Does Information Technology Always Help? Theory and Evidence from Taiwan's Banking Industry

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Information technology (IT) has been extensively adopted in banking industries, ranging from the introduction of automated-teller-machines, to phone-banking, tele-banking, PC banking and most recently internet banking. The reasons for this massive adoption of IT are mainly twofold: for individual banks, IT can reduce banks' operational costs (the cost advantage), and facilitate transactions among customers within the same network (the network effect). Thus it seems perfectly safe to argue that the introduction of IT service can enhance profits in the banking industry and hence this explains the mass rapidity in adoption.

This point of view, however, is not commonly shared by empirical studies. For example, Shu and Strassmann (2005) study 12 banks operating in USA, covering data from 1989 to 1997, and find out that although IT has been one of the most marginal productive factors among all inputs, it *cannot* increase banks' profits. Similarly, in more general studies covering all industries, Bermdt et al. (1992), Bermdt and Morrison (1995), Loveman (1988, 1994), Morrison and Berndt (1990) found that IT has *no significant* or even negative contribution to corporate profits.

This inconsistency in empirical results motivates us to contemplate IT's influence to the whole industry, rather than to the individual banks. It would be appealing to ask: When all banks in the industry have the same access to this cost-saving technology, will the cost advantage from adopting IT vanishes due to competition (in particular, price competition in banking industries)? Will the presence of multiple networks bring determinative benefits to each bank in the industry? The purpose of our paper is to provide the answers by investigating the equilibrium in a differentiated product model with network effects, and identify factors affecting each effect of IT. Then the testable results are examined empirically with the data from the banking industry in Taiwan, covering 47 domestic commercial banks from 1991 to 2004.

1. The Model

To cope with the observation that banks provide highly differentiated products, we adopt a simple location model (see Hotelling, 1929) with two competitive banks and infinitely many heterogenous consumers. That is, let A and B be two competitive banks in a banking industry, charging P^A and P^B for service. Without loss of generosity, assume a continuum of potential consumers indexed by x on the unit interval $[0, 1]$. To simplify, assume that bank A is located at 0, while bank B is located at 1. Each consumer chooses the service according to her valuation on service, service charges and the preference difference between her and the bank that provides the service.

Consider that bank A and B spend E^A and E^B on IT, respectively. For individual bank, the adoption of IT can reduce the operational cost (from c to null), and create

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a network effect to customer service. The network effect is captured by Rohlfs' (1974) setting where the valuation of service is positively related to the number of consumers in the same service. To distinguish the networks associated with different IT expenditures, rewrite the valuation of consuming bank i's service by $V^i(E^i)$, which is an increasing function of E^i.

Let n^A and n^B denote the number of consumers for bank A and B's service, respectively. A consumer x's utility is defined by (see also Shy, 1997)

$$\begin{aligned} U^x &= n^A V^A(E^A)\text{-}(x)\text{-}p^A \text{ for bank A;} \\ & \quad n^B V^B(E^B)\text{-}(1\text{-}x)\text{-}p^B \text{ for bank B} \end{aligned} \quad (1)$$

Now consider an indifferent consumer $\widehat{x}$, who is indifferent between consuming service from bank A or B, i.e., $n^A V^A(E^A) - (x) - p^A = n^B V^B(E^B) - (1-x) - p^B$. It is easily seen that for consumers $x < \widehat{x}$, service of bank A will be chosen; while for consumers $x > \widehat{x}$, service of bank B will be chosen. Thus we have $n^A = \widehat{x}$ and $n^B = 1 - \widehat{x}$. Replace n^i in the indifference condition, we have $\widehat{x} V^A(E^A) - (\widehat{x}) - p^A = (1-\widehat{x}) V^B(E^B) - (1-\widehat{x}) - p^B$, or alternatively

$$\widehat{x} = \frac{(1 - V^B(E^B)) - (p^A - p^B)}{2 - (V^A(E^A) + V^B(E^B))}.$$

Given the demand n^A and n^B, each bank i, $i = A, B$, chooses price p^i to maximize its profit π^i, where notice that the adoption of IT has cut the operational cost from c to null, but instead created an extra expenditure of adoption E^i.

Again, to simplify the analysis, the calculation is omitted here. The equilibrium prices after the adoption of IT are $p^A = \frac{(3-2V^B(E^B)-V^A(E^A))}{3}$ and $p^B = \frac{(3-V^B(E^B)-2V^A(E^A))}{3}$. In particular, the price difference p^A-$p^B = \frac{(V^A(E^A)-V^B(E^B))}{3}$. Moreover, the equilibrium demand for bank A is $n^A = \frac{3-V^A(E^A)-2V^B(E^B)}{6-3(V^A(E^A)+V^B(E^B))}$. Finally, the equilibrium profits after the adoption of IT are $\pi^A = (\frac{(3-2V^B(E^B)-V^A(E^A))}{3})\frac{3-V^A(E^A)-2V^B(E^B)}{6-3(V^A(E^A)+V^B(E^B))}$-$E^A$, and $\pi^B = (\frac{(3-V^B(E^B)-2V^A(E^A))}{3})\frac{3-2V^A(E^A)-V^B(E^B)}{6-3(V^A(E^A)+V^B(E^B))}$-$E^B$.

A comparison between these the equilibrium before the adoption of IT (which is omitted in this abstract) and the adoption after the adoption gives the following results. First, the adoption of IT can reduce the equilibrium prices. In addition to the reduction of operational cost, there is also an effect from network competition, i.e., more expenditure can not only reduce own prices, but also reduce the prices charged by the rival bank. Furthermore, if $V^A > V^B$, then bank A is the larger bank before the adoption of IT. If large bank spends more on IT, i.e., $E^A > E^B$, then the decrease in equilibrium price will be higher with large bank. Second, we compare the demand (i.e., $\frac{n^A}{n^B}$) for before and after the adoption of IT. It is obvious that, higher E^i can increase the relative size of n^i, and if $E^A > E^B$, $\frac{n^A}{n^B}$ will actually increase after adoption. Finally, the profit changes before and after the adoption of IT is ambiguous. As described, the prices drop down after the adoption of IT, but the price cut is more serious with large bank. Together with the result that if $E^A > E^B$, $\frac{n^A}{n^B}$ will actually increase after adoption, the overall effect on revenue terms are undetermined, and this leaves space for our discussion on empirical studies.

2. The Empirical Study

Following Shu and Strassmann (2005), we study the contribution of IT in a Cobb-Douglas production function, using panel data of domestic banks in Taiwan. Due to disadvantages of government or survey data, the data in this study is originated from Taiwan Economic Journal, where the variable 'equipment cost' can match the definition given in Bureau of Economic Analysis (BEA). We will cover 29 Taiwan domestic banks dating from 1991 to 2004.

Our estimation model is based on the following Cobb-Douglas function, due to Shu and Strassmann (2005),

$$\begin{aligned}\ln \pi_t^i &= \ln \alpha_0 + \alpha_I \ln E_t^i + \alpha_N \ln N_t^i \\ &\quad + \alpha_{IN} \ln IN_t^i + \alpha_L \ln L_t^i \\ &\quad + \alpha_{OE} \ln OE_t^i + u_i + v_t^i\end{aligned}$$

The output π is defined as the net sales or revenue in the income statement, and E, N, IN, L, and OE represent IT expenditure, non-interest expense, interest expense, staff cost, and operating expense which are explained in previous section. Therefore, through parameters estimation, we generate the impact from each input variable on the revenue. Since, we expect that IT and IT related variables will have positive effect on revenue, hence, α_I, $\alpha_N, \alpha_L, \alpha_{OE}$ should be positive. One the other hand, if the coefficient turns out to be negative, it means that the specified input has a negative contribution on revenue.

As argued earlier, the asset scales of each bank through the period varies dynamically, due to the development process of banks, such as new establishment, merger, consolidation. As a result, the traditional Cobb-Douglas production function, a log-linear model, did not fit our data set. If we adopt the traditional Cobb-Douglas production function only without considering the size effect, our empirical analysis would not capture the whole picture. In using the random effect the size effect will be dealt with to an error term because they are visible. Therefore, we modify model (1) to model (2)

$$\begin{aligned}\pi TA_t^i &= \alpha_0 + \alpha_{ITA} ETA_t^i + \alpha_{NTA} NTA_t^i \\ &\quad + \alpha_{INTA} INTA_t^i + \alpha_{LTA} LTA_t^i \\ &\quad + \alpha_{OETA} OETA_t^i + u_i + v_t^i\end{aligned}$$

In model (2), all variables are divided by TA , total asset. We expect that the higher ratio of IT in relation to the banks' assets, the higher ratio of their revenue. This situation is referred as "economies of scale" test and/or network effect.

There are *four explicit* results. First, the size of demand for IT facility is booming. Second, based on the Shu and Strassmann's model, IT variable is insignificant and inversely related to output Third, taking into size effect for consideration, the ratio of IT is significantly positive related to output and even the most marginal productiveness, verifying the network effect. Fourth, once non-interest expense occupied a higher ratio of bank assets it will have negative impact on revenue, confir4ming the general intuition.

As part of our empirical analysis, we found that the number of ATM increases steadily especially in 1994 growth rate reaching 27%. ATM sets can be viewed the IT input, whiles the number of bank card issued and circulations stand for the customers' demand on IT. The latter also is appropriate for credit card . Since 1995, the number of credit card circulations is booming dynamically, from 3.7 million to 45 million which is double than Taiwan total population even much higher than employment population.

In the traditional model, IT variable is insignificant and inversely related to output. On the contrary, in the modified model which considers the size effect, the ratio of IT is statistically significant at 1% level and positively related to output. This is an important finding. That is, if we were to focus on IT spending as an expense only, the result may not be exciting, but on the contrary, we treat IT expenditure as an investment, the result would be much more encouraging.

The empirical results based on the traditional and modified Cobb-Douglass production function and estimated by the fixedeffect and random-effect estimations. It is found that in the traditional model, IT variable is insignificant and inversely related to output. On the contrary, in the modified model which considers the size effect, the ratio of IT is statistically significant at 1% level and positively related to output. This is an important finding. That is, if we were to focus on IT spending as an expense only, the result may not be exciting, but on the contrary, we treat IT expenditure as an investment, the result would be much more encouraging.

Non-interest expense (N) is another variable showing different results in both models. For example, in the traditional model non-interest expense is statistically significant at 1% level, and positively relates to output. But in the modified model, the same coefficient became significantly negative. The implication of this finding is that once the non-interest expense occupied a higher ratio of bank assets it will have negative impact on revenue.

The emerging picture from our empirical analysis indicates that as a result of the structural economic deficiencies, which exist, the Taiwan banking sector has not fully utilized the IT investment potentials to maximize their profitability. There is an over-reliance of interest income earning streams as the principal source of revenue for the banks. Consequently, there is a lack of competition for other non-interest financial services, which makes competition rather weak in other non-interest services area. This finding is in line with Standard & Poor's research findings.

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