Asian Academy *of* Management Journal *of* Accounting *and* Finance

AAMJAF Vol. 21, No. 1, 201–236, 2025

THE IMPACT OF FINANCIAL INNOVATION, PRODUCT INNOVATION AND INSTITUTION INNOVATION ON BANKS' FINANCIAL PERFORMANCE IN THE UAE: EVIDENCE FROM CS-ARDL

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ABSTRACT

In today's competitive market, innovation is vital for long-term bank success. This study addresses a research gap by examining how financial, product and institution innovations impact the performance of the United Arab Emirates (UAE) banks. We adopted a new quantitative index to measure financial innovation, using information technology and employee training hours as proxies for institution innovation, while product innovation is uniquely assessed by total deposits through mobile banking applications. This study examines the impact of these innovations on the financial performance of UAE banks, differentiating between high-performing and low-performing banks as well as large and small banks. Using CS-ARDL modelling to analyse the data, we found that financial innovation positively impacts the financial performance of UAE banks across all subgroups. However, financial and institution innovations have a greater impact on high-performing and large banks than on low-performing and small banks, which often struggle with limited resources and expertise. Conversely, product innovation tends to significantly boost financial performance in lower-performing and small banks. This is because high-performing banks often face difficulties with new products in saturated markets, while large banks grapple with managing complex operations and extensive asset bases. These findings imply that choosing the right types of innovation can significantly improve bank performance.

Keywords: Financial innovation, Product innovation, Institution innovation, Banks performance, UAE banks, CS-ARDL

Received: 5 May 2024; Accepted: 5 November 2024; Published: 18 June 2025

To cite this article: Alnusair, S. I. S., Masron, T. A., Saqib, A., & Ibrahim, H. (2025). The impact of financial innovation, product innovation and institution innovation on banks' financial performance in the UAE: Evidence from CS-ARDL. *Asian Academy of Management Journal of Accounting and Finance, 21*(1), 201–236. https://doi.org/10.21315/aamjaf2025.21.1.8

To link to this article: https://doi.org/10.21315/aamjaf2025.21.1.8

INTRODUCTION

The rapid advancements in information and communication technologies (ICTs) have significantly accelerated innovation in financial services, driving transformative changes in the competitive landscape and digital progression. These innovations have introduced new financial products, services and institution frameworks, fundamentally altering the way banks operate and compete. Despite extensive debates on the role and importance of innovation in banking performance, there is a notable lack of empirical studies that comprehensively examine the effects of product, financial and institution innovations on the financial performance of banks, particularly within the context of the United Arab Emirates (UAE). Moreover, existing literature often overlooks the differential impact these innovations may have on the financial performance of larger versus smaller banks, as well as on high-performing versus lower-performing banks. In addition, while the impact of financial innovation on banking performance has been widely studied, these studies often fail to consider the individual effects of specific financial innovation facets—such as ICTs, the number of branches and the automated teller machine (ATM) availability—on financial performance.

In light of this, the current study aims to investigate the impact of product, financial and institution innovations on the financial performance of 13 UAE banks, specifically distinguishing between larger and smaller banks and between high- and low-performing banks over the period of 2002 to 2022. A novel quantitative index was employed to measure financial innovation, while institution innovation was proxied by information technology usage and employee training hours. Product innovation was uniquely assessed through total deposits made via mobile banking applications. To achieve the study's objectives, we applied the cross-sectional augmented autoregressive distributed lag (CS-ARDL) model to account for cross-sectional dependence and panel heterogeneity at the bank level. This approach also allowed us to establish long-term cointegration, and to derive short-term dynamic adjustments alongside long-term estimates.

Financial performance is crucial for banks to ensure stability, growth, regulatory compliance and effective economic management (Ashiru et al., 2023). However, the rise of disruptive technologies, rapid innovation and heightened competition now pose significant challenges to banks' profitability and growth prospects. Banks face competition not only from traditional peers but also from Fintech companies and other financial service providers, all while navigating shifting customer preferences toward digital banking and stricter regulatory demands designed to enhance stability and consumer protection. To remain

competitive and sustain growth, banks must quickly embrace financial, product and institution innovations. In this context, the present study examines how these innovations affect the financial performance of the UAE banks in an increasingly dynamic environment.

Over the past two decades, UAE banks have experienced a notable decline in financial performance, as evidenced by a significant drop in return on equity (ROE) (Figure 1). In comparison, UAE banks' ROE lower than regional competitors like Saudi Arabia and Qatar, even below the Gulf Cooperation Concil (GCC) average (Figure 2). Meanwhile, other financial service providers, such as Fintech companies, have seen substantial growth. For instance, digital transactions via Al-Ansari Exchange increased by 212% in 2023, now accounting for over 14% of total remittances (Figure 3). Moreover, the transactional value of neo-banking, a Fintech company, grew from USD65 million in 2019 to USD470 million in 2023, a 7.2-fold increase (Figure 4). This contrast highlights the declining performance of traditional UAE banks alongside the rising success of other financial service providers. To address this, UAE banks can boost competitiveness, improve performance and drive future growth through innovations including financial, product and institution innovations. This study, therefore, seeks to explore the relationship between these innovations and financial performance in the UAE banking sector.

"Financial innovation", as defined by Tufano (2003), includes innovative methods of distributing financial products (e.g., securitisation, credit scoring), new ways of accounting for financial transactions (e.g., electronic financial analysis), and advanced payment techniques (e.g., ATMs, internet banking, debit/credit cards, electronic money, e-bills pay, etc.). Meanwhile, "product innovation" involves the development and introduction of new products or services specifically designed to meet the needs of external users or the market (Judijanto et al., 2024). "Institution innovation' allows organisations to thrive and adapt in an era of rapid change by delivering crisis-driven and praxis-driven innovations (AlMalki & Durugbo, 2023). These innovations aim to improve payment systems, enhance customer transactions, improve credit availability and provide new, cost-effective ways for financial institutions to raise capital.

Various studies have explored the relationship between financial innovation and bank performance. Among these studies, Tahir et al. (2018) reported a favourable relationship between financial innovation and bank performance in Pakistan. Lee et al. (2020) observed similar trends in Organization of Economic Cooperation and Development (OECD) and non-OECD countries.

Ashiru et al. (2023) found this positive relationship in Nigeria, and Abbas et al. (2024) confirmed it in South Asian Association of Regional Cooperation (SAARC) nations. Beck et al. (2016) highlighted the crucial role of financial innovation in bank growth and stability in 32 OECD countries. However, some studies present conflicting evidence. For instance, Lee et al. (2020) noted a negative effect on bank stability in emerging markets, while Naeem et al. (2023) linked financial innovation to slower economic growth. Olalere et al. (2021) also found that in Malaysia and Nigeria, financial innovation intensified the negative impact of competition on firm value. Hence, the literature supports a strong link between financial innovation and banks financial performance, however, the evidence is at times mixed and conflicting.

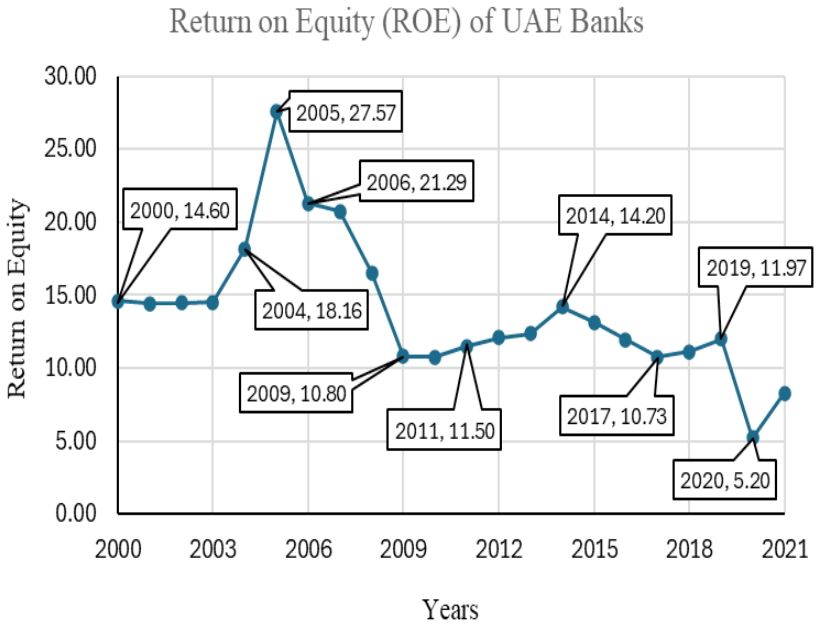

Figure 1: UAE banks' ROE (2000–2021) (Source: World Bank)

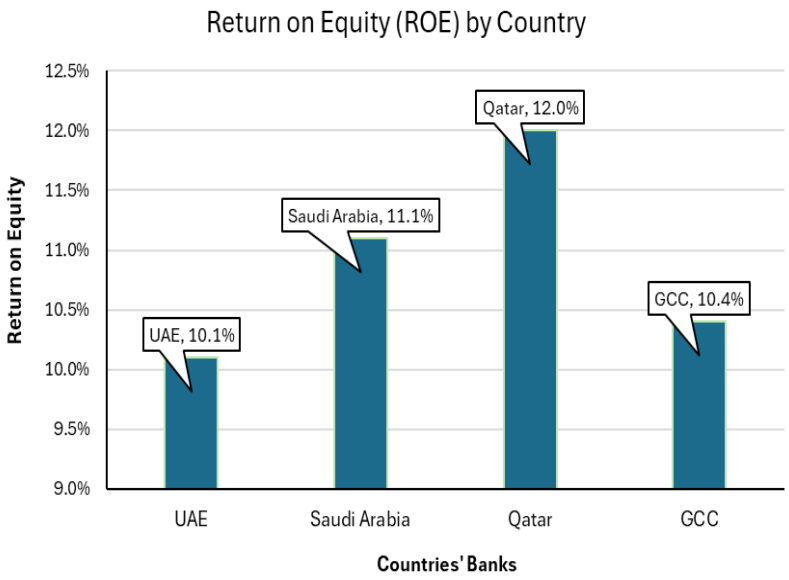

Figure 2: Regional ROE comparison in 2022 (Sources: Reuters, Company Financials, Kamco Invest Research)

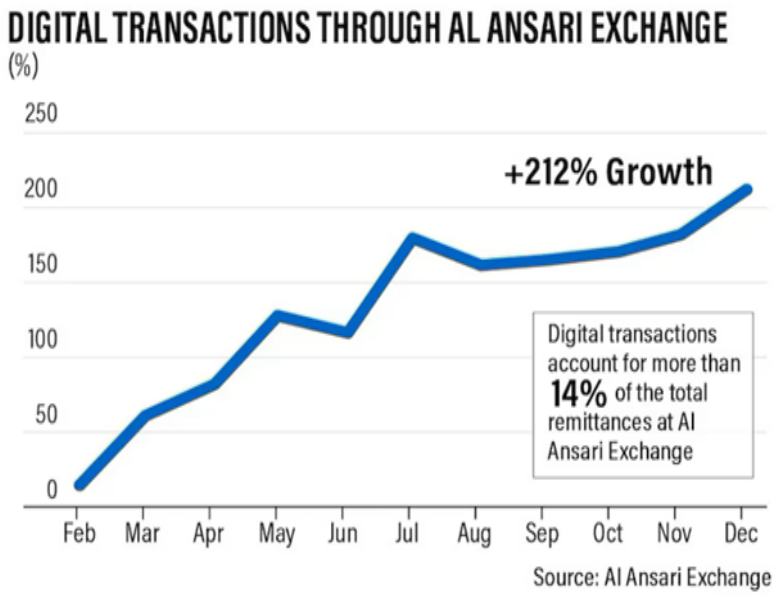

Figure 3: Digital transactions through Al-Ansari Exchange in 2023 (Source: https://alansariexchange.com/)

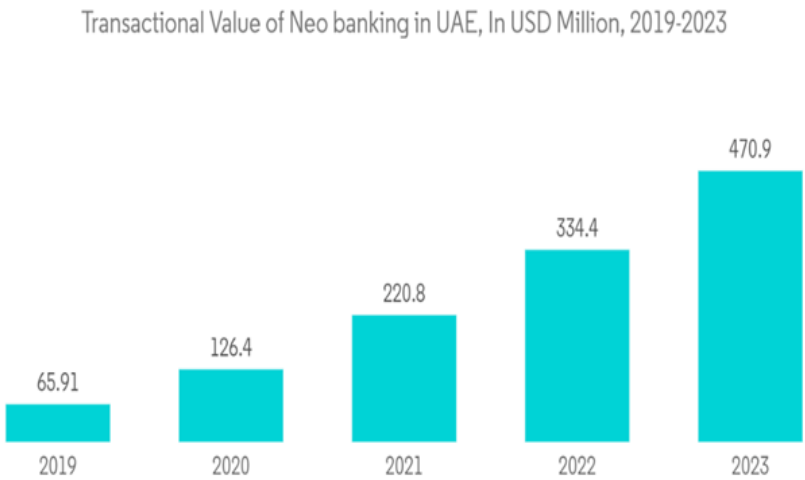

Figure 4: Transactional value of neo-banking in UAE (Million USD; 2019–2023). (Source: https://www.researchandmarkets.com/)

A few studies have explored the impact of product innovation on banks' financial performance. Asisi et al. (2023) found that product innovation significantly enhanced customer satisfaction and overall performance in Kenyan banks, emphasising the importance of continuous innovation for maintaining competitiveness and increasing market share. Enoruwa et al. (2023) also highlighted both positive and negative long-term effects of technological innovations, such as Internet and mobile banking, on bank performance in West African countries, measured by return on assets (ROA) and ROE. Similarly, Ashiru et al. (2023) demonstrated that innovations, including product innovations, significantly affected the performance of Nigerian banks. In India, Ghose and Maji (2022) found that Internet banking intensity significantly boosted the profitability of 67 commercial banks, with a stronger impact on public sector banks. However, Evian et al. (2021) reported contrasting results from Indonesia, where Internet banking had a positive impact on profitability, while mobile banking had a negative effect. Building on these findings, the current study investigates the role of product innovations in shaping the financial performance of UAE banks.

As per the institution innovation, very few studies examined its impact on banks' financial performance. For example, Lee et al. (2020) explored the link between financial innovation and bank performance, showing that institutional frameworks can significantly influence bank growth and performance. Their findings suggest that the regulatory and organisational context can either enhance or limit the benefits of financial innovations. Similarly, Mohamed and Olweny (2020)

found that institution innovation positively impacted the financial performance of Kenyan banks by improving operational efficiency and productivity. Their research emphasised the role of innovations in business structures and the creation of new financial intermediaries in driving profitability. Building on these insights, this study investigates how institution innovations influence the financial performance of UAE banks, considering the unique regulatory and market conditions in the region.

Banks vary considerably in their operations, resources and market strategies. Larger banks, with their substantial resources, often lead in innovation and risk management, while high-performing banks tend to adopt innovations more rapidly to maintain their competitive edge and drive growth. In contrast, smaller or lower-performing banks may prioritise financial stability over rapid innovation. Consequently, the impact of innovations can differ between large and small banks, as well as between high- and low-performing banks. To provide a deeper understanding, this study examines these impacts separately, offering tailored insights for different categories of banks. Specifically, it investigates how financial, product and institution innovations influence the financial performance of small versus large banks and low-performing versus high-performing banks.

Based on the above discussion, the current study makes four key contributions to the innovation-performance nexus within the banking sector. First, it comprehensively examines the impact of financial, product and institution innovations on the financial performance of UAE banks, addressing a notable gap in existing research where such multidimensional analysis has been scarce. Second, the study differentiates the effects of these innovations on large versus small banks, and high-performing versus low-performing banks, offering a more nuanced understanding of how innovations affect various banking categories. Third, it introduces a novel quantitative index for measuring financial innovation and uses unique proxies for institution and product innovations, such as information technology usage, employee training hours and mobile banking deposits, which enhances the methodological approach to studying innovation in banking. In addition, while the impact of financial innovation on banking performance has been widely studied, these studies often fail to consider the individual effects of specific financial innovation facets—such as ICT, the number of branches and ATM availability—on financial performance. Finally, by applying the CS-ARDL model, the study accounts for cross-sectional dependence and panel heterogeneity, allowing for a more accurate analysis of long-term relationships and short-term dynamic adjustments.

LITERATURE REVIEW

Schumpeter's Theory of Innovation (Brouwer, 1991) posits that innovation corrects market inefficiencies and imperfections, helping economic agents achieve desired outcomes and reduce economic volatility (Elsner, 2024). According to this theory, financial innovation enhances bank profitability by broadening the variety and quality of financial products and services available to households, consumers and investors. This includes the introduction of new financial products, services, markets and players, which improves the alignment of individual savers' needs with those of firms seeking to raise funds. Additionally, Schumpeter's theory suggests that financial innovation reduces agency costs, facilitates risk sharing, completes markets and lowers transaction costs, ultimately improving allocative efficiency and bank performance (Martins, 2024).

The impact of financial innovation on banks of varying sizes and operational efficiencies. Small banks benefit from their agility and ability to exploit niche opportunities, while large banks leverage their substantial resources for significant advancements. Efficient banks enhance their competitive edge through innovation, whereas less efficient banks risk being outcompeted. Innovation drives competition, shapes market dynamics, improves risk management and fosters long-term growth, emphasising its crucial role in the success and sustainability of the banking sector. Recent developments in Fintech, including financial, product and institution innovations, align with this theory by advancing digital payment systems, expediting the exchange of goods and services, and expanding the range of savings and lending products, leading to improved bank performance (Bobbo et al., 2024).

After the global financial crisis, the innovation–fragility perspective highlighted that financial innovations by reducing asymmetric information can lead to greater risk-taking because these innovations lower the costs associated with financial instability (Sun et al., 2024). Therefore, the new services provided by Fintech start-ups may either complement the traditional services offered by established banks to enhance their performance or replace them if they fulfill the same customer needs, potentially posing a threat to the performance of incumbent banks (Puschmann & Halimi, 2024). The COVID-19 pandemic initiated a new phase in the adoption of Fintech innovations as banks seized new opportunities from the surge in digital financial services (Muslim, 2024).

Despite this growing interest in the impact of financial innovation on bank performance, In particular, there remains a lack of literature that examines this topic using micro-level data especially in the UAE. Dwivedi et al. (2021) and Khalaf et al. (2023) used surveys and interviews in their papers. Lozano-Vivas

and Pasiouras (2014) and Beck et al. (2016) utilised R&D and off-balance sheet as a proxy to measure financial innovation; they conclude that financial innovation boosts the bank performance in terms of productivity and effeciancy. Ky et al. (2019) found a positive and significant relationship between mobile money and bank performance. Echchabi et al. (2021) found a positive relationship between Fintech companies and bank performance. Alkhazaleh and Haddad (2021) found that Fintech services have a significant and positive impact on customer satisfaction and bank revenue. Deng et al. (2021) found a significant negative relationship between Fintech and the level of bank risk-taking.

Furthermore, Almashhadani and Almashhadani (2022) found a positive and significant relationship between Fintech and the performance of foreign UAE banks. Mirza et al. (2023) found a positive relationship between Fintech implementation and the profitability of eurozone commercial banks. Yao and Song (2023) found a positive and significant relationship between Fintech and Chinese banks performance. Bousrih (2023) indicated that the use of cashless payments is statistically significant and positively related to the bank performance. Yudaruddin (2023) concludes that Fintech firms positively and significantly affect Islamic banks' performance, while Fung et al. (2020) found no distinct effects of innovation on bank performance. Fernando and Dharmastuti's (2021) study found that mobile payment had no significant relationship with performance. However, Bousrih (2023) found that the impact of mobile subscriptions used in mobile transactions negatively impacts the performance of banks.

Moreover, McNulty (2001) and Mercieca et al. (2007) explored the unique characteristics and performance of small banks. Terraza (2015) finds that bank capital boosts profitability, but the impact of liquidity ratios varies by bank size, highlighting significant differences in behaviour among banks of different sizes. Small regional banks excel in leveraging local market knowledge to serve small businesses, while large banks use their scale to offer a diverse range of financial products, enhancing their performance (Calenda, 2023). The impact of Fintech varies with bank size, with larger banks being more sensitive to Fintech developments compared to small and medium-sized banks (Ochenge, 2023). Technological innovations such as ATMs, point-of-sale (POS) systems, internet banking and mobile banking have been shown to enhance the performance of both large and small financial institutions (Enoruwa et al., 2023). Furthermore, banks that exhibit high levels of operational efficiency are better equipped to mitigate associated risks (Zouari-Hadiji, 2023), whereas those with poor risk management may face more significant challenges. Financial innovation affects banks differently based on size and performance (Gržeta et al., 2023). Based on previous literature, this article aims to analyse the link between financial, product and institution innovation and bank performance.

DATA AND METHODOLOGY

The following model specifies the influence of financial, product and institution innovations on the performance of UAE banks:

$$\ln ROE_{it} = \beta_0 + \beta_1 \ln FIN_{it} + \beta_2 \ln PIN_{it} + \beta_3 \ln INS_{it} + \beta_4 \ln AST_{it} + \varepsilon_{it} \quad (1)$$

We outline the basic model specification in Equation (1), where ln denotes the natural logarithm and β_0 represents the constant term, β_1–β_4 represent the coefficients, i depicts cross-sections (banks) at time t (years), and ε is the error term. The dependent variable, return on equity (ROE), is used to capture banks' financial performance. According to Kosmidou et al. (2005), ROE is a reliable indicator of future earnings and is most relevant to the primary equity capital providers. Given that the assets of UAE banks increased to AED3,873.1 billion in the first quarter of 2023 (KAMCO Invest, 2023), it is appropriate to study bank ROE. The independent variables for UAE banks include financial innovation (FIN), product innovation (PIN) and institution innovation (INS). Next, we controlled the size of the banks by taking the natural logarithm of banks' total assets, denoted by AST.

To estimate the impact of financial, product and institution innovations on financial performance, we included key variables alongside the financial innovation indicators. Moreover, our model estimates both short- and long-run effects within a single error correction framework and incorporates cross-sectional averages to account for cross-sectional dependency. However, including a large number of regressors and cross-sectional averages in a single error correction model can reduce degrees of freedom and potentially bias estimates (Saqib et al., 2023), particularly given our relatively small sample size (2002–2022). Therefore, to maintain efficient estimations and ensure efficient coefficient estimates, we opted to include only one control variable—bank size—in our model.

Previous research by Abdurrahman et al. (2024) indicates that increased innovation improves bank performance, leading us to expect a positive and significant relationship between ROE and financial innovation, product innovation and institution innovation. The study considers the lag values of dependent and independent variables, following Gujarati (2021). Innovations typically take time to impact business performance due to factors such as significant delays and capital expenses (Griliches, 1998). Investments in financial innovation often involve substantial costs and require time for recovery. Additionally, network externalities affect the implementation of electronic payments, leading to their initial development and rapid expansion (Shapiro & Varian, 1999).

Estimation procedure

Cross-sectional dependency (CSD) in banks refers to the interconnectedness of banks' financial conditions and performance within financial systems, where the actions of one bank can influence others. For example, the financial health of a large bank may affect smaller banks through lending, borrowing and other economic relationships. Common factors such as interest rate changes, regulatory adjustments and macroeconomic events create dependencies between banks' financial performance and other indicators. Market integration exposes banks to similar conditions, leading to correlated financial returns and risk exposures. Moreover, changes in central bank policies within the same regulatory jurisdiction can result in CSD (Wymeersch, 2021).

To assess CSD, the methodology proposed by Pesaran (2015) is commonly employed. This approach helps to address the presence of cross-sectional correlation, which may otherwise introduce biased coefficient standard errors. By using this methodology, the study aims to obtain more accurate and robust estimates of the relationships between the variables under consideration.

Equation (2) denotes Pesaran's CSD test:

$$CSD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{j=i+1}^{N}\gamma_{ji}\right)} \tag{2}$$

where cross-sectional units (N), time (T), *i* and *j* represent error correlation among the sample banks.

Stationarity testing

Most microeconomic data suffer from non-stationarity issues. To confirm the stationarity of variables, we employed the Panel Unit Root Test (CIPS), which is a crucial step before conducting cointegration and error correction modelling. The second-generation CIPS test, developed by Pesaran (2007), is known for its robustness in handling structural breaks, cross-sectional dependency and slope heterogeneity. This ensures more reliable and accurate results in the subsequent analysis.

$$\Delta y_{i,t} = a_i + \rho y_{i,t} - 1 + \sum_{J=1}^{pi} a_J \Delta y_{i,t-J} + \varepsilon_{i,t} \tag{3}$$

Cointegration test

The next step involves conducting cointegration tests to explore the relationship between financial innovations and the performance of UAE banks. Given the long panel in this study (T > N), panel cointegration tests are employed. Specifically, we use Pedroni's (2004) test, which is known for its effectiveness in long panels (Neal, 2014). Pedroni's test serves as the primary cointegration test in this investigation, providing a comprehensive assessment.

Pedroni's test evaluates the null hypothesis of "no cointegration" and uses a decision rule to reject it if the *p*-value is below 0.05. The test comprises three statistics that accommodate panel diversity, including short-term dynamics and long-term slope and intercept coefficients. Our results indicate rejection of the null hypothesis of "no cointegration" at a 5% significance level across all models, confirming the presence of cointegration relationships.

Cross-sectional Augmented Autoregressive Distributed Lag (CS-ARDL)

The present study employs the CS-ARDL model, initially developed by Pesaran and Smith (1995) and subsequently refined by Chudik and Pesaran (2015). By leveraging this advanced econometric approach, our analysis critically assesses the extent and nature of financial innovation's impact on bank performance. This study aligns with methodologies utilised in recent research, including JinRu et al. (2022), Jian and Afshan (2023), and Mir et al. (2024).

The CS-ARDL model is employed to analyse the impact of various factors, including financial, product and institution innovations, as well as bank size, on bank performance in both the short- and long-run. The use of the CS-ARDL model in our study is justified due to several key econometric challenges that it effectively addresses, making it superior to traditional regression methods for panel data. First, financial market integration and exposure to common stocks, such as changes in interest rates, can lead to cross-sectional dependency (CD) among banks, resulting in residual interdependence and potential omitted variable bias (Chan et al., 2024) and inefficient estimation (Zhao et al., 2022). To confirm the presence of CD, we employed Pesaran's (2015) CD test and observed cross-sectional interdependence in our sample banks. Second, in a panel setting, the impact of innovations may vary across individual banks, a phenomenon known as slope heterogeneity (SH). The case of not considering SH can lead to unreliable coefficients (Li et al., 2022). Therefore, we utilised Pesaran and Yamagata (2008) test and observed slope heterogeneity in our models. Given the issues of CD and

SH, the CS-ARDL model by Chudik and Pesaran (2015) is particularly suitable for our study, as it accommodates these issues and efficiently estimates both long-run effects and short-run adjustments, providing robust results.

The CS-ARDL model offers flexibility in integrating variables and addressing sample size limitations (T = 20; N = 13) (Ghatak & Siddiki, 2001). This method is particularly relevant when T > N (Erülgen et al., 2020) and accommodates variables integrated at different orders, effectively overcoming issues such as serial correlation, slope heterogeneity and endogeneity (Chudik & Pesaran, 2015). By employing the CS-ARDL method, detailed in Equation (5), we ensure a comprehensive modeling approach.

$$Y_{i,t} = \sum_{i=0}^{pu} \delta_{i,t} X_{i,t-1} + \sum_{i=0}^{pv} \varphi_{i,t} X_{i,t-1} + \dot{o}_{i,t} \tag{4}$$

$$Y_{i,t} = \sum_{i=0}^{pu} \delta_{i,t} X_{i,t-1} + \sum_{i=0}^{pv} \varphi_{i,t} X_{i,t-1} + \sum_{i=0}^{pw} \beta_i \overline{X}_{t-1} + \dot{o}_{i,t} \tag{5}$$

Next, we extend Equation (4) to Equation (5) by including the cross-section averages of the dependent and independent variables. Where the symbol is the dependent variable depicting ROE of bank *i* at time *t*. The parameter $X_{i,t-1}$ denotes all the regressors FIN, PIN, INS and AST. Moreover, $\overline{X}_{t-1}$ shows cross-sectional averages of all variables to alleviate the CSD problem due to the common spillover effect. Lastly, the titles *Pu*, *Pv* and *Pw* illustrate the lagged effects of each of the variables. Now we present the mean group estimator and the long-run effects with the help of Equation (6) and Equation (7), respectively.

$$\tilde{\mathrm{V}}CD - ARDL_i = \frac{\sum_{i=0}^{pv} \widehat{\gamma_{li}}}{1 = \sum_{i=0}} \widehat{\jmath\mathfrak{u}}_{l,t} \tag{6}$$

$$\bar{\hat{\mathrm{V}}}_{MG} = \frac{1}{N} \sum_{i=1}^{N} \hat{\mathrm{V}}_i \tag{7}$$

In the current study, the short-term coefficients are estimated as follows:

$$\Delta Y_{it} = \delta_i \left[Y_{i,t-1} - \omega_i X_{i,t-1} \right] - \sum_{i=0}^{Pu-1} \delta_{i,t} \Delta_i Y_{i,t-1} + \sum_{i=0}^{Pv} \rho_{i,t} \Delta_i X_{i,t-1} + \sum_{i=0}^{Pw} \alpha_i \overline{X}_t + \varepsilon_{i,t} \tag{8}$$

where in the above equation: $\Delta_i = t - (t-1)$

$$\tilde{\mathrm{V}} = -(1 - \sum_{i=0}^{Pu-1} \widehat{\jmath\mathfrak{u}}_{i,t}) \tag{9}$$

$$\tilde{\mathrm{V}}_i = \frac{\sum_{i=0}^{pv} \acute{\rho}_{i,t}}{\check{\iota}} \tag{10}$$

$$\bar{\tilde{\mathrm{V}}}_{MG} = \frac{1}{N}\sum_{i=1}^{N} \tilde{\mathrm{V}}_i \tag{11}$$

We will use a bound cointegration test to determine whether financial innovation and bank performance in the UAE have a long-term cointegration relationship. Bound cointegration relies on either the null hypothesis of no cointegration or the alternative hypothesis of cointegration.

Table 1
Variables' definition and data sources

Variables	Measurement	Data source
Bank performance	Return on equity.	S&P Global IQ.
Financial innovation (FIN)	Input ratios represent the acquisition of capital goods that are connected to activities relevant to innovation (ATM, ICT, Cards, Branches, Patent).	Bank audited financial statements, downloaded from each bank website.
Product innovation (PIN)	Value of deposit through mobile banking applications.	Bank audited financial statements, downloaded from each bank website.
Institution innovation (INS)	Informational technology and the number of employee training hours.	Bank audited financial statements, downloaded from each bank website.
Bank size (AST)	Log of bank total assets.	S&P Global IQ.

Source: Author creation.

Table 1 shows variables definitions and data sources. The data spans from 2002 to 2022. The study includes 13 banks: Abu Dhabi Commercial Bank (ADCB), Bank of Sharjah (BOS), First Abu Dhabi Bank (FAB), National Bank of Fujairah (NBF), Sharjah Islamic Bank (SIB), Abu Dhabi Islamic Bank (ADIB), National Bank of Ras Al Khaimah (RAKBANK), Ajman Bank (AJBNK), Umm Al Quwain Bank (NBQ), Emirates NBD Bank (ENBD), Dubai Islamic Bank (DISB), Emirates Islamic Bank (EIB) and Commercial Bank of Dubai (CBD). These banks were selected based on their consistent financial performance improvement, ensuring readily available data. Then, the sample was split into four sub-groups: high-performance banks (ROE), low-performance banks (ROE), large banks (Asset) and small banks (Asset).

$$FIN\ index = \sum_{it} \frac{\ln ATM + \ln CA + \ln PA + \ln BR + \ln ICT}{5} \tag{12}$$

where InATM is the number of ATMs used by bank customers to access various banking services, such as cash withdrawals, deposits and statement printing. This variable is o ften seen as a measure of a bank's commitment to technological advancement (Ditta & Saputra, 2020).

InCA refers to the number of bank cards (**CA**) issued and the variety of card classes. This variable captures the exclusivity experienced by customers, who receive unique cards based on their credit status classifications. Enhanced customer inclination towards the bank due to these exclusive cards leads to increased card usage frequency. The bank charges fees proportional to the customers' card usage (Saroy et al., 2023).

lnPA refers to the number of financial patents (PA) which indicates the level of investment a bank makes in acquiring patents. The aim is to safeguard the bank's costly and innovative products from being replicated by competitors. A higher patent score reflects a greater investment in financial innovation (Liu, 2022).

LnBR refers to the number of bank branches (BR) significantly affects customer access, leading to enhanced satisfaction and reduced branch congestion. Increased branch reach facilitates quicker service delivery, resulting in improved customer satisfaction and lower operational costs for the bank (Garg & Gupta, 2023).

ICT assesses the technological sophistication of the bank through its ICT infrastructure, encompassing desktops, laptops, servers and other components. It is anticipated that increased banking innovation will positively correlate with higher levels of ICT infrastructure (Issak & Odollo, 2023).

The current study first created a composite index of financial innovation and then examined the impact of individual financial innovation indicators on the financial performance of banks. To construct the composite index, a simple weighted average was applied, combining data from ATM, ICT, card, patent and branches. This approach was chosen to capture the multifaceted nature of financial innovation, which includes technological adoption, intellectual property and physical infrastructure. Specifically, ATMs, ICT and card were used to represent technological adoption, patents to reflect intellectual property and branches to account for physical infrastructure. The composite index allows for a more comprehensive and balanced assessment of financial innovation by incorporating these diverse dimensions rather than overemphasising any single aspect. For instance, while ATMs and cards highlight customer-facing innovations, patents capture the institutional aspect of financial innovation, and branches represent physical banking infrastructure expansion. Thus, our financial innovation index offers a holistic view of the banking sector's financial innovation activities.

EMPIRICAL RESULTS AND DISCUSSION

Summary Statistics and Correlation Analysis

Table 2 shows the descriptive statistics. These statistics were computed to ensure the consistency and reliability of the data. The analysis of financial performance indicators, particularly return on equity, reveals positive trends among UAE banks over the observed periods. The average ROE was 3.504%, with minimum and maximum returns of 1.401% and 4.147%, respectively. On average, the financial innovation index within these banks was 3.505%, with the minimum and maximum values being 2.358% and 4.674%, respectively. The financial innovation index showed the highest value in ICT at 14.801%, while the lowest value was recorded for bank branches at 1.098%.

When comparing different types of innovation, product and institution innovations showed higher average returns than the financial innovation index, recording 10.287% and 9.012% on average, respectively. For product and institutional innovation, the minimum recorded values were AED0.832 and AED6.217, respectively, while the maximum values were AED13.543 and AED10.983, respectively. The results suggest that UAE banks are increasingly embracing innovation, leading to improved financial performance driven by these financial innovations.

Table 2
Descriptive statistics (N = 294)

Variable	Mean	S.D.	Minimum	Maximum
ROE	3.504	0.379	1.401	4.147
FIN	3.505	0.413	2.358	4.674
ATM	5.204	1.022	2.639	6.831
CA	8.682	1.453	5.525	11.988
ICT	13.268	0.647	11.734	14.801
BR	2.316	0.896	1.098	4.983
PT	7.723	0.625	3.098	9.667
PIN	10.287	1.505	0.832	13.543
INS	9.012	0.737	6.217	10.983
AST	10.719	1.328	7.564	13.919

The study also conducted correlation analysis to identify the issue of potential multicollinearity. Table 3 presents the results of the correlation analysis, which is conducted to examine the relationships among the variables and to identify any

potential issues of multicollinearity. We observed no such case of multicollinearity as our correlated coefficients are well below the Gujarati and Porter (2009) threshold value of 0.8. They argued that a correlation coefficient of 0.8 is the threshold at which multicollinearity can become detrimental to regression analysis, potentially undermining the reliability and validity of the model. The correlation analysis in this study reveals that the regressors exhibit low-to-moderate levels of correlation, indicating the absence of multicollinearity.

Table 3
Correlation analysis

Variable	ROE	FIN	ATM	CA	ICT	BR	PT	PIN	INS	AST
ROE	1									
FIN	–0.017	1								
ATM	0.049	0.119	1							
CA	–0.010	0.413	0.328	1						
ICT	0.102	0.188	0.468	0.456	1					
BR	0.103	0.000	0.324	0.227	0.322	1				
PT	0.132	–0.167	0.282	–0.051	0.173	0.315	1			
PIN	0.170	–0.541	0.346	0.166	0.332	0.431	0.355	1		
INS	0.164	–0.252	0.312	0.117	0.270	0.344	0.727	0.483	1	
AST	0.089	–0.755	0.392	0.082	0.305	0.403	0.450	0.701	0.574	1

Pre-estimation Diagnostics

Next, we assessed cross-sectional dependence using Pesaran's (2015) CSD test, as shown in Table 4. While the financial innovation variable (FIN) rejects the null hypothesis of cross-sectional heterogeneity at the 10% significance level, all other variables are highly significant at the 1% level. This suggests that shocks affecting one UAE bank tend to spill over to others, likely due to the interconnectedness of the financial system and the regulatory oversight by the UAE Central Bank (UAECB) impacting all operating banks in the country.

Table 4
Pesaran's (2015) CSD test

Variable	CSD	*p*-value
ROE	2.723	(0.000)***
FIN	2.010	(0.045)**
ATM	37.121	(0.000)***

(*Continued on next page*)

Table 4 (*Continued*)

Variable	CSD	*p*-value
CA	36.908	(0.000)***
ICT	43.521	(0.000)***
BR	35.182	(0.000)***
PT	9.115	(0.000)***
PIN	13.081	(0.000)***
INS	16.880	(0.000)***
AST	7.522	(0.000)***

Notes: ** and *** are significant at 5% and 1%, respectively. *p*-values are presented in parentheses. H0: Cross-sectional independence.

Given the presence of cross-sectional dependence in the data, we performed second-generation CIPS tests to address issues inherent in panel data. Specifically, we utilised the CIPS tests developed by Pesaran (2007). The results presented in Table 5 show that all variables are non-stationary at the level, as indicated by the CIPS test outcomes.

Table 5
Panel unit root tests (CIPS)

Variables	Level		1st difference		Order
	C	C&T	C	C&T	
ROE	1.191 (0.883)	–1.551 (0.060)*	–3.782 (0.000)***	–4.800 (0.000)***	I (1)
FIN	–0.648 (0.258)	–0.880 (0.189)	–2.846 (0.000)***	–3.851 (0.000)***	I (1)
ATM	0.786 (0.784)	1.629 (0.948)	–8.869 (0.000)***	–3.793 (0.000)***	I (1)
CA	0.911(0.819)	1.899 (0.971)	–8.640 (0.000)***	–5.170 (0.000)***	I (1)
ICT	1.023 (0.847)	0.982 (0.837)	–9.478 (0.000)***	–8.941(0.000)***	I (1)
BR	0.019 (0.508)	–0.462 (0.322)	–9.287 (0.000)***	–8.004 (0.000)***	I (1)
PT	–0.076 (0.470)	–0.617 (0.269)	–9.595 (0.000)***	–7.854 (0.000)***	I (1)
PIN	2.108 (0.796)	–0.659 (0.255)	–4.053 (0.000)***	–4.164 (0.000)***	I (1)
INS	0.433 (0.667)	–0.376 (0.354)	–8.254 (0.000)***	–6.840 (0.000)***	I (1)
AST	1.040 (0.851)	0.523 (0.700)	–4.214 (0.000)***	–3.375 (0.000)***	I (1)

Notes: *, ** and *** are significance at 10%, 5% and 1%, respectively. *p*-values are presented in parentheses. C = with constant; C&T = with trend and I(1) shows the first difference stationarity.

We now aim to establish the cointegrating relationships among the variables under study. To address this, we applied Pedroni's (2004), Kao (1999) and Westerlund (2008) cointegration tests. The results, presented in Table 6, strongly support the alternative hypothesis, indicating a stable and long-term cointegrating relationship among the variables included in the model.

Table 6
Panel cointegration tests

Tests	Statistic	*p*-value
Pedroni's (2004)		
Modified Phillips–Perron test	1.031	(0.053)**
Phillips–Perron test	–7.150	(0.000)***
Augmented Dickey–Fuller test	–9.842	(0.000)***
Kao (1999)		
Modified Dickey–Fuller test	–3.183	(0.000)***
Dickey–Fuller test	–13.932	(0.000)***
Augmented Dickey–Fuller test	–2.774	(0.051)**
Unadjusted modified Dickey–Fuller test	–16.091	(0.000)***
Unadjusted Dickey–Fuller test	–20.305	(0.000)***
Westerlund (2008)		
Gt	–2.257	(0.000)***
Ga	–8.598	(0.943)
Pt	–17.531	(0.000)***
Pa	–11.483	(0.042) **

Notes: ** and *** are significance at 5% and 1%, respectively. *p*-values are presented in parentheses. Gt = Group-t statistic, Ga = Group-α statistic, Pt = Panel-t statistic, Pa = Panel-α statistic.

To this end, we assessed cross-sectional dependence, evaluated the unit root properties and established long-term cointegration relationships. Now, we can safely proceed with the estimation using the CS-ARDL model.

Findings from CS-ARDL Model

This section explores the short-run impacts of innovations, followed by the long-run effects on the financial performance of all UAE banks, and the third subsection examines the long-run impacts on large versus small and high- versus low-performing banks.

Short-run impacts of financial, product and institution innovations on financial performance

Table 7 presents the results from error correction model (ECM). The results show that, in the short run, financial innovation indicators, excluding cards, positively and significantly impact banks' financial performance. Similarly, ΔINS has a positive effect, while ΔPIN consistently shows a negative impact.

Overall, financial and institution innovations generally enhance bank performance, while product innovation tends to reduce banks' financial performance in the UAE. The coefficient estimates of ECM_{t-1} are consistently negative and significant across all models, indicating a strong adjustment speed towards long-term equilibrium. On average, the models take about two years to achieve equilibrium.

Table 7
ECM (DV: ROE)

Variable	ATM	CA	ICT	BR	PA
Constant	2.351 (0.000)***	2.299 (0.000)***	2.224 (0.000)***	2.117 (0.000)***	2.132 (0.000)***
ΔFIN	0.108 (0.514)	–0.720 (0.031)**	0.144 (0.058)*	0.501 (0.052)**	0.814 (0.021)**
ΔPIN	–0.041 (0.401)	–0.118 (0.026)**	–0.207 (0.041)**	–0.078 (0.056)**	–0.079 (0.053)**
ΔINS	0.610 (0.056)**	0.072 (0.369)	0.531 (0.000)***	0.078 (0.319)	–0.326 (0.056)**
ΔAST	0.506 (0.057)**	0.054 (0.474)	0.072 (0.373)	0.082 (0.263)	0.120 (0.059)*
ECM_{t-1}	–0.562 (0.000)***	–0.543 (0.000)***	–0.549 (0.000)***	–0.535 (0.000)***	–0.505 (0.000)***

Notes: *, ** and *** are significant at 10%, 5% and 1%, respectively. *p*-values are presented in parentheses.

Table 8 shows the long-run dynamics. The long-run estimation results illustrate that the financial innovation as well as bank size has a highly significant negative impact on bank performance, suggesting that increased financial innovation relates with lower financial performance. Schumpeter's Theory of Innovation suggests that increased financial innovation can decrease bank performance if innovations fail to gain market acceptance or are poorly timed, leading to regulatory backlash, inefficiencies or increased costs. This can result in diminishing returns and a negative impact on performance, as not all innovations are beneficial, and the destructive aspect of innovation can outweigh its creative potential (Ülgen, 2015).

Table 8
Long-run estimates dynamics (DV: ROE)

	FIN	ATM	CA	ICT	BR	PA
FIN	–0.221	0.044	0.200	–0.007	0.550	0.063
	(0.000)***	(0.026)**	(0.000)***	(0.757)	(0.011)**	(0.000)***
PIN	0.082	0.052	–0.113	0.180	0.177	0.054
	(0.018)**	(0.002)***	(0.014)*	(0.026)**	(0.036)**	(0.018)*
INS	0.072	–0.015	0.220	0.201	0.007	0.032
	(0.021)**	(0.405)	(0.013)*	(0.018)**	(0.779)	(0.186)
AST	–0.197	0.029	–0.139	–0.065	–0.064	0.105
	(0.000)***	(0.059)**	(0.015)*	(0.000)***	(0.058)**	(0.001)***

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Numbers in parentheses represent *p*-values.

Moreover, Transaction Cost Theory suggests that as organisations grow larger, they may face increasing internal transaction costs, such as bureaucratic inefficiencies and coordination challenges. These rising costs can outweigh the benefits of economies of scale, leading to a decline in overall performance. In large banks, the complexity and cost of managing extensive operations could reduce efficiency and negatively impact profitability.

Conversely, both product innovation and institution innovation have significant positive effects, indicating that enhancements in these areas improve performance. The positive impact of product and institution innovation on bank performance supports Schumpeter's Theory of Innovation, which emphasises that innovation drives competitive advantage and economic progress. By embracing innovation, banks enhance their performance and contribute to economic growth. Moreover, Model-specific findings further highlight that in the ATM model, FIN, AST and PIN positively and significantly impact bank performance, with FIN significant at the 5% level and AST and PIN at the 1% level, the Transaction Cost Theory supports the positive impact of bank size on performance by emphasising that banks reduce transaction costs.

While the other variables show significant relationships, INS demonstrates a negative and insignificant effect. According to Schumpeter's Theory of Innovation, institution innovations may fail to address market needs effectively or introduce complexities that outweigh their benefits, reflecting the risks and

uncertainties inherent in the innovation process. The cards model shows that card innovation positively affects the overall FIN index and INS, with significance at the 1% and 10% levels, respectively. However, PIN and AST have significant negative effects on ROE at the 1% level. The ICT model finds that PIN and INS have significant positive effects on ROE at the 5% level, whereas the overall FIN index is negative and insignificant, and AST has a significant negative coefficient. In the branch model, FIN and PIN have significant positive effects on performance at the 5% level, while AST is significantly negative at the same level, and INS is positive but insignificant. Finally, the patent model shows that FIN and AST have positive and significant coefficients at the 1% level, PIN has a significant positive effect at the 10% level, and INS has a positive but insignificant effect.

The overall negative effect of the financial innovation index, despite the positive contributions of individual components like ATM, PA, BR and CA, is likely due to the substantial negative influence of ICT. This discrepancy may result from interactions among components, differences in weighting, varying magnitudes of impact and potential measurement issues. The index may obscure the positive effects of some components because the negative impact of ICT overshadows them, highlighting the complex nature of how different innovations affect bank performance.

Long-run impacts of the innovations on financial performance of larger versus smaller and high-performing versus low-performing banks

Table 9 expands the analysis of long-run return on equity dynamics by employing the CS-ARDL approach across various sub-samples of banks, categorised by performance and size.

The ATM implementation has a positive impact on bank profitability by generating non-interest income from ATM services. Banks benefit from fee-based revenue through ATM utilisation, which boosts their profitability. Expanding ATM networks enhances bank performance by facilitating essential operations such as cash withdrawals and deposits, thereby improving operational efficiency and financial gains. ATMs contribute to increased bank profitability by reducing operational expenses, including branch maintenance, labour costs and other related overheads (Akhisar et al., 2015). Customers also perceive ATMs as safer and more secure than internet banking (Le & Ngo, 2020). Furthermore, ATMs help lower average operational costs and overhead expenses. According to Mawutor (2014), customers prefer ATMs for their time-saving benefits, easy access to cash and convenience in product usage.

Table 9
Long-run impact of innovations on small vs. large and low vs. high performing banks

Variable	FIN index	ATM	CA	ICT	BR	PA
High performance bank (ROE)						
FIN	0.248	0.143	0.100	0.216	0.331	–0.036
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.054)**
PIN	0.036	0.013	–0.032	0.040	–0.000	0.038
	(0.400)	(0.711)	(0.208)	(0.380)	(0.999)	(0.262)
INS	0.069	0.050	0.042	0.086	0.074	0.062
	(0.037)**	(0.031)**	(0.040)**	(0.000)***	(0.001)***	(0.019)**
AST	–0.155	–0.237	–0.160	–0.309	–0.264	0.258
	(0.001)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Low performance bank (ROE)						
FIN	–0.162	0.282	1.067	–0.106	0.572	0.467
	(0.006)***	(0.002)***	(0.000)***	(0.326)	(0.013)**	(0.002)***
PIN	–0.093	–0.065	0.620	–0.022	–0.029	0.125
	(0.000)***	(0.000)***	(0.000)***	(0.673)	(0.372)	(0.096)**
INS	–0.026	0.017	0.088	–0.126	–0.017	–0.150
	(0.427)	(0.487)	(0.466)	(0.000)***	(0.598)	(0.008)***
AST	–0.117	–0.276	–2.290	0.253	–0.465	0.0251
	(0.004)***	(0.001)***	(0.000)***	(0.051)**	(0.003)***	(0.796)
Large size bank (ASSET)						
FIN	0.746	–0.001	0.101	0.246	0.299	–0.052
	(0.000)***	(0.941)	(0.000)***	(0.000)***	(0.003)***	(0.000)***
PIN	–0.117	0.235	–0.020	0.212	1.013	0. 228
	(0.000)***	(0.000)***	(0.445)	(0.000)***	(0.000)***	(0.000)***
INS	0.030	0.008	0.041	0.070	0.142	0.055
	(0.523)	(0.750)	(0.049)**	(0.001)***	(0.000)***	(0.026)**
AST	0.077	–0.281	–0.173	–0.485	0.071	–0.308
	(0.027)**	(0.000)***	(0.000)***	(0.000)***	(0.212)	(0.000)***
Small size bank (ASSET)						
FIN	1.012	0.475	1.300	0.560	0.579	1.530
	(0.000)***	(0.011)**	(0.003)***	(0.000)***	(0.000)***	(0.005)***
PIN	0.053	0.161	0.088	–0.038	0.123	0.780
	(0.341)	(0.000)***	(0.125)	(0.163)	(0.032)**	(0.000)***
INS	–0.038	–0.157	–0.106	–0.102	–0.141	–0.221
	(0.714)	(0.002)***	(0.160)	(0.020)**	(0.000)***	(0.040)**
AST	–0.047	–0.076	0.092	–0.390	–0.245	–0.464
	(0.591)	(0.318)	(0.512)	(0.000)***	(0.008)***	(0.001)***

Notes: *** and ** denotes significance at 1% and 5% level, respectively. PIN = Product Innovation, INS = Institutional Innovation, FIN = Financial Innovation. Indicators are BR, ATM, CA, ICT and PA, AST = Assets. Numbers in parentheses represent *p*-values.

Moreover, credit cards significantly boost ROE, indicating that their utilisation enhances bank profitability and overall performance. This improvement is attributed to banks imposing higher charges on credit card usage (Tan, 2020). Consumers often overuse credit cards and fail to meet payment obligations promptly, incurring penalty interest for delayed payments (Gündoğdu & Taşkin, 2017). Indirect interactions, like credit card use, are crucial for banks (Akhisar et al., 2015). In addition, branches also have a significant positive effect, where a 1% increase in branches leads to ROE increases of 0.331, 0.572, 0.299 and 0.579, respectively. Branch expansion significantly boosts competition within the banking sector, potentially forcing weaker banks to exit the market (Carlson & Mitchener, 2005). The impact of branching on competition surpasses that of geographical diversification. Extensive branch networks enhance profitability by attracting more customers and providing added convenience, offsetting the costs associated with over-branching (Berger et al., 1997). Numerous branch locations benefit customers by improving convenience and removing branch restrictions can enhance service accessibility in both urban and rural areas, reducing the time, distance, and cost associated with banking services (Evanoff, 1988).

According to Transaction Cost Theory, ATMs lower operational expenses by decreasing the need for branch maintenance and labour, while credit cards generate additional revenue through fees and penalties. Branch expansion enhances profitability by improving customer access and increasing competition, which aligns with the theory's emphasis on minimising transaction costs and optimising resource allocation. By expanding ATM networks and branch locations, banks effectively reduce transaction costs and improve overall performance. These innovations align with Schumpeter's idea of "creative destruction", where new technologies disrupt existing practices and contribute to enhanced performance and profitability.

High-performing banks, which possess greater resources and expertise, may leverage financial innovations more effectively (Pernell, 2020). For every 1% increase in the overall FIN index, ROE in high-performing banks rises by 0.248, 0.143, 0.10, 0.216 and 0.331 points in FIN index, ATM, CA, ICT and BR, respectively. Previous research has established a positive and significant association between financial innovation and ROE, indicating that higher bank innovation leads to higher profitability (Ashiru et al., 2023). However, introducing patents in large banks can decrease ROE by 0.36 points. According to Schumpeter's Theory of Innovation, some innovations, such as patents, can lead to diminishing returns due to factors like technological obsolescence and intense market competition, and the significant R&D investments required for patents (Scotchmer, 2004). Additionally, focusing on patents may result in long-term opportunity costs and limited financial benefits. Market readiness and implementation challenges can further impede performance improvement (Anaba et al., 2024).

Schumpeter's Theory of Innovation suggests that high-performing banks leverage innovations like ATMs and ICT to boost profitability by enhancing efficiency and providing new services. High-performance banks may not see a significant boost in performance from introducing new products in a saturated market (Wang et al., 2024). Factors such as market saturation, strong customer loyalty to existing products, a focus on operational efficiency, regulatory constraints, resource allocation challenges and the complexity of their operations contribute to this limitation (Riaz et al., 2024). These banks often prioritise stability and efficiency over experimentation, which can limit the impact of new product innovations (Murinde et al., 2022). Additionally, regulatory hurdles and cumbersome rollout processes can further diminish the effectiveness of new products, making significant performance gains less likely. On the other hand, institution innovation positively impacts high-performance banks by enhancing efficiency, competitiveness, regulatory compliance, risk management, customer satisfaction, adaptability and sustainable growth (Mwiti, 2022).

By streamlining operations and reducing costs, banks can offer better services, stay ahead of competitors, attract new customers and retain existing ones. Innovative strategies help banks meet regulatory requirements, mitigate risks and foster a culture of adaptability. Continuous improvement in institutional practices ensures long-term success and profitability (Vandermerwe & Erixon, 2023). However, managing a large asset base has a significant negative effect on high-performance banks. This is due to increased operational complexity, risk exposure, regulatory constraints, resource allocation challenges, capital requirements and ROA. Larger asset bases can lead to higher administrative costs, inefficiencies and underutilisation, negatively impacting financial performance and market perception. Additionally, regulatory scrutiny and stricter compliance requirements can limit operational flexibility and raise compliance costs.

Additionally, inefficient or underutilised assets can depreciate and result in opportunity costs. Therefore, effective asset management is crucial for maintaining a healthy financial environment (Sitienei et al., 2023). Conversely, in the patent model, assets have a positive and statistically significant effect at the 1% level. Heggestad (1977) states that larger banks can leverage assets more effectively than smaller banks. Furthermore, there is a positive correlation between bank profitability and size (Alhassan et al., 2016; Menicucci & Paolucci, 2016).

ICT, such as computers and servers, enhance the performance of large banks by 0.21 and high-performance banks by 0.24. These findings illustrate that ICT accelerates growth, reduces operational expenses, facilitates the introduction of diverse banking services, enhances coordination of branch operations and enables adaptation to change in government regulations and policies.

These advancements ultimately contribute to improved profitability within the banking sector (Brynjolfsson & Hitt, 1996). Technological change and innovation are pivotal drivers of economic growth and firm performance (David, 1990).

The study reveals that patents significantly enhance ROE in low-performance and small banks by 0.467 and 0.153 units, respectively. Schumpeter's Theory of Innovation suggests that patents can significantly enhance ROE for low-performance and small banks by driving technological advancement and operational efficiency. For these banks, patents represent an opportunity to signal innovation and growth potential, which can improve market perception and investor confidence. Zhao et al. (2022) assert that investing in patents can significantly improve a bank's operational efficiency. Patent accumulation positively correlates with the bank's stock value, symbolising a firm's dedication to innovation and technological progress while safeguarding its core business interests. This proactive stance secures the company's growth and fosters increased investor confidence in its capacity for sustained expansion and longevity (Gambardella, 2023).

ATMs and product innovation also positively impact banking profitability. Highly educated customers demand more electronic services, leading to reduced operational expenses and increased revenues (Maseko & Kalama, 2022). Mobile banking apps directly enhance asset quality, resulting in heightened operational profitability and ROE (Mwita, 2023). Electronic banking offers low operational risk (Galletta et al., 2023), high returns and cost advantages, requiring advanced technology that increases bank profitability and positively influences the banking sector. Internet banking applications enable banks to enhance their focus on technological innovations (Alsmadi et al., 2023).

However, low-performing banks face challenges in effectively handling financial innovations due to limited resources, expertise and risk management, leading to increased exposure to credit, market and operational risks. These banks may struggle to allocate sufficient capital toward innovation initiatives, exacerbating their competitive disadvantage (Edeh et al., 2024). Compliance with regulatory standards related to financial innovations can be burdensome, potentially resulting in fines and reputational damage. According to Sharma (2023), the profitability of some electronic banking services negatively affects bank performance. Al-Smadi and Al-Wabel (2011) note that customers still heavily rely on traditional distribution channels despite the availability of electronic options. D'Andrea and Limodio (2024) highlights the significant infrastructure costs associated with Internet banking, coupled with an insufficient customer base, leading to a detrimental effect on banks' profitability.

Despite increased advertising budgets for Internet banking, the preference for traditional branch-based services persists, preventing the anticipated cost reductions from electronic banking services. This situation leads to diminished profitability as the lack of electronic banking infrastructure impedes cost-effectiveness, particularly in developing countries, where Internet infrastructure often relies on outdated technology (D'Andrea & Limodio, 2024). Furthermore, customer perceptions of low-performing banks engaging in complex financial innovations may erode trust and loyalty, further hindering their performance. These challenges underscore the importance of strategic planning, risk management, regulatory compliance and capital allocation for successful innovation efforts in the banking industry (Olawale et al., 2024).

In conclusion for low-performance and small banks, the adoption of such technologies can help mitigate high operational costs and enhance service delivery. Nevertheless, these banks may struggle with the high costs of implementing and maintaining innovative technologies, regulatory compliance and risk management. Transaction Cost Theory highlights the importance of balancing the benefits of innovation with the costs associated with managing these advancements to avoid exacerbating the banks' financial challenges.

CONCLUSION

In recent decades, advancements in the financial system, particularly following deregulation, have increased competition among banks. To stay ahead, banks have focused on reducing costs and maximising revenue. They have adopted service innovations and technological advancements to differentiate themselves and offer more efficient, user-friendly solutions to their clients. In light of this, the current study investigates the impact of financial, product, institution innovation on UAE banks' financial performance. We also differentiate between the impact of these innovations on the financial performance of smaller versus larger and lower-performing versus high-performing banks. We applied CS-ARDL model and dataset ranging from 2002–2022 involving 13 UAE banks. To capture financial innovation, we considered the number of branches, ICT, ATM machines, patents and cards. Product innovation was captured by mobile banking transactions and institution innovation was measured through employee training hours and information technology.

Our findings show that financial innovation positively impacts the financial performance of UAE banks across all subgroups. However, financial and institution innovations have a greater impact on high-performing and large banks than on low-performing and small banks, which often struggle with

limited resources and expertise. Conversely, product innovation tends to significantly boost financial performance in lower-performing and small banks. This is because high-performing banks often face difficulties with new products in saturated markets, while large banks grapple with managing complex operations and extensive asset bases. These findings imply that choosing the right types of innovation can significantly improve bank performance.

POLICY IMPLICATIONS

Our findings suggest three key policy implications. First, the positive impact of financial innovation on banks' financial performance underscores the need to expand their financial innovation capabilities to meet growing customer demands. This could involve integrating financial innovation with other types, such as product and institutional innovations, to achieve more effective outcomes and enhanced financial performance. Banks should also explore innovative approaches to expand their presence and customer base, such as collaborating with social media platforms like Google, developing cashless branches, implementing digital payment systems and introducing robotics in the banking sector. Second, policymakers should encourage high-performing and large banks to focus on financial and institutional innovations, as these have the most substantial impact on their financial performance. Third, there is a need to support small and lower-performing banks in leveraging product innovations, which have been shown to significantly enhance their financial outcomes, offering a pathway for these banks to improve competitiveness. Finally, promoting tailored innovation strategies that align with specific strengths and market conditions can help banks optimise their performance and contribute to a more resilient banking sector in the UAE.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study was conducted under a few limitations. First, the study time period is limited to 20 years (2002–2022) due to the limited availability of comprehensive data on financial, product and institution innovations. A larger panel dataset could provide more robust findings. Second, due to the limited timeframe and a higher number of regressors, we included only a single control variable, bank size, in examining the impact of these innovations on the financial performance of banks. Third, our analysis focused solely on UAE banks. Future studies could extend the time period and broaden the analysis to include other GCC countries, enhancing the robustness and generalisability of the findings. We also recommend future research to explore how these innovations might influence the financial stability and long-term growth of the UAE banking sector.

FUNDING

There is no financial assistance or grant acquired for this project.

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