Effect of Fintech on the Productivity in the Taiwan Banking Industry

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Abstract: The development of financial technology has fostered a wave revolutionary change in financial service industry worldwide. The objective of this study is to examine whether the adoption of Fintech contributes to the productivity growth of the Taiwan banking industry in 2015. To investigate such potential effect, the study use the preferred Cost Malmquist Index to estimate the 25 listed sample banks over the period from 2010 to 2015. The empirical result suggests the observed period 2014-2015, the $\Delta PTE$, $\Delta AE$, $\Delta PE$, and $\Delta CSE$ are improving by 0.01%, 0.13%, 0.42%, and 0.10% respectively. Moreover, the degree of $\Delta T$ deterioration is much improved relative to the other observe periods without adoption of Fintech. It provides the positive evidence to support an adoption of Fintech contribute a potential growth of competitiveness of the Taiwan banking industry.

Key words: Cost Malmquist productivity index, bank productivity, fintech.

1. Introduction

The theory of modern financial intermediation suggests that the security, privacy, trust and information asymmetry are the niches of the existence of financial intermediaries. Nevertheless, the traditional financial intermediary requires many layers to obtain such quality. In the aftermath of the 2008 U.S. financial crisis, consumers has casted a doubt on the efficiency of the traditional financial intermediary. Driven by this force and the advances of technology, several savvy start-ups using financial technology has foster a wave of Fintech revolutionary which is actually taking out the market share and changing the landscape of financial incumbent. These destructive innovations spans in four aspects, infrastructure, money and payment, market, and marketplace, for example, Bitcoin, robot advisor, and P-to-P lending. Overall, those innovations of Fintech have provided more convenient, secure, and efficient services to the consumers. Thus, the effectiveness of disruptive innovation actually resides on the removing of the layers of intermediaries which have long embedded in the traditional financial services. The global Fintech development activity is relative slow from 2008 to 2011 but become explosive in 2015. The Fintech has spreading from the U.S.A., Europe, and the Asia since 2015.

To ensure the soundness of financial system and sustainable growth of the financial institutions in the revolutionary Fintech era, Taiwan Financial Supervisory Commission (TFSC) has declared 2015 as the first year of Fintech in Taiwan and announced a series of policies to promote the development and applications
of Fintech in its financial industry. On May 12, 2016, TFSC further announced the Fintech Development Strategy White Paper which discloses its vision and policy directions regarding the revolutionary Fintech Innovation, and its proposed landscape of Taiwan Fintech society in 2020. TFSC has allowed financial institutions to own 100% share of the Fintech firms. To secure their landscape and sustainable growth, several major Taiwan domestic banks have fostered a wave of innovation to cope with the hyper competition from new Fintech start-ups. A sound cost efficiency and productivity is very important to the sustainable growth of Taiwanese financial institutions. Thus, an evaluation of the effect of adoption Fintech on the productivity of banking industry has become an important issue. The objective of this study is to examine the effect of Fintech development on the productivity in the Taiwan banking industry.

The remainder of this paper is organized as follows. Section 2 presents a review of the relevant literature. Section 3 provides a discussion of the methodology used in the study, which is followed by an evaluation of the results on Section 4. The paper concludes with a summary analysis of the findings in Section 5.

2. Review of Literature

Recently, the Cost Malmquist productivity Index (CM) approach has been evolved as a preferred approach to estimate productivity change [1]-[3], (Maniadakis and Thanassoulis, 2004: Yang and Huang, 2009: Yang, Huang and Sheng, 2010). The origination of the CM approach can be traced to the master piece of Maniadakis et al. (2004). Before the work of Maniadakis et al. (2004), the research of productivity namely used the traditional production-based Malmquist indexes which failed to capture one of the most important aspects of managements, the allocative efficiency. Maniadakis et al. (2004) [1] suggested that the impact of allocative efficiency change on productivity change should be accounted for in the model. Since then the CM has become a preferred approach in the estimation of productivity.

Previous literature has well documented that the variable returns to scale (VRS) is more flexible and envelopes the data in a tighter way than the constant returns to scale (CRS) under DEA approach (Yang et al., 2009) [2]. Departing from the work of Maniadakis et al. (2004), Yang et al. (2009) relief the assumption of CRS and proposed an alternative CM based on the VRS to estimate productivity change. Their empirical result further provide evidence to support that the CM approach outperform the traditional approach in the sense that the alternative approach convey inside cost information which carry important managerial implication.

3. Methodology

Assume that at time period t a decision making unit (DMU) or a Taiwan’s bank uses N inputs \((x^t)\) to produce M outputs \((y^t)\). The production technology at time t defines the input requirement set as: \(L'(y^t) = \{x': x' \text{ can produce } y^t\}\). The input distance function \([4]-[6]\) (Shepherd 1970; Färe 1988; Färe et al. 1994) is defined at time t as: \(D^t_f(y^t, x^t) = \sup_{\rho} \{ \rho : (x'/\rho) \in L'(y^t), \rho > 0 \}\). The input distance function is the reciprocal of the Farrell’s (1957) \([7]\) input-oriented measure of efficiency and so \(D^t_f(y^t, x^t)\) can be used to measure production technical efficiency at time period t, i.e.,

\[
TE^t_f(y^t, x^t) = \frac{1}{D^t_f(y^t, x^t)} \leq 1
\] (1)

A similarly defined distance function, denoted by \(D^{t+1}_f(y^{t+1}, x^{t+1})\), can be used to measure efficiency in time period t+1, i.e. \(TE^{t+1}_f(y^{t+1}, x^{t+1}) = 1/D^{t+1}_f(y^{t+1}, x^{t+1})\). In order to assess change in productivity over
time or the Malmquist index, two mixed-period input distance functions need to be defined as:

\[
D_{E_{t}^{(1)}}(y_i^{(1)}, x_i^{(1)}) = \sup_{\rho} \left\{ \rho : (x_i^{(1)} / \rho) \in L'(y_i^{(1)}), \rho > 0 \right\}
\]

and

\[
D_{E_{t}^{(1)}}(y', x') = \sup_{\rho} \left\{ \rho : (x' / \rho) \in L_{E_{t}^{(1)}}(y'), \rho > 0 \right\}.
\]

When input prices, \( w' \in R^N_+ \), are available, one may define the production technology in terms of cost function, which is

\[
C'(y', w') = \min_{x} \left\{ w'x : x \in L(y'), w' > 0 \right\}
\]

The cost function, \( C'(y', w') \), which is dual to the input requirement set \( L(y') \) of production, is the minimum cost of producing a given output \( y' \) with the input prices at \( w' \) under the \( t \)th period technology. Corresponding to the input distance function or the input-oriented technical efficiency, the \( t \)th period cost efficiency \( CE'(y') \) is defined as

\[
CE'(y', x', w') = \frac{C'(y', w')}{w'x'} \leq 1
\]

Had the outputs \( y_t \) were produced under the \((t+1)\) production technology and input prices at \( w_{t+1} \), the cost function would be \( C_{t+1}^{(1)}(y_i^{(1)}, w_i^{(1)}) = \min_{x} \left\{ w_i^{(1)}x : x \in L_{t+1}(y_i^{(1)}), w_i^{(1)} > 0 \right\} \). Similarly, \( C'(y_i^{(1)}, w_i^{(1)}) = \min_{x} \left\{ w_i^{(1)}x : x \in L_i(y_i^{(1)}), w_i^{(1)} > 0 \right\} \). Thus, \( C_{t+1}^{(1)}(y_i^{(1)}, w_i^{(1)}) \) and \( C'(y_i^{(1)}, w_i^{(1)}) \) are the mixed-period minimum cost functions. The corresponding mixed-period cost efficiencies are

\[
CE_{t+1}^{(1)}(y_i^{(1)}, x_i^{(1)}, w_i^{(1)}) = \frac{C_{t+1}^{(1)}(y_i^{(1)}, w_i^{(1)})}{w_i^{(1)}x_i^{(1)}} \quad \text{and} \quad CE_i'(y_i^{(1)}, x_i^{(1)}, w_i^{(1)}) = \frac{C_i'(y_i^{(1)}, w_i^{(1)})}{w_i^{(1)}x_i^{(1)}}.
\]

Dual to the measure of the production Malmquist productivity index, the Cost Malmquist productivity index is defined as the geometric mean of the two ratios of cost efficiency,

\[
CM = \left[ \frac{CE_{t+1}^{(1)}(y_i^{(1)}, x_i^{(1)}, w_i^{(1)}) \times CE_{t+1}^{(1)}(y_i^{(1)}, x_i^{(1)}, w_i^{(1)})}{CE_i'(y_i^{(1)}, x_i^{(1)}, w_i^{(1)}) \times CE_i'(y_i^{(1)}, x_i^{(1)}, w_i^{(1)})} \right]^\frac{1}{2}
\]

The Cost Malmquist productivity index \((4)\) measures the change over time in cost efficiency. Parallel to the decomposition of production Malmquist productivity index, the CM may be decomposed into the effects due to the improvement in production technology, in production efficiency, due to variation in input prices and production scale. Recently, Maniadakis et al. (2004) have proposed a decomposition of CM under the assumption of constant returns to scale technology. However, since the evidence shown that the sample banks operation in Taiwan is more likely subject to variable returns to scale, we further extend the decomposition of the Cost Malmquist productivity index under the variable returns to scale.

It can be shown that the Cost Malmquist productivity index \( CM \) can be decomposed as follows:

\[
CM = \Delta PTE \times \Delta T \times \Delta AE \times \Delta PE \times \Delta CSE
\]
where the first component $\Delta PTE$ is the pure technical efficiency change and the second component $\Delta T$ is the technical change can be defined as follow:

$$\Delta PTE = \frac{D^t_{IV}(y, x)}{D^t_{IV}(y', x')} - TE^t_{IV}(y, x') \frac{TE^t_{IV}(y', x')}{TE^t_{IV}(y, x)}$$

$$\Delta T = \left[ \frac{D^t_{IV}(y, x)}{D^t_{IV}(y', x') \times D^t_{IV}(y', x')} \times D^t_{IV}(y', x') \right]^{\frac{1}{2}}$$

The third component $\Delta AE$ is the allocative efficiency change defined as

$$AE = \frac{C^t_{IV}(y, w) \times D^t_{IV}(y', w') / w'x'}{C^t_{IV}(y, w) \times D^t_{IV}(y', w') / w'x'}$$

The subscript "V" under the cost function indicates the measure of production cost under variable returns to scale technology. The numerator, as shown by Maniadakis et al. (2004) and denoted as $AE(y', x', w') = C^t_{IV}(y', w') \times D^t_{IV}(y', w') / w'x'$, is the input-oriented measure of allocative efficiency at time period t. The $\Delta AE$ represents the change over time the allocative efficiency, $\Delta AE = AE^t_{IV}(y', x', w') / AE^{t+1}_{IV}(y', x', w')$. If the allocative efficiency $AE^t_{IV}(y', x', w') = 1$, it implies that the cost efficiency is identical the technical efficiency.

The fourth component of the Cost Malmquist decomposition $\Delta PE$ is the price effect change, i.e.,

$$\Delta PE = \left[ \frac{C^t_{IV}(y, w) \times D^t_{IV}(y', x') / w'x'}{C^t_{IV}(y, w) \times D^t_{IV}(y', x') / w'x'} \times \frac{C^t_{IV}(y, w) \times D^t_{IV}(y', x') / w'x'}{C^t_{IV}(y, w) \times D^t_{IV}(y', x') / w'x'} \right]^{\frac{1}{2}}$$

The first term inside the brace measures the impact of relative input price changes from $w'$ to $w^{t+1}$ on the shift of minimum cost frontiers in producing $(y', x')$, while the second term measures the shift in producing $(y^{t+1}, x^{t+1})$. The input effect change $\Delta PE$ is then defined as the geometric mean of the terms.

The fifth component of the Cost Malmquist decomposition $\Delta CSE$ represents the cost scale efficiency change, i.e.,

$$\Delta CSE = \left[ \frac{C^t_{IV}(y, w) \times C^t_{IV}(y', w')}{C^t_{IV}(y, w) \times C^t_{IV}(y', w')} \times \frac{C^t_{IV}(y, w) \times C^t_{IV}(y', w')}{C^t_{IV}(y, w) \times C^t_{IV}(y', w')} \right]^{\frac{1}{2}}$$

Each term of the ratio, for example, $\Delta CSE^t(y', w') = \frac{C^t_{IV}(y', w')}{C^t_{IV}(y, w)}$ measures the efficiency of getting closer to optimum scale size in minimizing the cost of producing $y'$ at input price $w'$. Thus, the cost scale
efficiency change, \( \Delta CSE \) is defined as the geometric mean of the cost efficiency at scale sizes \( y^t \) and \( y^{t+1} \) in \( t \) and \( (t+1) \) periods.

Thus, overall the decomposition of the Cost Malmquist productivity index is as follows:

\[
CM = \Delta PTE \times \Delta T \times \Delta AE \times \Delta PE \times \Delta CSE
\]

(10)

Values of the above five components, \( \Delta PTE, \Delta T, \Delta AE, \Delta PE \) and \( \Delta CSE \), of greater than unity suggest deterioration, while values of less than unity suggest the improvement.

To compute and decompose the Cost Malmquist productivity index \( CM \) requires the computation of the minimum cost function under both VRS and CRS technologies, \( C^t \) and \( C^t_C \). For the \( k \)th DMU (i.e. sample bank) \( C^t_k \) is computed from the following linear programming problems:

\[
\text{Min } x, \lambda \quad w^{t}_{kn} x_n = C^t_V(y^t, w^t)
\]

(11)

subject to

\[
\sum_{j=1}^{J} \lambda_{j} y^t_{jn} \geq y^t_{kn}, \quad m = 1, 2, ..., M
\]

\[
\sum_{j=1}^{J} \lambda_{j} = 1
\]

\[
\lambda_{j} \geq 0, x_{n} \geq 0.
\]

For the minimum cost function \( C^t_C(y^t, w^t) \) under the constant returns to scale technology, it can be calculated by relaxing the constraint \( \sum_{j=1}^{J} \lambda_{j} = 1 \) from (11). As for the mixed-period cost function \( C^t_C(y^{t+1}, w^{t+1}) \), it can be similarly computed as follows:

\[
\text{Min } x, \lambda \quad w^{t}_{kn} x_n = C^t_V(y^{t+1}, w^t)
\]

subject to

\[
\sum_{j=1}^{J} \lambda_{j} y^{t+1}_{jn} \geq y^{t+1}_{kn}, \quad m = 1, 2, ..., M
\]

\[
\sum_{j=1}^{J} \lambda_{j} = 1
\]

\[
\lambda_{j} \geq 0, x_{n} \geq 0.
\]
\[ \sum_{j=1}^{I} \lambda_j = 1, \lambda_j \geq 0, x_n \geq 0. \]

Other cost functions, \( C_x^{c+1}(y, w^{c+1}) \), \( C_x^{c+1}(y', w^{c+1}) \), \( C_C^{c+1}(y, w^{c+1}) \), and \( C_C^{c+1}(y', w^{c+1}) \) are similarly obtained with and without the constraint \( \sum_{j=1}^{I} \lambda_j = 1. \)

4. Empirical Results

This study uses a balanced panel data of 25 listed Taiwanese banks from 2010 to 2015. The data are collected from the TEJ database, Financial Statistics Monthly which is published by the Central Bank of Taiwan. All the nominal variables have been deflated by the annual consumer price index of Taiwan with the base year being 2010. The study adopts intermediation approach to select input and output variables. In addition to total loans \( (Y_1) \) and investments \( (Y_2) \), non-interest revenues \( (Y_3) \) was taken as an output variable, to account for the increasing proportion of fee income in bank revenue. Input variables include labor input \( (X_1) \), borrowed funds \( (X_2) \), and physical capital \( (X_3) \). The input price variables include labor price \( (W_1) \) (Personnel expenses / labor input), funds price \( (W_2) \) (Deposit and loan interest expenditure / borrowed funds) and Capital price \( (W_3) \) (Business and management expenses labor cost / physical capital).

All of the sample banks are commercial banks, therefore the banking activities are very much in line with each other. However, there are considerable variations in bank size. Moreover, the use of output growth to assert the increase of productivity faced the potential criticism that the increase of some DMU outputs were mainly from the accumulation and increase of factors and less from the technology advancement and efficiency improvement [8]. Therefore, the introduction and decomposition of CM are essential. Table 1 summarizes the descriptive statistics of all 25 sample banks over the observed periods.

<table>
<thead>
<tr>
<th>Year</th>
<th>Y1 Mean</th>
<th>Y2 Mean</th>
<th>Y3 Mean</th>
<th>X1 Mean</th>
<th>X2 Mean</th>
<th>X3 Mean</th>
<th>P1 Mean</th>
<th>P2 Mean</th>
<th>P3 Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>769000000</td>
<td>270000000</td>
<td>3896193</td>
<td>4671</td>
<td>1020000000</td>
<td>16138410</td>
<td>6502</td>
<td>8569942</td>
<td>11032377</td>
</tr>
<tr>
<td>2011</td>
<td>636000000</td>
<td>224000000</td>
<td>2593204</td>
<td>4801</td>
<td>892000000</td>
<td>9295694</td>
<td>6024</td>
<td>6881394</td>
<td>9706874</td>
</tr>
<tr>
<td>2012</td>
<td>2410000000</td>
<td>1450000000</td>
<td>27361743</td>
<td>10708</td>
<td>3850000000</td>
<td>813000000</td>
<td>861880</td>
<td>36453834</td>
<td>38540275</td>
</tr>
<tr>
<td>2013</td>
<td>70217208</td>
<td>2583171</td>
<td>348633</td>
<td>865</td>
<td>108000000</td>
<td>861880</td>
<td>873</td>
<td>914619</td>
<td>1492594</td>
</tr>
<tr>
<td>2014</td>
<td>601000000</td>
<td>253000000</td>
<td>3435750</td>
<td>4598</td>
<td>940000000</td>
<td>1583208</td>
<td>6018</td>
<td>7761437</td>
<td>1026088</td>
</tr>
<tr>
<td>2015</td>
<td>538000000</td>
<td>161000000</td>
<td>265625</td>
<td>483</td>
<td>800000000</td>
<td>9295694</td>
<td>6024</td>
<td>4926725</td>
<td>9636106</td>
</tr>
</tbody>
</table>

Table 1. Descriptive Statistics by Taiwan Bank Industries for a Time Period 2010-2015
Table 2 summarizes results of the CM productivity indexes and component values for the entire sample banks in Taiwan from 2010 to 2015. CM is decomposed into \( \Delta \text{PTE} \), \( \Delta T \), \( \Delta \text{AE} \), \( \Delta \text{PE} \), and \( \Delta \text{CSE} \). The results were computed using the models presented in Section 3. \( \Delta \text{CSE} \) is 1.0001 in table 2 that indicates the VRS exists in Taiwan Banking industry for the observation period. Departing from traditional approach, a value of index greater than one indicates deterioration, while a value of index less than one indicates an improvement. In the entire observation period, \( \Delta \text{PE} \) is improving, \( \Delta \text{PTE} \) remains constant, \( \Delta T \), \( \Delta \text{AE} \) and \( \Delta \text{CSE} \) are slightly decreasing. It indicates that 0.18% CM index loss is significantly caused by \( \Delta T \), \( \Delta \text{AE} \) and \( \Delta \text{CSE} \). Our empirical results show that allocative efficiency change improve by 0.6% which indicate that \( \Delta T \), \( \Delta \text{AE} \) and \( \Delta \text{CSE} \) are important factors contributing to the productivity loss of sample banks over the full observed period. This evidence further reconfirms that the CM outperform traditional IM approach in the sense that CM captures more insight managerial information on the productivity change.

The column 2 of Table 2 indicates CM index are slightly greater than 1, which reveals that each of the subperiods 2010 to 2014 sample banks encountering productivity loss. However the sources that productivity decrease may come from many various resources. In comparision to the other observed time period, the 2014-2015 period, CM has the most significant decrease, 0.47%. \( \Delta T \) is 1.0021 indicating a 0.21% decrease in technology, is the major source of change. While the other components, \( \Delta \text{PTE} \), \( \Delta \text{AE} \), \( \Delta \text{PE} \), \( \Delta \text{CSE} \) are improving.

Table 2. CM Index and Component Values of Taiwan Bank Industries for a Time Period 2010-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>CM</th>
<th>( \Delta \text{PTE} )</th>
<th>( \Delta T )</th>
<th>( \Delta \text{AE} )</th>
<th>( \Delta \text{PE} )</th>
<th>( \Delta \text{CSE} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Year</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>2010-2011</td>
<td>1.0014</td>
<td>0.9999</td>
<td>1.0025</td>
<td>1.0017</td>
<td>0.9943</td>
<td>1.0003</td>
</tr>
<tr>
<td>2011-2012</td>
<td>1.0025</td>
<td>1.0001</td>
<td>1.0018</td>
<td>1.0016</td>
<td>0.9944</td>
<td>0.9998</td>
</tr>
<tr>
<td>2012-2013</td>
<td>1.0007</td>
<td>1.0004</td>
<td>1.0030</td>
<td>1.0013</td>
<td>0.9937</td>
<td>1.0011</td>
</tr>
<tr>
<td>2013-2014</td>
<td>1.0018</td>
<td>0.9998</td>
<td>1.0039</td>
<td>1.0002</td>
<td>0.9942</td>
<td>1.0004</td>
</tr>
<tr>
<td>2014-2015</td>
<td>1.0047</td>
<td>0.9999</td>
<td>1.0021</td>
<td>0.9987</td>
<td>0.9958</td>
<td>0.9990</td>
</tr>
<tr>
<td>Full period</td>
<td>1.0018</td>
<td>1.0000</td>
<td>1.0022</td>
<td>1.0006</td>
<td>0.9954</td>
<td>1.0001</td>
</tr>
</tbody>
</table>

\[ \text{CM} = \Delta \text{PTE} \times \Delta T \times \Delta \text{AE} \times \Delta \text{PE} \times \Delta \text{CSE} \]

5. Conclusion

The development of financial technology has fostered a wave of revolutionary change in financial service industry worldwide. In fact, the Fintech start-ups provide divinity of banking services in a trustable and
much efficient way which are taking out the market share and changing the landscape of financial incumbent. The evaluation of productivity change during the Fintech era has become a very important issue. On the other hand, the CM approach has evolved as a more preferred approach to the measurement of firm productivity. The objective of this study is to investigate the effect of Fintech on the productivity in the Taiwan banking industry. To investigate such potential effect, the study use the CM, to estimate the 25 listed sample banks over the period from 2010 to 2015. The empirical result suggests the observed period, 2014-2015, the \( \Delta \text{PTE}, \Delta \text{AE}, \Delta \text{PE}, \) and \( \Delta \text{CSE} \) are improving by 0.01%, 0.13%, 0.42%, and 0.10% respectively. Consistent with the objective of Fintech development, which attends to provide banking service in a more efficient operation and less cost. Although the level of technology improvement requires longer time horizon, but the above captioned index reveals that the adoptions of financial technology proposed by bank regulators carry the positive effect on the overall competitiveness of the banking industry in Taiwan.

References


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