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Research Paper

Assessing the efficiency of pure-play internet banks in South Korea, Japan and China with data envelopment analysis

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ABSTRACT

This study aims to provide empirical insight into the efficiency of major pure-play internet banks in South Korea, Japan and China (that is, KakaoBank, K Bank, Sony Bank, Jibun Bank and WeBank). We employed the data envelopment analysis model and adopted a profit-oriented approach to measuring the efficiency of the banks between 2017 and 2020. In addition, we ran fixed cross-section regression to measure the relationship between net profit and the input and output variables. We found that in 2017 Sony Bank was run efficiently, but KakaoBank, K Bank and Jibun Bank were run inefficiently. In 2018 WeBank and Sony Bank were efficient, and the efficiency scores of KakaoBank and Jibun Bank were close to 1, meaning they ran fairly efficiently; however, K Bank was run inefficiently. In 2019 KakaoBank, WeBank and Sony Bank were run efficiently, and Jibun Bank's efficiency score was close to 1, meaning it was run fairly efficiently, but K Bank was run inefficiently. In 2020 KakaoBank and Sony Bank were run efficiently but K Bank was run inefficiently.

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In addition, Jibun Bank's efficiency score decreased slightly compared with 2019. Fixed cross-section regression showed the strongest relationship between net profit and noninterest expense. However, the relationship between net profit and noninterest income is also strong. We recommend that banks prioritize managing noninterest expenses and income to achieve sustainable profits.

Keywords: digital banks; web-only banking; internet-only banking; challenger bank; data envelopment analysis (DEA); banking efficiency.

1 INTRODUCTION

The banking system performs a critical social and economic role in economies. Banking institutions are at the center of financial systems. They operate as intermediaries: they borrow funds from depositors and issue corporate bonds and, in return, grant loans to their clients and through capital markets by making investments in debt instruments. Banking institutions play a vital role in the money supply and the efficient distribution of funds in an economic system. In addition, banking systems generate income from their services. Banking institutions have diverse activities, including consumer, corporate and investment banking, and currency, commodity and security trading on stock exchanges. They are obliged to follow national and international regulations. Their efficiency is monitored closely by regulatory authorities and investors due to the critical significance of the banking sector to the economy and the risks banking institutions face. Poor performance of banks frequently causes distress, which can result in bankruptcy and have severe financial, economic and social ramifications.

Unlike previous efficiency studies on bricks-and-mortar banks, this paper focuses on pure-play internet banks. Such banks collect deposits within the Savings Deposit Insurance Fund rules for their country. In addition, they provide banking services through electronic channels (ie, the internet), but not through physical branches. Bricks-and-mortar banks with branches that use internet banking as an alternative distribution channel are not considered within this context. Pure-play internet banks leverage big data, artificial intelligence and blockchain to understand their customers' behavior patterns. In this way, they can provide customer-centered but not face-to-face services. The rise of pure-play internet banking is due to information technology and database developments in the financial market.

Thus, pure-play internet banking, an innovative financial service, has evolved as a global trend, while the financial services sector has expanded and developed due to the rise in pure-play internet banks. The pure-play internet banking business model offers advantages to both banks and customers.

For example, banks that provide internet-only services do not need to bear branch operating costs such as rent, employee salaries and electricity; pure-play internet banks can also quickly become profitable, as their fixed asset investments (eg, buildings) and other operating expenses are significantly reduced. It is assumed that there are no increases in other expenses to compensate for the decrease in fixed asset investment and branch operating expenses, and that sufficient income can be generated. Pure-play internet banks get the opportunity to expand their deposit customer base by applying a higher interest rate to deposits, reflecting some of the savings made from operating expenses. In addition, the ability of these banks to serve the broader hinterland may enable them to grow faster than traditional banks.

The most crucial advantage for deposit customers is that these banks yield higher interest rates than traditional banks because they can reflect any savings from fixed costs (eg, high-cost branches) in deposit clients' interest. In addition, pure-play internet banks often apply lower interest rates to newly employed or self-employed individuals that cannot provide collateral, have medium credibility or cannot generally access credit at reasonable interest rates in conventional banks (which generally offer loans and services to people with high credibility and income).

However, there are some disadvantages associated with pure-play internet banks. A survey conducted on three different generations of customers in the United States in 2020 revealed that they were satisfied with their existing bricks-and-mortar banks and thus did not feel the need to open an account in any digital bank. The baby boomer generation wanted to make more face-to-face transactions than Generations X and Y. In addition, nearly 20% of respondents across all three generations stated that they did not trust purely digital banks.[1]

In a similar survey conducted among US consumers in 2021, 25% of respondents cited "data security" as the main reason why they did not prefer pure-play internet banks, while the second most common reason was that they perceived fraud risks to be lower in traditional banks than in digital banks. In addition, over 20% of survey participants did not see purely digital banks as "banks". The element of trust ranked fourth among the reasons why consumers in the United States do not use purely digital banks.[2]

We expect pure-play internet banks to operate efficiently since they do not have branch operating costs. Thus, in this empirical paper, we examine the efficiency of leading pure-play internet banks in South Korea, China and Japan.

[1] URL: www.statista.com/statistics/1239448/reasons-not-to-use-digital-only-banking-usa/.
[2] URL: www.statista.com/statistics/1271685/.

The remainder of the paper is organized as follows: Section 2 reviews the relevant literature; Section 3 presents our methodology; Section 4 details the empirical study and discusses the findings; and Section 5 states our conclusions and provides recommendations for improving banks with lower efficiency.

2 LITERATURE REVIEW

Banking efficiency is viewed differently by different people. Traditional commercial banks are agents of a transformation process, and they convert a collection of inputs into a set of outputs according to various theoretical conceptions. In commercial bank operations, these inputs and outputs are connected by a production function, which determines the maximum achievable outputs for a given amount of inputs. However, there is no widespread agreement on the production function of commercial banks that reflects these banks' objectives.

The way a bank makes decisions regarding its operations with a given preference structure is referred to as bank behavior. There are three basic bank behavior models adopted by the input–output specification in data envelopment analysis (DEA) models: the production method, the intermediation method and the value-added method. These methods are distinct in concentrating on various bank operations and motives to maximize shareholder return. The handling of deposits, which have input and output characteristics, is the fundamental source of differentiation. Each of these methods is explained in detail in the following paragraphs.

The production method

There are two types of production method: the service-oriented approach and the user-cost approach. Commercial banks' primary goal is to generate deposits (liabilities), loans (assets) and other services. In both types of production methods, deposits are viewed as outputs. The service-oriented approach incorporates deposits as an output alongside loans and interest revenue. Benston (1965) was one of the first researchers to use this approach. Hancock (1991) came up with the user-costs approach; in this scenario, deposits act as both inputs and outputs of a commercial bank's cost/profit function.

The intermediation method

Sealey and Lindley (1977) promoted the intermediation method, which assumes that a commercial bank's primary goal is to generate output (ie, loans and investments) by utilizing liabilities (including deposits), labor and capital as inputs. A commercial bank is a key intermediary in the economy, and its main job is to convert deposits into loans. According to the intermediation method, the deposits are used as inputs and

loans as outputs. The profit-oriented approach discussed in this paper is an extension of the intermediation method. The profit-maximizing motive of commercial banks (which are still financial intermediaries) is stressed within this approach. The profit-oriented approach tends to grasp the bottom-line effects of financial intermediation. Interest and/or noninterest expenses are used as inputs, and interest and/or noninterest income are used as outputs by focusing on the commercial bank as a profit-maximizing company. The description above preserves the minimizing and maximizing features of inputs and outputs and addresses the difficulty in identifying deposits as either an input or an output.

Note that there are two approaches to using the intermediation method to measure the intermediation components. Like the Sealey and Lindley (1977) model, the asset-oriented approach uses the value of intermediated funds as a metric. The profit-oriented (or income- or revenue-based) approach, on the other hand, uses financial income metrics, since it is interested in the cost–revenue comparison. Empirical studies utilizing this approach (Noulas 2001; Barr *et al* 2002; Sturm and Williams 2004; Das and Ghosh 2006; Avkiran 2009) frequently use interest and noninterest expenses as inputs and interest income and noninterest revenue as outputs. The primary purpose of decomposing the total costs and revenue is to identify sources of inefficiency; that is, to determine whether inefficiency is generated by financing activities or operations and noninterest service-related activities.

In recent research, the profit-oriented intermediation approach has become increasingly popular, emphasizing a financial intermediary's capacity to maximize profit. This variation's popularity stems from the benefits of the intermediation method in tackling the issue of interest expenses. Interest expenses typically make up one-half to two-thirds of overall costs, according to Berger and Humphrey (1997). Banking organizations use this approach to generate income over all business costs (Leightner and Lovell 1998). The input–output specification is consistent with the DEA approach, which calls for reduced inputs and maximized outputs. Profit orientation requires the minimization of production costs and the minimization of total expenses to maximize profit. Further, this approach eliminates the debate about the function of deposits. Kamecka (2010, pp. 37–40) highlights this approach, which Ahn and Le (2014, pp. 19–20) support. As previously noted, several approaches to commercial bank efficiency favor the utilization of diverse inputs and outputs. The intermediation method is arguably the most widely employed in banking (Ahn and Le 2014, pp. 9, 18).

The value-added method

The value-added method assumes that both liability and asset categories have specific output characteristics. Only those categories that generate a significant amount of

value-added are considered outputs, while the others are classified as either inputs or intermediate products, depending on their characteristics. Berger *et al* (1987) and Berger and Humphrey (1997) advocated for this technique.

Table 1 shows the typical inputs and outputs for each method (Ahn and Le 2014, p. 21).

Developments in information technology and databases in the financial market have led to the emergence of pure-play internet banking. As mentioned in Section 1, this business model has more advantages than disadvantages. Therefore, even traditional bricks-and-mortar banks will likely provide most of their services on the internet in the future.

Since pure-play internet banking is a new way of doing business, there is scant literature on this subject. We want to share a few studies on the profitability of pure-play internet banks to understand their strengths and weaknesses. DeYoung (2001) examined the financial performance of banks operating in the United States that only offer services over the internet and found that pure-play internet banks are less profitable than traditional banks with bricks-and-mortar branches. High personnel expenses, low noninterest income and an inability to create core deposits are cited as reasons for low profitability. Compared with traditional branch banking, pure-play internet banks did not have lower overheads and higher total deposit interest rates. This finding is the opposite of what might be expected (see Section 1). However, DeYoung found that pure-play internet banks did tend to grow faster than traditional branch banks, as expected. Dandapani and Lawrence (2008) similarly attribute pure-play internet banks' low profitability (and failure) between 1995 and 2006 to high operating expenses. Zhang *et al* (2020) examined the performance of US pure-play internet banks compared with their traditional and traditional/digital counterparts over the preceding 18 years. Their regression analysis results obtained with the ordinary least squares (OLS) method showed that pure-play internet banks had lower profitability and could manage their operating expenses less effectively than traditional banks. Their findings revealed that pure-play internet banks need time to achieve economies of scale and accumulate experience. The increase in activity resulting from the scale effect significantly boosts the profitability of Chinese banks (Chen *et al* 2022). Cyree *et al* (2009) find that even if pure-play internet banks cannot achieve profitability, their efficiency is higher than branch bank start-ups, and their profit potential is high once they reach economies of scale.

In summary, studies have revealed that banks that only provide services over the internet initially showed rapid growth, but, owing to high operating expenses, could not make a profit until they achieved economies of scale.

It has been observed that following the emergence of pure-play internet banks, existing traditional banks made interest rates more competitive, offered more internet

TABLE 1 Typical inputs and outputs.

Approach	Typical inputs	Typical outputs
Asset-oriented intermediation approach	Number of (full-time equivalent) employees Physical capital (US$) Deposits (US$) Purchased funds (US$) Other liabilities (US$)	Loans (US$) Securities and other investments (US$)
Profit-oriented intermediation approach	Interest expense (US$) Noninterest expense (US$)	Interest income (US$) Noninterest income (US$)
Production approach	Number of (full-time equivalent) employees Fixed assets (US$)	Number of loan accounts Number of deposit accounts Number of transactions
User-cost approach	Number of (full-time equivalent) employees Physical capital (US$) Time deposits (US$)	Loans (US$) Demand deposits (US$)
Value-added approach	Purchased funds (US$) Number of (full-time equivalent) employees Physical capital (US$)	Deposits (US$) Loans (US$)

Source: adapted from Ahn and Le (2014, p. 21).

banking services and designed more user-friendly banking applications. In other words, the contribution of pure-play banks to the banking sector has been positive (World Bank 2020).

Our study is, to the best of our knowledge, the first to provide empirical insight into the efficiency of the leading pure-play internet banks in South Korea, Japan and China. We examine the efficiency of KakaoBank, K Bank, Sony Bank, Jibun Bank and WeBank. In addition, our study sheds light on the regulatory authorities and the corporations willing to adopt the pure-play internet banking business model.

3 METHOD

In this empirical study, the DEA model was used to assess the efficiency profiles of pure-play internet banks. We used interest and noninterest expenses as input variables and interest and noninterest income as output variables to measure profitability efficiency. Moreover, a fixed cross-section regression was run to measure the relationship between the net profit, as the dependent variable, and the input variables (the interest and noninterest expenses) and output variables (the interest and noninterest income) as the independent variables. The efficiencies of each bank between 2017 and 2020 were compared. The change in the efficiency of each bank year by year was also analyzed and assessed.

3.1 Data

In this study, we used yearly interest income, noninterest income, interest expense and noninterest expense data for each of the four banks between 2017 and 2020 to measure the efficiency via the profitability approach. We did not set a minimum data requirement for DEA since it is a nonparametric method. In addition, we had an additional 56 data points above the minimum requirement for panel data analysis.

Interest income is an important measure of earnings in banks. It is the revenue generated by loans, mortgages and securities. Interest expenses are costs on checking and savings accounts, certificates of deposit and corporate bonds. Noninterest income is defined as the money banks earn from operations other than their primary intermediation activity (taking deposits and issuing loans) or investments.[3] Noninterest income is the portion of the bank's revenue from service, transaction fees and guarantee commissions. Moreover, the penalty costs, such as late charges and over-the-limit fines, imposed by credit card issuers are examples of noninterest income. Institutions also levy fees that produce noninterest income to boost earnings and maintain liquidity in

[3] URL: www.bankrate.com/glossary/i/interest-income/#:~:text=Interest%20income%20is%20generated%20by,pay%20some%20form%20of%20interest.&text=Net%20interest%20income%20is%20the,and%20savings%20accounts%2C%20and%20CDs (accessed February 19, 2022).

case of higher default rates (Chen 2020). A cost other than interest costs on deposits and securities is a noninterest expense; employee wages, bonuses, benefits, rentals, marketing expenses and other operational expenses involved in the bank's everyday operations are typical examples (Banton 2023).

We accessed KakaoBank's financial statements via the investing.com database,[4] K Bank's financial statements from the Financial Statistics Information System (FISIS),[5] Sony Bank's financial statements from its website,[6] Jibun Bank's financial statements from its website[7] and WeBank's financial statements from its website.[8] We manually extracted data from the 2017, 2018, 2019 and 2020 annual financial statements of KakaoBank, K Bank, Sony Bank and Jibun Bank. However, only WeBank's 2018 and 2019 financial statements are available in the public domain. We converted all the data to US dollars using the year-end exchange rate.

3.2 Data envelopment analysis

We used DEA to measure the productive efficiency of each bank's decision-making unit (DMU) empirically or to calculate the relative performance of organizational units. DEA is a nonparametric method. The DMU observed empirically to be the most efficient is taken as the production frontier for benchmark comparison with all other DMUs. The objective function is

$$\max \varphi = \frac{\sum_{j=1}^{n} y_{rj}\lambda_j}{\sum_{j=1}^{n} x_{ij}\lambda_j} \quad \text{subject to } \frac{\sum_{j=1}^{n} y_{rj}\lambda_j}{\sum_{j=1}^{n} x_{ij}\lambda_j} \leqslant 1 \text{ for each unit } j,$$

where y_{rj} denotes the output values from DMU with $j = 1, \ldots, n$ observations and $r = 1, \ldots, s$ outputs; x_{ij} $(i = 1, \ldots, m,\ j = 1, \ldots, n)$ denotes the input values for each DMU; λ_j $(j = 1, \ldots, n)$ denotes the weights for the input and output; and φ denotes the efficiency score.

We use an output orientation where DEA maximizes the output for a given input level; in other words, it indicates the amount by which a firm can increase its output for a given input level. The model assumes a constant returns-to-scale technology (CRS model); this is appropriate when all firms are operating at an optimal scale (Charnes *et al* 1978).

[4] URL: www.investing.com/pro/KOSE:A323410/financials/income_statement.
[5] URL: https://efisis.fss.or.kr/fss/fsiview/indexw.html.
[6] URL: www.sonyfg.co.jp/en/financial_info/annualreport/.
[7] URL: www.jibunbank.co.jp/corporate/financial_information/.
[8] URL: www.webank.com/en/financialReport/list.

3.3 Regression

We used panel data regression using panel least squares with a fixed cross section to describe the relationship between net profit and the input and output variables (we did not include WeBank data in the analysis because it only covers 2018 and 2019).

The model is defined by

$$y_{it} = \alpha_i + \boldsymbol{\beta}' \boldsymbol{X}_{it} + \varepsilon_{it},$$

where y denotes the dependent variables, α is the intercept, $\boldsymbol{\beta}$ is the coefficient of regressions, $\boldsymbol{X}$ denotes the dependent variables, ε is the error of the model, we set $i = 1, 2, \ldots, N$ for N the number of individuals or cross-sections, and we set $t = 1, 2, \ldots, T$ for T the number of time periods. Panel data is a two-dimensional concept where the same individuals are observed repeatedly over different periods of time. Generally, panel data can be seen as a combination of cross-sectional and time series data. Cross-sectional data is described by a single observation of multiple objects and their corresponding variables at a specific point in time (ie, an observation is taken once), whereas time series data observes only one object recurrently over time. The model comprises the panel data characteristics obtained by collecting data from the same multiple objects over time.

The fixed estimation method is commonly used in cross-sectional settings. Fixed effects are used in linear regressions to account for unobservable confounding factors. They are binary indicators that denote group membership and are included as covariates in the regression analysis. When entered as covariates in linear regression, they computationally eliminate the mean differences between the observations in the indicator group and all other observations. This demeaning process adjusts the regression coefficient estimates of other modeled covariates to account for all confounding factors relating to these group differences: a powerful method for combatting bias in linear regression estimates. The fixed effects portions of specifications are handled using orthogonal projections. In the simple one-way fixed effect specifications and the balanced two-way fixed specification, these projections involve the familiar approach of removing cross-sectional or period-specific means from the dependent variable and exogenous regressors and then performing the specified regression using the demeaned data (Baltagi 2021).

In the fixed effects regression, we actually look at the within R^2. This comes from the prediction equation

$$\hat{Y}_{i,t} - \hat{\bar{Y}}_{i,\cdot} = (X_{i,t} - \hat{\bar{X}}_{i,\cdot})\hat{\beta},$$

where $\hat{\bar{Y}}_{i,\cdot}$ and $\hat{\bar{X}}_{i,\cdot}$ are the grand means of the variables. So, R^2 gives the goodness-of-fit measure for the individual mean detrended data, which disregards all the information in the data.

TABLE 2 DEA model results for 2017 (in US dollars).

Name	Input 1: interest expense	Input 2: noninterest expense	Output 1: interest income	Output 2: noninterest income	Efficiency
KakaoBank	16 753 620	145 977 300	47 306 440	15 975 300	0.3120
K Bank	7 049 060	88 546 120	19 670 440	2 055 780	0.2009
Sony Bank	76 998 480	191 541 600	235 621 920	76 101 600	1
Jibun Bank	12 227 760	260 086 320	217 124 880	68 269 440	0.8073

4 EMPIRICAL RESULTS

This section assesses and analyzes the DEA and fixed cross-section regression results. We used Microsoft EXCEL for the analysis of the data.

4.1 The results of the DEA model

Efficiency refers to the peak level of performance that uses the least amount of inputs to achieve the highest amount of output. If the efficiency score is 1, it means efficiency is achieved. KakaoBank's efficiency (0.3120) and K Bank's efficiency (0.2009) were less than 1 (Table 2), and thus they are inefficient. K Bank and KakaoBank launched their innovative products and services in 2017 but could not generate enough income to cover operational expenses in their early years. These results are similar to the findings of DeYoung (2001), Dandapani and Lawrence (2008) and Zhang *et al* (2020). Sony Bank's efficiency was 1, and so it was operating efficiently. Sony Bank was founded in April 2001, and thus had enough time to achieve economies of scale by 2017. Moreover, Sony Bank could cover its operating expenses with its income. Jibun Bank's efficiency was 0.8073, and it operated less efficiently than Sony Bank but more efficiently than KakaoBank and K Bank in 2017. Jibun Bank was founded in 2008, and there was room for efficiency improvement.

In 2018, KakaoBank's efficiency was 0.9228 (Table 3): a drastic improvement compared with its 2017 efficiency (0.3120). KakaoBank operated more efficiently than K Bank but less efficiently than WeBank, Sony Bank and Jibun Bank. K Bank's efficiency was 0.4552, and thus less than 1, in 2018. However, this was essentially a jump compared with its 2017 efficiency (0.2009). K Bank was the least efficient bank in 2018; it could not generate enough income to cover its operational expenses. Jibun Bank's efficiency was 0.9858 in 2018: an improvement compared with its 2017 efficiency (0.8073). Its 2018 value is close to 1 and thus it can be considered efficient. WeBank and Sony Bank's both had an efficiency of 1, and thus were efficient. WeBank (China) was founded in 2014 and in four years had generated enough interest income to cover its operational expenses. This is similar to Chen *et al*'s (2022)

TABLE 3 DEA model results for 2018 (in US dollars).

Name	Input 1: interest expense	Input 2: noninterest expense	Output 1: interest income	Output 2: noninterest income	Efficiency
KakaoBank	99 428 931	244 247 531	264 391 834	73 455 868	0.9228
K Bank	23 729 709	97 165 789	54 244 347	5 830 559	0.4552
WeBank	476 673 833	1 006 004 158	1 279 173 033	1 126 673 774	1
Sony Bank	70 498 989	198 365 607	258 468 936	72 268 075	1
Jibun Bank	12 227 760	260 086 320	246 933 401	101 640 374	0.9858

TABLE 4 DEA model results for 2019 (in US dollars).

Name	Input 1: interest expense	Input 2: noninterest expense	Output 1: interest income	Output 2: noninterest income	Efficiency
KakaoBank	213 858 199	318 878 862	383 125 057	192 555 919	1
K Bank	40 872 294	103 262 426	77 130 407	3 130 371	0.6111
WeBank	982 871 291	1 390 042 692	2 341 964 594	1 615 456 252	1
Sony Bank	79 550 172	216 054 696	293 846 904	90 005 916	1
Jibun Bank	18 831 384	346 944 780	276 322 488	122 422 404	0.9553

findings that Chinese banks have a positive profitability improvement. The activity effect derived via the scale effect positively contributes to profitability performance. We could only access WeBank's financial data for 2018 and 2019.

In 2019, KakaoBank, WeBank and Sony Bank were efficient, and Jibun Bank was somewhat efficient (Table 4). KakaoBank started operating efficiently three years after it had been founded. This was an outstanding achievement. This result confirms Cyree *et al*'s (2009) statement that "even if pure-play internet banks could not achieve profitability, their efficiency is higher than branch bank start-ups, and their potential is high once they reach economies of scale". On the other hand, K Bank was the least efficient bank (0.6111) under review for this year; it could not generate enough income to cover its operational expenses in 2019. Nevertheless, this was an improvement from 0.4552 in 2018.

KakaoBank and Sony Bank kept operating efficiently in 2020 (Table 5). However, both K Bank and Jibun Bank's efficiency fell compared with 2019. The fall in efficiency for K Bank was due to the initial challenge faced by Korea's pure-play banks: their ability to increase capital was constrained due to regulatory restrictions. Kakao fixed this problem quickly in July 2019, but K Bank could not. It had no choice but to suspend new operations in April 2019 due to insufficient capital. Thus, K Bank

TABLE 5 DEA model results for 2020 (in US dollars).

Name	Input 1: interest expense	Input 2: noninterest expense	Output 1: interest income	Output 2: noninterest income	Efficiency
KakaoBank	176 186 072	395 631 234	497 728 578	242 782 145	1
K Bank	23 304 758	118 747 397	66 048 255	5 414 636	0.4787
Sony Bank	89 501 464	253 547 248	327 830 856	110 377 736	1
Jibun Bank	21 542 536	418 558 632	313 597 912	178 075 952	0.8085

could not grant loans and increase its net interest income. At the end of July 2020, K Bank was recapitalized with additional capital. Finally, the regulatory problem that prevented increasing capital was solved (World Bank 2020). These results confirm the findings of Banker *et al* (2010), who examined Korean banking institutions from 1995 to 2005. Their study suggested that efficiency is positively related to capital.

Jibun Bank's efficiency fell in 2020 compared with 2019 due to a decline in market demand. In 2020, the value of outstanding consumer loans granted by domestically licensed banks in Japan amounted to ¥9.9 trillion. Compared with the previous year, outstanding consumer loans declined by more than 4%.[9]

4.2 The results of the fixed cross-section regression

The regression results for input variables show that a 1% increase in the noninterest expense decreases profit by 0.001078 percentage points, whereas a 1% increase in the interest expense decreases profit by 0.000778 percentage points (Table 6).

The regression result for output variables showed that a 1% increase in noninterest income increases profit by 0.000975 percentage points, whereas a 1% increase in interest income increases profit by 0.000835 percentage points. The coefficient of multiple determination in our model shows that 0.967681 of the change in profit can be explained by the independent variables: noninterest expense, interest expense, interest income and noninterest income. In other words, the independent variables in the model explain most of the variance in the dependent variable. The independent variables (noninterest expense, interest expense, interest income, noninterest income) were statistically significant at 5% and less significant at other levels.

5 CONCLUSIONS

This paper provides empirical insight into the efficiency of leading pure-play internet banks in South Korea, Japan and China. We employed a profit-oriented approach to

[9] URL: www.statista.com/statistics/1214301/japan-outstanding-consumer-credit-of-banks/.

TABLE 6 Fixed cross-section regression results.

(a) Regression analysis results

Variable	Coefficient	SE	t-statistic	Prob.
C	4 736.472	39 169.80	0.120922	0.9067
INTINCOME	0.000835	0.000171	4.880997	0.0012
NONINTINCOME	0.000975	0.000371	2.625571	0.0304
INTEX	−0.000778	0.000267	−2.913023	0.0195
NONINTEX	−0.001078	0.000319	−3.379701	0.0096

(b) Effects specification: cross-section fixed (dummy variables)

Variable	Value	Variable	Value
R^2	0.967681	Mean dependent variable	−21 226.06
Adjusted R^2	0.939403	SD dependent variable	58 835.08
SE of regression	14 483.15	Akaike information criterion	22.30621
Sum of squared residuals	1.68E+09	Schwarz criterion	22.69251
Loglikelihood	−170.4497	Hannan–Quinn criterion	22.32599
F-statistic	34.21941	Durbin–Watson statistic	2.209117
Pr(F-statistic)	0.000024		

SE, standard error. SD, standard deviation.

examine the efficiency of KakaoBank, K Bank, Sony Bank, Jibun Bank and WeBank between 2017 and 2020.

The efficiencies of each bank were then compared, and the change in efficiency of each bank year on year was analyzed and assessed. To the best of our knowledge, this is the first paper to measure the efficiency of pure-play internet banks by employing the DEA method.

Contrary to expectation, pure-play internet banks have lower profitability than traditional banks and cannot manage their operating expenses as effectively. This finding reveals that pure-play internet banks need time to achieve economies of scale and accumulate experience. Our fixed cross-section regression results showed the strongest relationship occurred between net profit and noninterest expense. For this reason, we recommend that pure-play internet banks with lower efficiency focus on managing noninterest expenses closely. The relationship between net profit and noninterest income is also vital. A decrease in noninterest expenses and an increase in noninterest income will improve the efficiency and profitability of less efficient pure-play internet banks.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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