependent variables indicate that banks in Kyrgyzstan exhibit persistent profitability compared to Kazakhstan.

Next, the regression shows a positive and significant influence of bank digitalization on bank profitability in Kyrgyzstan, with a coefficient of 0.0004 on ROA. The result aligns with the earlier findings in such countries as Ukraine (Versal et al., 2022), Vietnam (Nguyen et al., 2023), and China (Chao et al., 2024), which underscore the role of bank digitalization in improving profitability. However, the effect of digitalization on net interest margins is not significant. This is mainly due to the ongoing traditional practices in the loan issuance process, limiting the impact of digital advances on the net interest margins of local banks.

Table 6. GMM regression: Bank Profitability

Variables	Kyrgyzstan		Kazakhstan	
	ROA	NIM	ROA	NIM
Lag	0.0001***	0.0001	-0.0003**	-0.0005*
BD	0.0004***	0.0015	-0.0009	0.0162 .
Diversification	0.0001***	0.0001***	0.0001***	-0.0001**
Size	0.0006**	0.0044*	0.0018*	-0.0094
LLPTL	0.0001***	0.0001*	0.0001**	-0.0002
GDP growth	0.0002	0.0016	0.0011*	-0.0094*
Instruments	28	28	28	28
J-test (p-value)	0.828	0.944	0.753	0.883
AR1 (p-value)	0.9718	0.233	0.3566	0.5155
AR2 (p-value)	0.1548	0.9701	0.334	0.5413
Wald Test	1142.5***	6080***	168.66***	3362.52***

Notes: ROA - return on assets, NIM - net interest margin, BD - bank digitalization, Size - bank size, LLPTL – loan loss provisions to total loans, J-test is the Hansen test for overidentifying restrictions of instruments, AR1 and AR2 are Arellano–Bond tests for first- and second-order serial correlations, Wald test evaluates the significance of individual coefficients in the model. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1'' 1.

Source: Authors' computations

Conversely, in Kazakhstan, the influence of digitalization on ROA and NIM is insignificant. This disparity reflects differences in the digital maturity stages between the two countries, with Kazakhstan being more digitally advanced. When all market participants invest in technology, it may result in lower prices, reduced efficiencies and reduced profits (Kriebel & Debener, 2019).

4.2. Pooled regression

This section presents the consolidated results from the pooled analysis of the banking sectors in Kyrgyzstan and Kazakhstan, as outlined in Table 7. Unlike sub-sample regressions presented in Tables 5 and 6, the results of the pooled regressions exhibit less robust model diagnostics, as evidenced by the weak outcomes of the Wald tests. This indicates that the pooled models may not be reliable for making inferences about the impact of explanatory variables. Additionally, pooled regression models demonstrate relatively weaker statistical significance among the examined variables. Sub-sample regressions demonstrate more robust diagnostics; therefore, offering more accurate and detailed insights for country-specific analyses.

Table 7. Pooled regression results

Variables	Lerner Index	Boone Indicator	ROA	NIM
Lag	0.0004*	0.0001	0.0001	-0.0003
BD	0.0021**	0.0001	0.0002	0.0048
Diversification	0.0048*	-0.0066 .	0.0004*	0.0058*
Size	0.0004*	-0.0001*	0.0001**	0.0002***
LLPTL	0.0003	0.0041	0.0023	0.0003**
GDP growth	0.0016	-0.0018	0.0002	-0.0003
Lag:KG_dummy	0.0019	-0.0024	0.0002	-0.0001
BD:KG_dummy	0.0004	0,0002	0.0001**	0.0001*
Div.:KG_dummy	0.0004	0.0003	0.0001	0.0001
Size:KG_dummy	0.0008	-0.0261	0.0001	-0.0167
LLPTL:KG_dummy	0.0048	-0.0148	0.0001	-0.0094
GDP:KG_dummy	0.0010	-0.0001	0.0001	-0.0001
Instruments	*40*	*40*	*40*	*40*
J-test (p-value)	*0.954*	*0.795*	*0.7559*	*0.5213*
AR1 (p-value)	*0.973*	*0.5443*	*0.5139*	*0.1411*
AR2 (p-value)	*0.9914*	*0.01458*	*0.64*	*0.8645*
Wald Test	*0.005*	*0.684*	*0.00*	*1.7456*

Notes: *ROA* - return on assets, *NIM* - net interest margin, *BD* - bank digitalization, *Size* - bank size, *LLPTL* - loan loss provisions to total loans, *Div.* - diversification *J-test* is the Hansen test for overidentifying restrictions of instruments, *AR1* and *AR2* are Arellano–Bond tests for first- and second-order serial correlations, *Wald test* evaluates the significance of individual coefficients in the model. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1'' 1.

4.3. Robustness Tests

To verify the accuracy of the findings, several robustness tests were performed. First, the initial regression models were re-estimated using alternative bank competition and profitability measures. Furthermore, tests were performed to assess the endogeneity of baseline and alternative variables and detect any overidentification issues with the instrumental variables employed.

4.3.1. Alternative Variables

As alternative measures of bank competition, the analysis employed the Herfindahl-Hirschman Index and the Panzar-Rosse model, while return on equity replaced bank profitability, as presented in Table 8. The analysis was conducted for the data set of Kyrgyzstan and Kazakhstan combined. The findings using alternative variables confirm the baseline results. The negative and significant coefficient of bank digitalization on the Herfindahl-Hirschman Index (-0.0026) indicates that increased bank digitalization decreases bank concentration. Similarly, the positive and significant coefficient of bank digitalization on the Panzar-Rosse model (0.0061) shows that bank digitalization promotes competitive behavior in banks. Similarly, the effect of digitalization on Return on Equity (0.022) supports the findings of the baseline results, indicating that digitalization improves bank profitability.

Table 8. GMM regression using alternative variables of bank competition and profitability

Variables	Competition		Profitability
	HHI	PRM	ROE
Lag	0.0001***	0.0003*	0.002**
BD	-0.0026***	0.0061*	0.022***
Diversification	0.0002***	0.0003***	0.000***
Size	0.0107***	0.0163**	-0.017***
LLPTL	0.0003	0.0003	-0.001***
GDP growth	-0.0002	0.0216*	0,054*
Instruments	28	28	28
J-test (p-value)	0.823	0.719	0.922
AR1 (p-value)	0.018	0.043	0.016
AR2 (p-value)	0.4281	0.588	0.3202
Wald Test	4124.61***	137.98***	10680***

Notes: HHI - Herfindahl-Hirschman Index, PRM - Panzar-Rosse Model, ROE - return on equity, BD - bank digitalization, Size - bank size, LLPTL – loan loss provisions to total loans, J-test is the Hansen test for overidentifying restrictions of instruments, AR1 and AR2 are Arellano–Bond tests for first- and second-order serial correlations, Wald test evaluates the significance of individual coefficients in the model. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1'' 1. Source: Authors' computations

4.3.2. Endogeneity and Overidentification Tests

Next, the Durbin-Wu-Hausman test was performed to assess the endogeneity of variables, along with the Sargan test to check for overidentification issues among instrumental variables used in the study. The tests were facilitated by conducting alternative regressions using Ordinary Least Squares (OLS) and Two-Stage Least Squares (2SLS) methods, as outlined in Table 9.

Table 9. Alternative regressions and diagnostic tests

Variable	Competition		Profitability	
	OLS	2SLS	OLS	2SLS
Intercept	-0.455	1.141	-0.165	-0.207
BD	0.004*	0.001*	-0.001**	-0.001**
Diversification	0.852*	2.611*	0.555***	0.823***
Size	0.032	0.056	0.006*	-0.008
LLPTL	-0.485	-0.857	-0.146	-0.251
GDP growth	0.007		-0.001*	
	Statistic	p-value	Statistic	p-value
Weakness of instruments	50.403	< 2e-16***	42.103	< 2e-16***
Wu-Hausman	0.878	0.358	0.404	0.530
Sargan	0.732	0.823	0.951	0.622

Notes: OLS - Ordinary Least Squares, 2SLS - Two-Stage Least Squares methods, BD - bank digitalization, Size - bank size, LLPTL – loan loss provisions to total loans, Wu-Hausman - Durbin-Wu-Hausman test of the endogeneity of variables, Sargan - test of overidentifcation among variables. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1'' 1.
Source: Authors' computations

Overall, the low p-values of the instruments and the strong statistical values in both models suggest that the instruments used are strong and relevant. Durbin-Wu-Hausman tests resulted in insignificant values, indicating no statistical evidence of endogeneity. The Sargan statistic with insignificant p-values suggests that the overidentifying restrictions are valid, implying that the instruments are appropriate and not correlated with the error terms.

5. Conclusion and Recommendations

In conclusion, the comparative analysis of the banking sectors in Kyrgyzstan and Kazakhstan reveals distinct competitive dynamics. Although both countries display characteristics of monopolistic competition, Kazakhstan shows a lower level of competition, evidenced by a higher Lerner Index and Boone Indicator, suggesting greater market power and less competitive pressure. In contrast, Kyrgyzstan's banking system is characterized by higher competition and lower market power.

Additionally, the research utilized two-step GMM to analyze the interconnections among bank digitalization and other key variables of interest. The impact of bank digitalization on the competitive landscape is divergent between the two countries. In Kyrgyzstan, digitalization is gaining momentum by significantly enhancing banks' competition and operational efficiency. Conversely, in Kazakhstan, the impact of digitalization on competition is not significant. Considering the higher level of bank digitalization in Kazakhstan, the effect of bank digitalization tends to diminish as digitalization becomes widely adopted. Additionally, the study highlights that state interventions play significant roles in shaping market dynamics, contributing to increased market power in both countries. These insights necessitate nuanced regulatory strategies to mitigate the dominance of state-controlled banks and ensure a competitive market landscape. Policymakers are encouraged to foster competition by preventing monopolistic practices and promoting innovation and efficiency. Moreover, the evident benefits of digitalization should prompt further encouragement of digital initiatives within the banking sector.

Regarding profitability, Kyrgyzstan's banks show sustained profitability, in contrast to Kazakhstan, where the impact of digitalization on profitability is less marked. This finding confirms the presence of the "IT profitability paradox" in the region. While the technological adoption among banks in Kazakhstan is higher than in Kyrgyzstan, the widespread digitalization does not necessarily translate into increased profitability for banks. This suggests that as digital solutions become commonplace, their direct contribution to profitability may decrease, highlighting the need for banks in Kazakhstan to continuously innovate beyond current advancements to sustain unique competitive advantages and enhance financial performance. Yet, in Kyrgyzstan, bank digitalization was found to positively affect profitability, affirming the critical role of digitalization in improving financial performance and competitive positioning. Given these findings, bank managers in Kyrgyzstan should accelerate digital adoption to capitalize on favorable market conditions. Failure to do so could

leave them at a competitive disadvantage, potentially falling behind in both innovation and market share. Overall, bank managers should prioritize digitalization as a key strategic initiative. By investing in digital solutions, they can surpass less efficient rivals and expand their market share.

From the limitations of our study, it is important to highlight that the findings are based on a relatively narrow geographical scope. This may constrain the generalizability of the results to other regions or broader economic contexts. Based on this, future research should aim to expand the sample by including a wider variety of countries and providing a more comprehensive understanding of the impact of bank digitalization on various bank indicators. Also, given the dynamic nature of the banking sector and the increasing trend of bank digitization, continuous research is essential to understand the evolving impacts of digitalization, competition, and macroeconomic variables. Further studies could explore the long-term effects of these factors on banking stability and profitability.

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