Following the Leader’s Innovation or Leading Follower’s Innovation: Taiwan’s Banking Industry Analysis

Jen-Ying Shih * and Tsai-Hsiu Lin

Graduate Institute of Global Business and Strategy, National Taiwan Normal University, Taipei 10610, Taiwan; b60202brian@gmail.com
* Correspondence: jyshih@ntnu.edu.tw
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Abstract: In response to the rapid development of the global economy and FinTech innovation, Taiwan’s government has continuously promoted digital transformation policies for the financial industry and encouraged the industry to strengthen infrastructure constructions and upgrade innovative financial services and patents. Novel ideas are proposed to create a new situation and make banks invincible but it is questionable if such innovations necessarily bring competitiveness or business performance. To answer this question, we analyzed market competition using the PR test and data envelopment analysis (DEA) to study the operational efficiency of banks. K-means were also used to segment banks into three groups, Leader, Chaser, and Laggard. The data included financial (business performance) and patent data (innovation) of Taiwan’s banks from 2013 to 2020. The research results revealed that the market competition in the Leader group was the most intense. Quasi-public banks were relatively inefficient in creating revenue, while private banks were more efficient. The Chaser group showed the most apparent changes in operational efficiency from 2013 to 2020. The banks in the Laggard group needed to strengthen the relative efficiency of revenue, and financial innovation needed to be individualized in this competitive market group.

Keywords: financial innovation; market competition; relative efficiency; DEA

1. Introduction

Is innovation always good for competitiveness or business performance? Two cases were studied to answer this question. The Shanghai Commercial and Savings Bank (SCSB) was the first bank in Taiwan to offer 24 h service of automatic teller machines (ATM) and cooperate with convenience stores for the service. SCSB was undoubtedly a pioneer in the banking industry at that time. However, under fierce competition, the SCSB’s ATM occupancy rate of convenience stores in recent years has decreased due to large consumer banks’ marketing. E. Sun Bank once wanted to launch electronic money but as various online payments in Taiwan have become popular, they gave up the project. After adjusting the innovation strategy to the target market, they introduced mobile payment in the e-commerce market combined with cross-border transactions as the services are used by people. Although it is not the most advanced technology, it meets the expectations of consumers.

The above two cases showed that the use of the newest innovative technology for services may not be enough to outperform the competitors. The service needs to meet the demand of the target customer to obtain a competitive edge. Novel ideas sometimes create a situation for banks to remain competitive but it is unclear when individual banks face an unsolvable situation and what they need to do for it. It is also questionable how much effort needs to be put into the development of the service and how long it would take.

In response to the rapid development of the global economy and financial technology, Taiwan’s government has continuously promoted digital transformation in the financial
industry and encouraged the industry to build infrastructures and provide innovative financial services. However, the banks always keep an eye on what competitors are doing. Innovation cannot be achieved by following what others do. The authority is vigorously promoting financial innovation and digital transformation to enhance the global competitiveness of Taiwan’s financial industry.

Therefore, it is required to provide useful information in developing innovation strategies considering any difference in the intensity of market competition of banks according to their size and the promotion of financial patents to enhance competitiveness. In this study, we analyzed the degree of competition in Taiwan’s financial market using the data envelopment analysis (DEA) and the PR test for the financial data of Taiwan’s banking industry and the government’s financial data [1]. The efficiency of the operation of banks of different sizes was evaluated.

The organization of this article is as follows. After introducing the research background and purpose in Section 1, Section 2 reviews the related literature regarding financial innovation, market competition, and business performance evaluation. Section 3 describes the data set and analytical models. Finally, the research results and conclusion are presented in Sections 4 and 5.

2. Literature Review

2.1. Financial Innovation

There is no consistent standard for financial innovation. Most research extended Schumpeter’s viewpoint on innovation [2] to define financial innovation. Reference [2] claimed that innovation was the driving force for the advancement of society. Innovation was to constantly break the old framework through a cycle of continuous reorganization among new products, methods, markets, resources, and organizations. Reference [3] mentioned that financial innovation was to provide new products, new transaction models, new organizational behaviors, or new services to meet the needs of financial market participants. Financial innovation included novel financial technologies or ubiquitous equipment such as automatic teller machines (ATMs). Any change in financial-related participants, products, services, and processes can be called innovation. It is a financial phenomenon that reflects market changes in satisfying consumer demand or increasing suppliers’ profits.

Compared with innovation, the patent system has cons and pros. References [4,5] mentioned that because financial innovation was relatively easy to imitate for a new financial product, competitors could launch similar ones in the market to obtain short-term benefits. It is difficult for financial institutions to use this innovation to obtain higher returns. Reference [6] argued that the emergence of the patent system encouraged and protected the benefits brought by innovation. The patent system is open and transparent, and provides better rewards for innovations that are easy to copy but costly to develop. However, the innovation is incremental or requires multiple different combinations of technology. Benefits and protection of the patent may suffer losses due to early disclosure of information.

Taiwan’s financial regulatory authorities vigorously promote the transformation of banks and financial patents. More researchers have paid attention to the quantitative data of financial patents for their analytical value. Taiwan’s central bank pointed out that if financial institutions implement the patent system, the system becomes more suitable for financial innovation.

Reference [7] studied consumer and corporate finance banks from 1994 to 2007 in Taiwan’s financial environment. The innovation of technological services by corporate finance banks has not been effective for financial performance. However, the innovation deployed by consumer finance banks has effectively increased operating income and market share. Reference [8] showed that the banking industry gradually reduced its attention to financial innovation because the intensity of market competition increased, which let the degree of market competition and financial innovation show a negative correlation from
2003 to 2011 in Taiwan. It coincided with Schumpeter’s theory. The financial innovation of the leader can create profits but competition and imitation may weaken leaders’ willingness to re-innovate. Reference [9] suggested that banks appropriately increased employee salaries to stimulate innovation activities and create more profits. Then, better profits could allow banks to have more resources for financial innovation. Positive feedback could be formed within the enterprise.

In terms of the external environment, it was mentioned that financial innovation improved the efficiency of the public’s use of financial services and the enhancement of this momentum stimulated the invention and popularization of new technologies [10]. Conversely, changes in demand caused by technological progress and economic growth catalyzed financial innovation. Therefore, financial innovation, technological progress, and economic growth have a positive relationship. Based on the above arguments, investment in financial innovation is beneficial to the public in terms of convenience and efficiency. However, the revenue and competitiveness of banks are related to how many resources a bank needs to invest, which is the main concern of this study.

2.2. Market Competition and PR Test

For the impact of innovation, the degree of overall market competition is considered first. Two major theories were reviewed in this study to discuss innovation and market competition. One is the “Schumpeter Theory” which explains that innovative products disturb the equilibrium of a competitive market and allow gaining a short-lived monopoly [2]. In this theory, the innovator tries their best to prolong the monopoly, while the opponents try to break the innovator’s monopoly through improvement or imitation. Such a competitive relationship weakens the innovator’s willingness to re-innovate. The other is the “competition avoidance hypothesis”. Although competition causes companies lagging far behind to stop innovating, it still helps companies compete with each other and accelerate innovation because companies hope to dominate the market and lead competitors by a large margin through innovation to avoid competition [11].

The PR test [1] was used to observe the degree of market competition in the non-structural analysis by calculating the relevant degree of market competition by the H statistical value [9]. $H \leq 0$ means monopoly, $0 < H < 1$ means monopolistic competition, and $H = 1$ means perfect competition. The PR test has been widely used to evaluate competitive behavior [12]. Reference [13] used linear regression to obtain the value of H statistics. However, it also has limitations and inconveniences. For example, to use the PR test method, it must be confirmed that the overall market is in a long-term equilibrium because a whole set of sample data is what is the only way to properly calculate H statistical value. Therefore, it is more suitable to calculate the degree of market competition within a certain range but, in this case, the individual competitiveness of a single case is not examined. The degree of market competition in Asian countries from 1994 to 2008 showed perfect or exclusive competition in the banking industry [14].

2.3. Business Performance Evaluation with DEA

The traditional profit sources of the banking industry are interest income and non-interest income. Reference [15] proposed that banks with more deposits have higher risks and therefore need higher net interest margins. Therefore, the correlation between deposit scale and net interest profit margin is positive. However, smaller banks have higher profit margins than large banks. In the non-interest income of Taiwan’s banking industry, the higher the non-interest income, the lower the relative risk value [16].

For the evaluation of business performance with innovation, indicators of financial risks are used. For example, the current Basel III regulations provide a risk reference indicator for financial institutions. Reference [17] studied the relevant regulations of Basel III and pointed out that if the regulations of Basel III comply with the prediction of the bank’s Z-Score and return on asset (ROA), the bank’s default risk is reduced during the crisis. In recent years, Taiwan has referred to the capital adequacy ratio defined by Basel
II when measuring Domestic Systemically Important Banks (D-SIBs). Therefore, for the operating performance and profitability of various banks, the capital adequacy ratio needs to be considered as a relevant research factor.

Pareto proposed the idea of the non-dominance solution. Although apples and oranges cannot be compared, two oranges and three apples are better than one orange and two apples. This non-overriding solution is also called Pareto optimality. DEA adopts the concept of Pareto optimality as a mathematical model derived from the concept of technical efficiency evaluation. Reference [18] constructed a Charnes, Cooper, and Rhodes (CCR) model with various inputs and outputs assuming a fixed scale return (Constant Return to Scale (CRS)). The technical efficiency value model called the Banker, Chames, and Cooper (BCC) model was proposed assuming Variable Return to Scale (VRS) [19]. Most relevant studies were based on the expansion of the two models. Most of the DEA analysis tools provide improvement targets among variables. The most important information of the DEA model is to provide the relative efficiency of input and output factors and the most favorable results under the objective environment. The DEA model is widely used for research on the innovation and technology of the financial industry. For example, the factors affecting the technical efficiency of the US banking industry were studied using the model [20], and the result showed that the scale of the bank was positively correlated with the efficiency value.

Regardless of the businesses of the company, the core value is judged by the public based on its operating performance. Innovation is important in a competitive market. Market competitiveness and business performance are indicators of the innovation of new products, services, and models. Most of the previous studies analyzed the technical efficiency and performance of each bank in the market or its scale. The size of the banks varies all the time. Big banks are the leaders in the industry. To prevent the followers from having the opportunity to surpass, they use various innovative methods by cooperating with the government regarding government policies or securing unique customer bases. When discussing the technological innovation of the banking industry, it is appropriate to study different groups separately to observe what role banks of different sizes need to play for the competition.

3. Research Method

3.1. Data Set

We obtained the financial data from Taiwan banking companies from 2013 to 2020 in the Taiwan Economic Journal (TEJ) database and the patent information on the banking industry from the Intellectual Property Bureau of the Ministry of Economic Affairs. Because Taiwan’s banking industry is subject to government supervision, the Bank of Taiwan (BOT) is responsible for cooperating with the government, and when observing the total assets of 34 banks in 2013, the assets of BOT far exceeded those of others. Therefore, we excluded BOT. A total of 33 banking companies were selected in this study.

3.2. Segment of Banks by Scale

Based on total assets and net income in 2013, we clustered 33 banks into three groups using K-means as shown in Table 1. The banks in the leader group had a large asset size and net income.

Table 1. Three bank groups in 2013.

<table>
<thead>
<tr>
<th></th>
<th>Laggard</th>
<th>Leader</th>
<th>Chaser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of banks</td>
<td>19</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Average Total Assets (NT$ 1 m)</td>
<td>391,794</td>
<td>2,376,754</td>
<td>1,441,082</td>
</tr>
<tr>
<td>Average Net Income (NT$ 1 m)</td>
<td>8258</td>
<td>38,405</td>
<td>26,389</td>
</tr>
</tbody>
</table>

Data source: TEJ database.
3.3. Financial Patents

The number of financial patent applications in Taiwan’s banking industry was scarce before 2016, but with the development and promotion of financial technology, it has increased since 2017. The number of patents of 33 banks has increased from 158 in 2017 to more than 500 pieces per year in 2020 (Figure 1). For the types of patent applications (code of the international patent classification (IPC)), Figure 2 shows the bar chart of the patents applied for by the 33 banks. G06Q40 (finance and insurance) is the largest, followed by G06Q20 (payment solutions), G06Q10 (administrative management) and G06Q30 (e-commerce). Most patents filed by Taiwan’s banking industry focused on the application of financial technology.

![Figure 1. Number of patents publicly announced by 33 banks.](https://topic.tipo.gov.tw/patents-tw/sp_ipcq-full-101.html (accessed on 30 March 2023)).

![Figure 2. Bar chart of financial patents according to the IPC classification code of 33 banks from 2013 to 2020 (https://topic.tipo.gov.tw/patents-tw/sp_ipcq-full-101.html (accessed on 30 March 2023)).](https://topic.tipo.gov.tw/patents-tw/sp_ipcq-full-101.html (accessed on 30 March 2023)).

3.4. Market Competition by PR Test

To construct a PR Model, we set Net Revenue as a target variable and labor price (PL), capital price (PC), and price of fund (PF) as input variables. The definition of the PR Model is shown in Table 2.
Table 2. Operational definition of variables in the PR model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Role</th>
<th>Variable Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnTR</td>
<td>Target Variable</td>
<td>ln (Net Revenue)</td>
</tr>
<tr>
<td>lnPL</td>
<td>PL</td>
<td>ln (Employee salary and benefits/(Total Assets-Total Fixed Assets))</td>
</tr>
<tr>
<td>lnPC</td>
<td>PC</td>
<td>ln (the other administration and operating expense/Total Fixed Assets)</td>
</tr>
<tr>
<td>lnPF</td>
<td>PF</td>
<td>ln (Interest expense/Deposit amount)</td>
</tr>
<tr>
<td>lnTA</td>
<td>Control Variable</td>
<td>ln (Total Assets)</td>
</tr>
<tr>
<td>lnBIS</td>
<td>Control Variable</td>
<td>ln (Capital adequacy ratio)</td>
</tr>
<tr>
<td>lnPT</td>
<td>Control Variable</td>
<td>ln (Effective number of patents)</td>
</tr>
<tr>
<td>lnLR</td>
<td>Control Variable</td>
<td>ln (Overdue loan ratio)</td>
</tr>
</tbody>
</table>

The relationship between market competition and innovation is presented in the PR Model (Equation (1)). H statistics are determined by Equation (2).

\[
\ln TR = \alpha + \beta_1 \ln PL + \beta_2 \ln PC + \beta_3 \ln PF + \gamma_1 \ln TA + \gamma_2 \ln BIS + \gamma_3 \ln PT + \gamma_4 \ln LR, \tag{1}
\]

\[
H \text{ statistics} = \beta_1 + \beta_2 + \beta_3, \tag{2}
\]

where \(\beta_1, \beta_2,\) and \(\beta_3\) are estimated from Equation (1).

3.5. Input and Output of DEA Model

In the analysis of relative cost efficiency, the input and output are as follows.

- Input: operating expenses, net self-owned capital, and total deposits.
- Output: total risk assets and total loans.

Output is at a fixed level, and input is relative efficiency.

The relative revenue efficiency analysis factors are as follows.

- Input: total risky assets, total loans, interest expenses.
- Output: fee income, interest income.

When the input is assumed to be fixed, the relative efficiency of output is obtained. Input-oriented efficiency (cost-relative efficiency) of the CCR model is represented by Equations (3)–(5), while the output-oriented efficiency (revenue-relative efficiency) is referred to Ref. [21].

\[
\min H_k = \theta - \epsilon \left( \sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+ \right), \tag{3}
\]

s.t. \[
\sum_{j=1}^{n} \lambda_j X_{ij} + S_i^- = 0 X_{ik}, \tag{4}
\]

\[
\sum_{j=1}^{n} \lambda_j Y_{rj} - S_r^+ = Y_{rk}, \tag{5}
\]

\(H_k\) = relative efficiency value of the \(k\)th DMU.
\(\theta = 1\) represents efficient.
\(\lambda_j\) = relative efficiency value of the \(j\)th DMU.
\(X_{ij}\) = the \(i\)th input of the \(j\)th DMU.
\(Y_{rj}\) = the \(r\)th output of the \(j\)th DMU.
\(S_i^-\) = the \(i\)th input slack.
\(S_r^+\) = the \(r\)th output surplus.
\(n\) = the number of DMU.
\(m\) = the number of inputs.
\(s\) = the number of outputs.
4. Result and Discussion

4.1. PR Model Analysis

Table 3 shows the results of three bank groups during 2013–2016 and 2017–2020. The PR model adopted a regression method. The explanatory power of each group’s model was above 80%. The degree of market competition of the Leader group was 0.9771 from 2013 to 2016, and 1.033 from 2017 to 2020, indicating a state of perfect competition. The degree of the Chaser group was 0.4319 from 2013 to 2016 and increased to 0.5456 from 2017 to 2020. The degree of the Laggard group was 0.1468 from 2013 to 2016 and 0.0942 from 2017 to 2020, which indicated that the degree of market competition was monopolistic. However, the PR model only calculated the H statistics within a group. Thus, it did not show the changes in the individual competitiveness and technology gap of a single bank. Therefore, the DEA model was used to explore the changes and relationships between the technical efficiency and business performance of each bank.

Table 3. Market competition analysis using H statistics.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>lnPC</td>
<td>0.3248 ***</td>
<td>0.1688 ***</td>
<td>−0.0487</td>
<td>−0.2494 *</td>
<td>−0.0034</td>
<td>0.0599 *</td>
</tr>
<tr>
<td>lnPF</td>
<td>−0.1129</td>
<td>0.1193 *</td>
<td>0.2049 *</td>
<td>0.022</td>
<td>−0.2136 ***</td>
<td>−0.0948</td>
</tr>
<tr>
<td>lnPL</td>
<td>0.7652 ***</td>
<td>0.7449 ***</td>
<td>0.2757 *</td>
<td>0.7731 *</td>
<td>0.3637 ***</td>
<td>0.1292</td>
</tr>
<tr>
<td>lnTA</td>
<td>0.8153 ***</td>
<td>0.78 ***</td>
<td>0.4459 ***</td>
<td>1.052 ***</td>
<td>0.9048 ***</td>
<td>0.9554 ***</td>
</tr>
<tr>
<td>lnBIS</td>
<td>0.156</td>
<td>0.5622 *</td>
<td>1.172 ***</td>
<td>0.8665 *</td>
<td>0.986 ***</td>
<td>1.1506 ***</td>
</tr>
<tr>
<td>lnPT</td>
<td>0.0125</td>
<td>0.002</td>
<td>−0.1798 *</td>
<td>−0.0692 *</td>
<td>0</td>
<td>−0.0167</td>
</tr>
<tr>
<td>lnLR</td>
<td>−0.001</td>
<td>0.1104 ***</td>
<td>−0.2355 ***</td>
<td>−0.22</td>
<td>−0.0385</td>
<td>−0.0338</td>
</tr>
<tr>
<td>H statistics</td>
<td>0.9771</td>
<td>1.033</td>
<td>0.4319</td>
<td>0.5456</td>
<td>0.1468</td>
<td>0.0942</td>
</tr>
<tr>
<td>R-square</td>
<td>0.9712</td>
<td>0.9848</td>
<td>0.8964</td>
<td>0.8452</td>
<td>0.9181</td>
<td>0.9287</td>
</tr>
<tr>
<td>Adjusted R-square</td>
<td>0.9611</td>
<td>0.9795</td>
<td>0.8601</td>
<td>0.791</td>
<td>0.9097</td>
<td>0.9214</td>
</tr>
<tr>
<td>Number of observations</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>Market Competition</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Change in Competition</td>
<td>Increase</td>
<td>Increase</td>
<td>Decrease</td>
<td>Decrease</td>
<td>Decrease</td>
<td>Decrease</td>
</tr>
</tbody>
</table>

*** p < 0.01, * 0.01 < p < 0.1.

4.2. CCR Model Results of Leader Group

Using the annual data from 2013 to 2020, the CCR model was used to obtain the input-oriented and the output-oriented efficiency (Figure 3). The relative cost efficiency and revenue efficiency of most banks in the Leader Group were above 75%. The relative cost efficiency of Cathay United Bank (Tick No: 5835) in 2020 was lower than 75%. The relative revenue efficiency of private banks was better than that of quasi-public banks. In 2013 and 2020, the Land Bank of Taiwan (Tick No: 5857) showed the best relative cost efficiency. In 2020, the gap between the relative cost efficiency of all banks and the Land Bank increased significantly. Most banks showed stable or slightly declined relative revenue efficiency. Only Taiwan Cooperative Bank (Tick No: 5854) increased efficiency by 5.50% from 79.20 to 84.70%.

Figure 4 shows that, since 2017, the number of financial patents increased significantly. In terms of the number of effective patents in the three bank groups, the Leader group and Chaser group accounted for 95%. We analyzed the patents of the two groups. According to the statistics, from 2017 to 2020, the number of patents by quasi-public banks was 981, and that by private banks was 334 (Figure 5). Table 4 shows the correlation coefficient between the number of effective patents and financial performance variables.
**Figure 3.** Scatter plot of CCR Model for Leader Group based on cost efficiency and revenue efficiency in 2013 and 2020.

**Figure 4.** Number of effective patents of the three bank groups. (ps. Blue bars belong to Leader group; orange bars belong to Chaser group; purple bars belong to Lagger group).

**Figure 5.** Statistics on number of invention and new model patents from 2017 to 2020. (Seven quasi-public banks).
Table 4. Correlation coefficient table between the number of effective patents and financial performance variables.

<table>
<thead>
<tr>
<th></th>
<th>Private Banks</th>
<th>Quasi-Public Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>net self-owned capital</td>
<td>0.59</td>
<td>0.49</td>
</tr>
<tr>
<td>total deposits</td>
<td>0.66</td>
<td>0.5</td>
</tr>
<tr>
<td>total loans</td>
<td>0.66</td>
<td>0.46</td>
</tr>
<tr>
<td>fee income</td>
<td>0.59</td>
<td>0.55</td>
</tr>
<tr>
<td>interest income</td>
<td>0.57</td>
<td>0.31</td>
</tr>
</tbody>
</table>

5. Conclusions

Using financial innovation and efficiency analysis, we studied the current market competition in Taiwan’s banking industry and the differences in the efficiency of their operations in different groups of banks. It was reviewed whether individual banks had to strengthen their investment in financial innovation or just follow in the footsteps of leaders. The analysis result of effective patents (Figure 5 and Table 4) showed that the correlation between the number of effective patents and financial performance variables of quasi-public banks was less significant than that of private banks. In cost and revenue efficiency (Figure 3), quasi-public banks showed lower values than private banks. The number of inventions and patents of quasi-public banks was about three times higher than that of private banks (Figure 5). The degree of market competition in the Lagger group showed monopolistic characteristics. They showed decreased efficiencies and less investment in patents. This unwillingness to invest in increasing patents and strengthening market competitiveness coincided with the “escape from competition hypothesis”. The banks were losing their motivation to invest in innovation. The Leader group was in the phase of perfect competition. In the market competition of the Chaser group, the changes in the competition degree were rapid in the two periods. During the eight years, two banks had caught up with the leader group in terms of the size.

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