The Effects of Financial Regulation on Cost Efficiency: Evidence From the Hong Kong Banking Industry

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This paper constructs a transcendental logarithmic cost function for describing the production technology of banks. Rather than adopting traditional approaches, this paper develops a new approach to specify the essential outputs and inputs of banks. It is finds that banks had to tolerate higher operating costs in the first few years after the removal of regulations. In response, banks sought for new revenue by expanding fee-based financial services rather than reduced operating costs by adjusting their input combinations or output combinations. The deregulation also forced banks to pursue active technical progress, and larger banks performed better than smaller banks.

Keywords: financial regulation, banking industry, cost efficiency

INTRODUCTION

There are two extreme methods to allocate resources efficiently and fairly, namely command system and market system. A command system allocates scarce resources by the order of someone in authority. When a market system allocates scarce resource, the person who is able and willing to pay the highest price get the resource. The public interest theory (Pigou, 1932) says that regulation is needed for the protection of the public interest of society, and thus it supports the command system and asks for more regulations. While the regulatory capture theory (Stigler, 1972) claims that regulation serve private interests of particular groups only, and therefore it supports market system and encourages deregulation. Furthermore, the regulatory dialectic theory (Kane, 1977) points out that there is a dynamic development of regulation. The regulated firms will change their behavior to bypass the regulations imposed on them, so the government needs to amend the regulations from time to time. Kroszner & Strahan (2014) summarizes the evolution of financial regulations by saying "Regulatory change was driven by technological, legal, and economic shocks that affected competition among different groups". Therefore, the impact of regulation change is an industry-specific and market-specific issue. Production technology, market structure and firms' behaviors of a particular industry should be examined thoroughly for formulating appropriate industrial policy by the government.

Over the three decades before the 2007-8 financial tsunami, financial deregulation was a major trend in the banking industry around the globe. Financial deregulation was typically undertaken to increase competition among banks and improve cost efficiency of banks. Among the studies on cost efficiency, Tirtiroglu et al. (2005) and Kondeas et al. (2008) find that the banking systems became more efficient after deregulation in the US and all 15 nations in the EU, respectively. However, Kumbhakar et al. (2001) shows that technical efficiency of Spanish savings banks declined after deregulation. In addition, Chortareas et al. (2012) also proves that strengthening capital requirements improved the efficient operations of banks in 22 EU countries. The contrasting results on the relationship between financial deregulation and bank efficiency necessitate analysis of more banking industries. For it indicates that the effects of financial deregulation vary across economies and may depend to a great extent on the market structure of the banking industry.

The majority of research studies on the cost effects of financial regulation have focused on banking industries of Western countries, which have clear-cut local markets for many financial products and are rather dispersed. It is important for policy formulation to see if these results carry over into other territories. This paper endeavors to supplement the existing literature by investigating an important Asian economy, Hong Kong, in which the banking industry is more territory-wide in scope with a much higher level of market concentration. In addition, there are two practical reasons for studying the banking industry in Hong Kong. First, Hong Kong is the premier offshore financial center to Mainland China. Subsequently, the efficiency of the Hong Kong banking industry is vital for economic development of Mainland China, which is the second largest economy in the world. Second, Hong Kong is an international banking center in which about 70 of the world's largest 100 banks operate. Being one of the most profound banking systems in the world, other banking systems (like the banking system in Mainland China) have much to learn from the valuable experience of Hong Kong.

Followed the global trend of financial deregulation, the Hong Kong government implemented a financial reform at the turn of the 21st century. The major changes in banking legislation included abolishing the interest rate caps, removing the branching restriction on foreign banks, and relaxing the market entry criteria to the local banking business. It is generally believed that the deregulation fosters competition among banks; however, its effects on cost efficiency of banks warrant further investigation.

For the studies on the Hong Kong banking industry, Chan and Koo (1998) argue that the interest rate caps had created a monopsonistic market for deposit. As a result, banks in Hong Kong earned extra profits from depositors through setting low interest rates before the deregulation. Chong (2010) finds that the spreads between bank deposit rates and market interest rates have tightened sharply after the removal of interest rate controls. Kwan (2003) further shows that the interest rate deregulation lowers profits and hence market values of banks. In order to determine the welfare implication of banking deregulation, Ho (2010) jointly estimates a system of differentiated product demand and pricing equations, and use conduct parameters to identify market structure. He finds that the banking industry becomes more competitive and the consumers are better-off after the deregulation. However, the literatures do not discuss cost efficiency implication of the banking deregulation. Using a multiproduct cost function, this paper provides a framework to study cost efficiency change which is essential to the formulations of banking regulation.

This rest of this paper is arranged as follows. Section 2 presents the cost function estimation method followed by the empirical model specification and a brief overview of the Hong Kong banking data in Section 3. The empirical results are discussed in Section 4 and Section 5 concludes this paper.

METHODS

In this paper, we follow the traditional industrial organization studies that assume single technology for all the firms in the industry. To stipulate an empirical model for this study, this paper constructs a flexible transcendental logarithmic cost function for describing the production technology of commercial banks. The transcendental logarithmic cost function was widely used for banking studies - see, for example, Hughes & Mester (2011), Simper & Hall (2012) and Phan et al. (2016). In these studies, a bank's objective is assumed to minimize its total input cost of producing given levels of outputs, with the technology given.

The cost function estimation method requires that outputs and inputs be distinguished in advance, for quantities of outputs and prices of inputs are arguments in the cost function. Incorrect classification of outputs and inputs leads to bias in estimated parameters and misleading conclusions. Unfortunately, the absence of such a classification rule has led to controversies in the estimation of cost functions for banking technology for several decades (Molyneux et al., 1996, p.156). Among these controversies, whether deposits should be treated as an output or input seems to be the hottest issue and has been found to be material in the analysis of the estimated cost function.

Empirical research studies that investigate cost structure of banks usually take one of two approaches, either the production or the intermediation approach, in specifying the outputs and inputs of banks (Clark, 1988). The production approach considers banks as firms that employ labor and capital to produce various types of loan and deposit services. Under this approach, the appropriate measurements of bank outputs are the number of loan and deposit accounts or number of various types of transactions performed. Operating costs excluding interest expenses are the costs of banks in the empirical analysis. Alternatively, the intermediation approach treats banks as intermediators of financial assets. Savings of depositors are collected by banks and then transfers to firms to finance productive projects. The values of loans and investments are taken as outputs; and capital, labor and deposit are generally treated as inputs. Therefore, the total cost, operating cost plus interest expense, should be used in the empirical analysis.

It is obvious that deposit is treated as an output under the production approach while it is treated as an input under the intermediation approach.

The production approach has several shortcomings. First, banks are treated as services providing firms whose outputs cannot be measured by physical quantities. Second, banks produce many services and some of them are not charged directly, such as checking services. Finally, based on this approach, the cost only takes into account of operating cost but not the interest expense which is of equally importance to bank survival.

The intermediation approach has also been subjected to criticisms. Firstly, it does not recognize the distinction between the two inputs, customer deposit and purchased fund from other institutions. Banks with different compositions of funds may have different cost structures. In addition, the operating costs of banks are related primary to deposit-taking activities rather the investing activities. Thus, using investments as an output is faulty.

As a major contribution to the literature, this paper develops a new approach to overcome these shortcomings. This new approach, called asset transformation approach, views banks as financial intermediaries that transform customers' deposits into loans in two steps. The asset transformation performed by banks is illustrated graphically in Figure 1 and Figure 2.

In the first step of asset transformation, banks collect funds from individual depositors and pool the funds together for loaning out later or lending in the interbank market. In the second step, banks further transform the pooled funds into loans that are taken by firms to finance productive projects or by individuals to finance their consumption. In the second step, however, banks may not loan out exactly the amount of deposits they have collected in the first step. Those banks take in more deposits than their lending opportunities would lend surplus pooled funds to other banks in the interbank market, so they are called deposit-surplus banks. For those banks make more loans than deposits they have taken in, they would need to borrow pooled funds from the interbank market, so these banks are called deposit-deficit banks. The interbank lending is comparable to selling intermediate goods to other banks and the interbank borrowing is comparable to buying intermediate goods from other banks. In other words, under this new approach, banks are treated as vertically integrated firms that participate in both upstream deposit-taking activities and downstream loan-making activities. In the upstream production, banks utilize capital, labor and funds of depositors to produce pooled funds. In the downstream production, they employ capital, labor and the pooled funds produced by the upstream activities to further produce loans. Thus, pooled funds are the output of the upstream production and, at the same time, the input for the downstream production of banks.

FIGURE 1
A FRAMEWORK OF ASSET TRANSFORMATION FOR A DEPOSIT-SURPLUS BANK

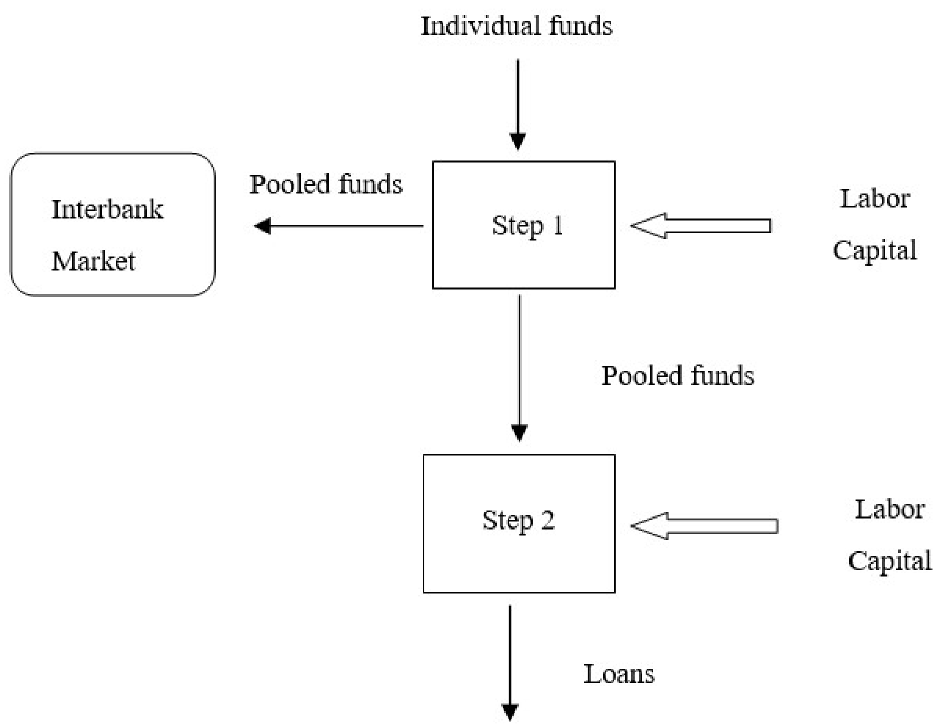
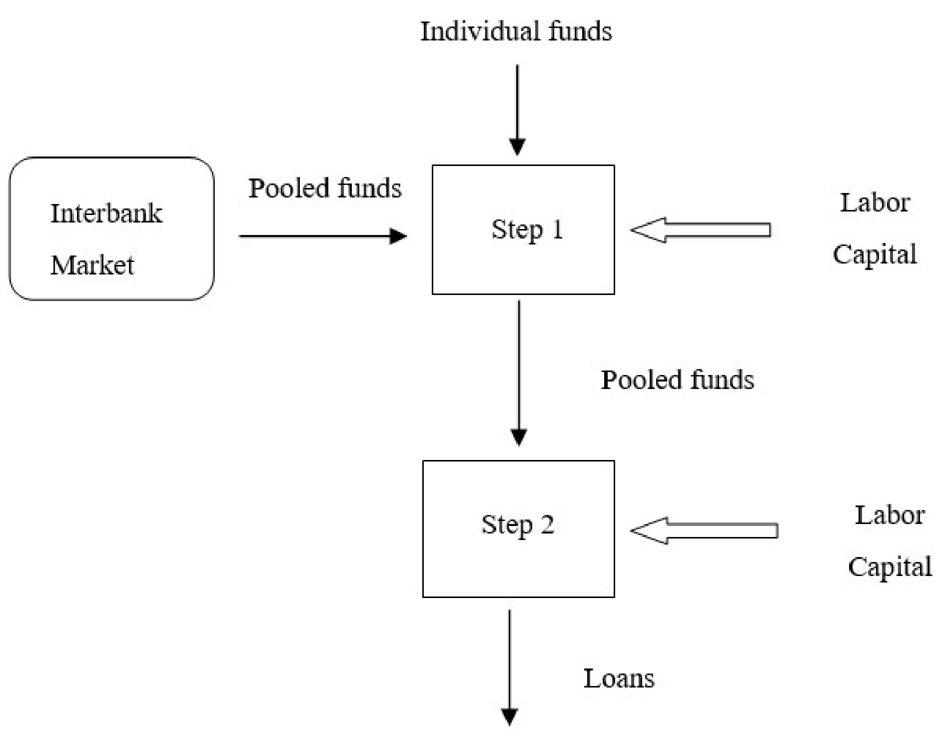


FIGURE 2
A FRAMEWORK OF ASSET TRANSFORMATION FOR A DEPOSIT-DEFICIT BANK



Follow from the above asset transformation approach, loan and pooled fund are the outputs of both kinds of bank. On the other hand, pooled fund, labor and capital are the inputs of deposit-deficit banks. However, pooled fund is not an input of deposit-surplus banks. Therefore, deposit-surplus banks employ one less input than deposit-deficit banks.

Besides performing asset transformation, we recognize the fact that modern banks offer various types of financial services, such as securities trading and cash management, to customers and generate various kinds of fee incomes from them. Thus, we incorporate fee-based banking services as another output of banks. To summarize, a 4-input-3-output model is needed to characterize the cost function of deposit-deficit banks, while a 3-input-3-output model is enough to characterize the cost function of deposit-surplus banks.

For an empirical study on cost function of banks, value of deposits can be treated a measurement of the upstream production (pooled funds) of banks, while value of loans can be treated a measurement of the downstream production (loans) of banks. Subsequently, value of deposits and loans are two measurements of bank outputs, and should be included as arguments of the cost function of banks. On the other hand, follow from the above two-step asset transformation approach, pooled fund is treated as an input in the production process of deposit-deficit banks. Therefore, its price together with the prices of deposits, capital and labor should also be included as arguments of the cost function of deposit-deficit banks. However, for the deposit-surplus banks, pooled fund should not be treated as an input in the production process. Therefore, there is no need to include the price of pooled fund as an argument of the cost function of deposit-surplus banks. This distinction between the cost functions of deposit-deficit banks and deposit-surplus banks is important. For it is difficult to get relevant data on pooled funds and estimate the cost function of deposit-deficit banks. In other words, it is much easier empirically if we estimate a cost function for a group of deposit-surplus banks only.

The asset transformation approach developed in this paper has a number of advantages over the two traditional approaches. Firstly, this approach point out that sometimes it is necessary to treat different banking groups separately, otherwise, misleading conclusions are very likely to be drawn, based on the analysis by pooling all banks together. Secondly, if most data in hand come from deposit-surplus banks, empirical study can employ an empirical model of deposit-surplus banks, i.e. production function or cost function can have one less inputs. It may mean reducing many independent variables for the empirical model and raising the efficiency of the estimated parameters. Thirdly, as value of deposits can be treated a measurement of the upstream production (intermediate goods) of banks, value of deposits can be used as one of the measurements of bank outputs in an empirical study. In other words, deposit can be viewed as both an input and an output of banks. This settles the argument over whether deposit should be treated as an input or output, and corrects the specification error that appears in many previous studies. Fourthly, this approach does distinguish banks' customer deposits and pooled funds from other banks, and treat them as two different inputs. This can correct another kind of specification error that appears in many previous studies. Fifthly, this approach attributes the costs of banks to the high value-added deposit-taking activities instead of the low value-added investing activities. This makes the empirical model appear more sensible. Sixthly, with a better model specification, our empirical model gives a better fit to the data. This is particular important to the cost analysis in this paper. Finally, this approach can provide new insights to the production technology of banking, such as whether there exist scope economies between deposit-taking activities and fee-based banking services.

EMPIRICAL MODEL AND DATA

Follow from the above arguments, this paper uses a transcendental logarithmic cost function of the following form:

$$
\begin{aligned}
\ln C = {} & A+\sum_i B_i \ln y_i+\sum_k C_k \ln p_k+(1/2)\sum_i \sum_j D_{ij} \ln y_i \ln y_j \\
& +(1/2)\sum_k \sum_l E_{kl} \ln p_k \ln p_l+\sum_i \sum_k F_{ik} \ln y_i \ln p_k \\
& +G_t T+(1/2)G_{tt}T^2+\sum_i H_{it}T * \ln y_i+\sum_k I_{kt}T * \ln p_k \\
& +J_r R+K_{tr}T * R+\sum_i L_{ir}R * \ln y_i+\sum_k M_{kr}R * \ln p_k,
\end{aligned} \tag{1}
$$

where ln denotes the natural logarithm; C is total cost; y_i (i = 1,2, ...,m) denotes the i^{th} output; p_k (k = 1,2, ...,n) denotes the k^{th} input price; A, B_i , C_k , D_{ij} , E_{kl} , F_{ik}, , G_t , H_{it} , I_{kt} ,J_r , K_{tr} , L_{ir} *and* M_{kr} are the parameters to be estimated; T a time trend variable to capture technical progress in the period of investigation. In addition, a dummy variable R is introduced to control for the effects of deregulation on the technology of bank. A value of zero is assigned for banks in the pre-deregulation period and a value of one for banks in the post-deregulation period.

The transcendental logarithmic model is often criticized for the existence of severe multicollinearity that results from the estimation of the interactive variables. The multicollinearity problem would make parameter estimates inefficient. There are several ways to improve the efficiency of estimation. By jointly estimating the cost and cost share equations, the multicollinearity problem can be reduced. With the help of the Shepard's lemma we can derive the cost share equations of inputs by partially differentiating the cost function with respect to input prices. For instance, the share equation of input k is given below:

$$\frac{\partial \ln C}{\partial \ln p_k} = S_k = C_k + \sum_{i=1}^{n} E_{ki} \ln p_i + \sum_{i=1}^{m} F_{ik} \ln y_i + I_{kt}T + M_{kr}R \qquad k = 1,2, ..., n \tag{2}$$

where $S_K = p_k y_k/C$ is the share of costs accounted for by the input k. There are n share equations as above for n inputs. The parameters in these share equations are subsets of those in the cost function; consequently, these share equations can be used together with the cost function to acquire more efficient estimates of the parameters. It is because these share equations introduce no additional unknown parameters into the model, if they are estimated along with the cost function, this would increase the degrees of freedom n times without adding to the number of parameters to be estimated. In other words, this allows more information about the input prices faced by the bank and the operation of the bank (total costs, the distribution of total costs across inputs, and the output generated by these costs) all to be used in the estimation of the parameters of the model. However, as the cost shares must sum to unity and hence the n share equations are linearly dependent, one of the share equations must be abandoned in the estimation. We may use any n-1 of the above share equations together with the cost function to estimate for the parameters.

Moreover, in order to generate a well-behaved cost function, the parameters must satisfy some regularity conditions. The first condition on the parameters is cross price effects are symmetric, which means that the effect of p_i on y_j is the same is the effect of p_j on y_i. For our cost function to exhibit symmetry, it requires that

$$D_{ij} = D_{ji} \, ; \qquad i, j = 1,.......,m \tag{3}$$

$$E_{kl} = E_{lk} \, . \qquad k, l = 1,……..,n \tag{4}$$

Another condition on the parameters is that imposed by linear homogeneity of the cost function with respect to input prices. That is to say, a proportional increase in all input prices must magnify total cost by the same proportion, holding all outputs constant. In order that our cost function is homogeneous of degree one in input prices, it requires that

$$\sum_{k=1}^{n} C_k = 1; \tag{5}$$

$$\sum_{k=1}^{n} E_{kl} = 0; \qquad l = 1,2,\ldots\ldots,n \tag{6}$$

$$\sum_{k=1}^{n} F_{ik} = 0; \qquad i = 1,2,\ldots\ldots,m \tag{7}$$

$$\sum_{k=1}^{n} I_{kt} = 0; \tag{8}$$

$$\sum_{k=1}^{n} M_{kr} = 0. \tag{9}$$

In summary, parameters in the cost function (1) should be estimated together with any n-1 of the share equations (2) subject to the constraints (3), (4), (5), (6), (7), (8) and (9).

Based on the asset transformation approach developed in last section, this paper classifies the outputs of banks into three types, loans (y_1), deposits (y_2) and fee-based banking services (y_3). They are measured by average dollar balance of loans, average dollar balance of deposits and net fee and commission income respectively. Since we only use data of deposit-surplus banks, the input, pooled funds from interbank market, can be ignored. Therefore, there are only three inputs for banks, namely, individual fund, labor and capital. The price of depositors' funds (p_1) is proxy by the average rate of three-month time deposits published by the Hong Kong Monetary Authority. The price of labor (p_2) is set equal to the real indices of payroll per person engaged in financial and insurance activities industry, while capital price (p_3) equals the rental indices of private domestic property. Similarly, the cost share of depositors' fund, labor and capital are denoted by S_1, S_2 and S_3 respectively. Economic theory indicates that firm would try to minimize its economic cost rather than explicit operating cost in allocating its resources. The total cost (C) of a bank is, therefore, its economic cost, includes operating expenses, interest expenses and opportunity cost of shareholders' funds. The inclusion of opportunity cost of shareholders' funds is particularly important for our analysis. It is because Hong Kong banks use to maintaining a higher ratio of capital to assets as compare to other economies. We estimate the opportunity cost of shareholders' funds by multiplying its average balance with the average yield of three-year Exchange Fund Notes. The time trend (T) is assigned with value equal to 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18 for years 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009 and 2010 respectively.

We obtained data of Hong Kong banks from the annual reports published by 20 locally incorporated licensed banks for the years 1993-2010. We have taken 1993 to 2001 as the pre-deregulation period, while 2002 to 2010 are post-deregulation years. Since this paper considers deposit-surplus banks only, 25 data with deposits less than loans are taken way. There are total 335 useful data in the eighteen-year period of investigation. All the relevant data are expressed in 2010 Hong Kong dollar by dividing them with the Implicit Price Deflator of Gross Domestic Product of Hong Kong.

RESULTS

We form a system of equations by joining the cost function (1) with the deposits and labor share equations. Maximum likelihood estimates of the parameters of the model are computed using iterated Seemingly Unrelated Regression (SUR) subject to the constraints (3), (4), (5), (6), (7), (8) and (9). In order to overcome the data limitation, Avery (1977) developed the SUR model which facilitates the estimation of a system of equations by pooling cross-sectional and time series data.

The estimates of the parameters are shown on Table 1. It can be observed that most of the estimated coefficients are significant at the 5% level. As implied by the linear dependence of share equations, the results associated with using other combinations of share equations are identical to those reported in Table 1.

TABLE 1
PARAMETER ESTIMATES OF COST FUNCTION

Parameter	Variable	Parameter Estimate	Standard Error	T for H_0: Parameter=0	Prob > |T|
A	INTERCEPT	-1.400062	1.657688	-0.844587	0.3985
B_1	$\ln y_1$	-1.024099***	0.363715	-2.815666	0.0050
B_2	$\ln y_2$	1.202686**	0.580295	2.072541	0.0385
B_3	$\ln y_3$	0.280344	0.404398	0.693240	0.4883
C_1	$\ln p_1$	0.501133***	0.100092	5.006713	0.0000
C_2	$\ln p_2$	0.065604	0.044975	1.458686	0.1450
D_{11}	$\ln y_1 * \ln y_1$	0.054218***	0.017728	3.058305	0.0023
D_{22}	$\ln y_2 * \ln y_2$	-0.196987*	0.115884	-1.699857	0.0895
D_{33}	$\ln y_3 * \ln y_3$	0.082027	0.054855	1.495347	0.1351
D_{12}	$\ln y_1 * \ln y_2$	0.140719***	0.051438	2.735678	0.0063
D_{13}	$\ln y_1 * \ln y_3$	-0.084178**	0.041929	-2.007645	0.0450
D_{23}	$\ln y_2 * \ln y_3$	0.001235	0.064012	0.019296	0.9846
E_{12}	$\ln p_1 * \ln p_2$	-0.040449***	0.002138	-18.92120	0.0000
E_{13}	$\ln p_1 * \ln p_3$	-0.041372***	0.005576	-7.419801	0.0000
E_{23}	$\ln p_2 * \ln p_3$	0.047520*	0.024553	1.935415	0.0532
F_{11}	$\ln y_1 * \ln p_1$	0.001693	0.006490	0.260886	0.7942
F_{21}	$\ln y_2 * \ln p_1$	0.048659***	0.014727	3.304046	0.0010
F_{31}	$\ln y_3 * \ln p_1$	-0.031089**	0.013972	-2.225074	0.0263
F_{12}	$\ln y_1 * \ln p_2$	0.014444***	0.003166	4.562236	0.0000
F_{22}	$\ln y_2 * \ln p_2$	-0.019574***	0.006474	-3.023282	0.0026
F_{32}	$\ln y_3 * \ln p_2$	0.001288	0.006437	0.200068	0.8415
G_t	T	-0.083355	0.063212	-1.318665	0.1876
G_{tt}	T * T	0.037839***	0.004184	9.044682	0.0000
I_{1t}	$\ln p_1 * T$	0.009736***	0.002831	3.439322	0.0006
I_{2t}	$\ln p_2 * T$	-0.003350***	0.001292	-2.593700	0.0096
H_{1t}	$\ln y_1 * T$	-0.006983	0.004800	-1.454788	0.1461
H_{2t}	$\ln y_2 * T$	-0.006896	0.009040	-0.762903	0.4457
H_{3t}	$\ln y_3 * T$	0.015920	0.009790	1.626114	0.1043
J_r	R	1.688309**	0.737127	2.290392	0.0222
K_{tr}	T * R	-0.359089***	0.035379	-10.14972	0.0000
M_{1r}	$\ln p_1 * R$	-0.235946***	0.031000	-7.611186	0.0000
M_{2r}	$\ln p_2 * R$	0.050906***	0.012093	4.209603	0.0000
L_{1r}	$\ln y_1 * R$	0.087661*	0.046920	1.868291	0.0620
L_{2r}	$\ln y_2 * R$	0.136313	0.100870	1.351366	0.1769
L_{3r}	$\ln y_3 * R$	-0.224962**	0.106204	-2.118211	0.0344

***, ** and * refer to significant at 1%, 5% and 10% levels, respectively.

Observe that some of the estimated coefficients are imprecise and the high values of R^2, suggests that multicollinearity may exist. In the present case, this is not necessarily a major problem. It is because the estimated parameters are estimates of the gradient and Hessian of the underlying cost function. The economic effects of interest, such as technical change and deregulation effect, are functions of the parameters, and these may be estimated with more precision.

The financial deregulation around the turn of the twenty-first century has substantially altered the operations of banks in Hong Kong. The purpose of this section is to identify the structural change in the bank technology. By incorporating a dummy variable *R* into the estimation, the effects of deregulation on the cost of bank can be captured by the following:

$$Dereg = \frac{\partial \ln C}{\partial R} = J_r + K_{tr}T + \sum_i L_{ir} \ln y_i + \sum_k M_{kr} \ln p_k \tag{10}$$

where *Dereg* is an approximation to the proportional change in total cost as a result of deregulation. This change in cost can be further divided into four categories.

The change in cost arises from the pure effect of deregulation saves all inputs in proportional manner is measured by:

$$PureDereg = J_r \tag{11}$$

The change in cost arises from making technical progress is measured by:

$$TechDereg = K_{tr}T \tag{12}$$

The cost change brought about by producing output in a nonproportional manner is measured by:

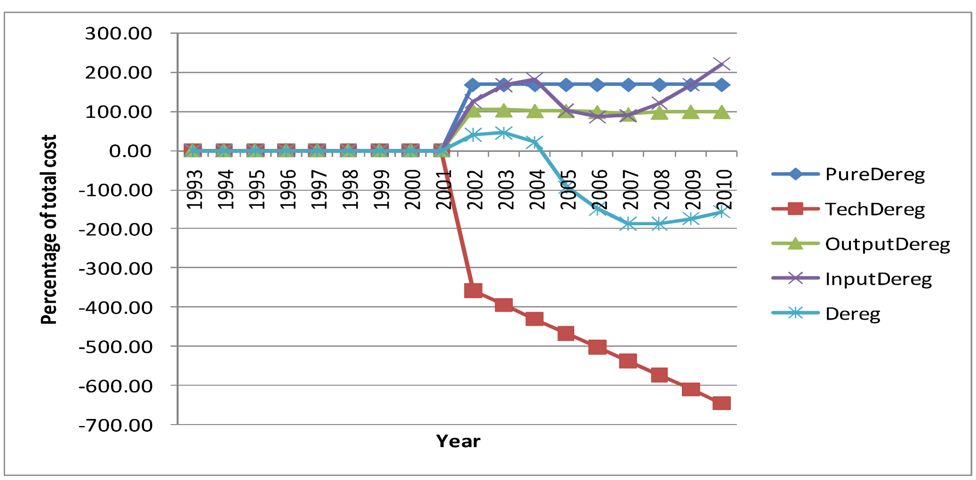
$$OutputDereg = \sum_i L_{ir} \ln y_i \tag{13}$$

The cost change result from using input in nonproportional manner is given by:

$$InputDereg = \sum_k M_{kr} \ln p_k \tag{14}$$

Figure 3 shows the respective cost changes of the banks over the period of investigation. It is found that banks had to tolerate a higher cost in the first few years after deregulation. Obviously, it is mainly a result of the pure effect of deregulation. Since *PureDereg* were positive for the whole post-deregulation period, it indicates that the deregulation has created an unfavorable input environment for the banks. Furthermore, both *InputDereg* and *OutputDereg* were positive for the whole post-deregulation period. It reflects the fact that banks pursue the business strategy of expanding fee-based financial services in order to reap a higher return on these activities, rather than concentrating on reducing operating cost by adjusting their input combinations or output combinations. However, deregulation did forced banks to pursue active technical progress and ended up with good result. Technical progress even enables banks to reduce their costs to below pre-deregulation level four years after deregulation. The uprising of Internet banking in recent years is a good example of using new cost-saving technology by banks.

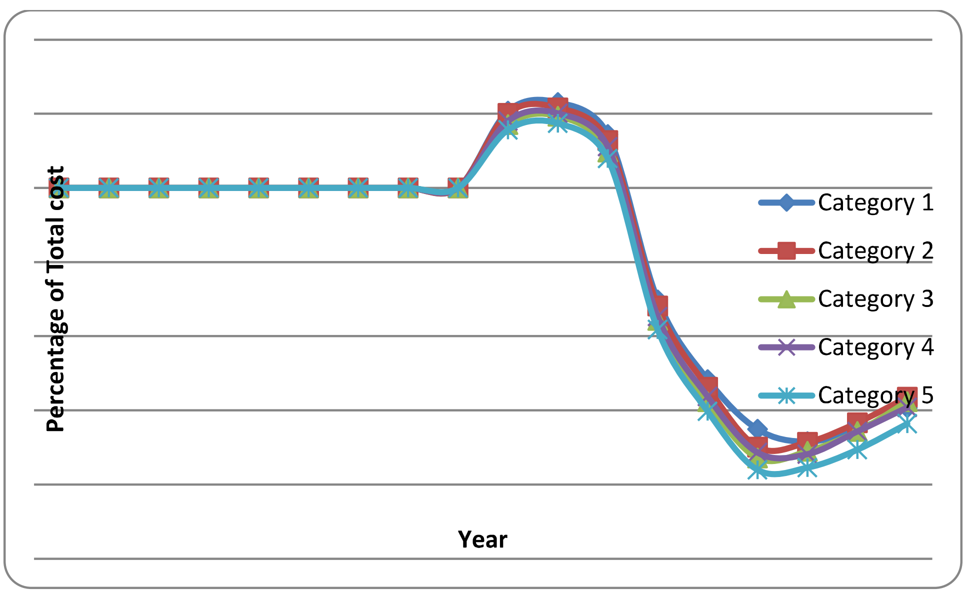
FIGURE 3
RESPECTIVE CHANGES IN COST ARISING FROM DEREGULATION



Individual bank's ability in adapting to changes in business environment may depend on its operation size. A large bank may be less capable of adapting to changes as a result of its sheer size and the more bureaucratic organization. On the other hand, a small bank may not be good at adapting to changes too as it does not have the financial strength to implement all kinds of IT projects. Therefore, we need to analyze the change in cost of banks with different total asset sizes. We classified the 20 local banks into five categories with Category 1 being the smallest and Category 5 being the largest. In Figure 4, we present the total change in cost of each category of banks arising from the deregulation. Although the differences across five categories are not great, it seems that larger banks were less affected by the deregulation and they recovered at a faster rate. Banks in Category 5 were least affected by the deregulation and they recovered at a fastest rate. Banks in Category 1 were greatest affected by the deregulation and they recovered at a slowest rate.

In this section, we would like to further investigate the impact of deregulation on technical progress of banks. We claim that the deregulation resulted in greater competition among banks in Hong Kong. Keen competition in turn forced banks to strive hard in order to survive. Besides improving their services provided to customers, the measures adopted may include making better use of advance machineries, such as automatic teller machines and electronic banking and innovative methods of production. Accordingly, cost of banks should be reduced. In other words, our first hypothesis is that deregulation induces technical progress in banking industry. Furthermore, the individual bank's ability in adapting to changes in business environment may depend on its operation size. Large banks may be less capable of adapting to changes as a result of its sheer size and the more bureaucratic organization. On the other hand, small banks may not be good at adapting to changes too as they do not have the financial strength to implement all kinds of IT projects. Therefore, our second hypothesis is that the ability of bank in adapting to changes in business environment decrease with its operation size.

FIGURE 4
TOTAL CHANGE IN COST OF DIFFERENT CATEGORIES OF BANK ARISING FROM DEREGULATION



To test the above two hypotheses, technical progress of banks with various sizes are computed. By observing the trend in technical progress with size, we can infer the relationship between a bank's operation size and its ability in adapting to change. Technical progress （$Tech$） in multi-output firms can be represented by the common rate of input reduction while holding outputs fixed, and can be expressed as:

$$Tech = -\frac{\partial \ln C}{\partial T} \tag{15}$$

where $ln\, C$ and T are the natural logarithm of total cost and the time trend variable, respectively . Using our empirical model, technical progress can be expressed as:

$$Tech = -\left[G_t + G_{tt}T + \sum_{i=1}^{3} H_{it} \, ln \, y_i + \sum_{k=1}^{3} I_{kt} \, ln \, p_k + K_{tr} * R\right] \tag{16}$$

The technical progress arises from the pure effect of technology advance which saves all inputs in proportional manner is measured by:

$$PureTech = -[G_t + G_{tt}T] \tag{17}$$

The saving brought about by producing output in a nonproportional manner is measured by:

$$OutputTech = -\left[\sum_{i=1}^{3} H_{it} \, ln \, y_i\right] \tag{18}$$

The saving from using input in nonproportional manner is measured by:

$$InputTech = -\left[\sum_{k=1}^{3} I_{kt} \, ln \, p_k\right] \tag{19}$$

The additional saving arises from the deregulation is given by:

$$DeregTech = -[K_{tr} * R] \tag{20}$$

Figure 5 shows the respective technical progresses of all banks over the period of investigation. It is found that banks started to achieve significant technical improvement after 2001, after which Hong Kong had deregulated the banking industry. Consequently, it is logical to claim that deregulation did force bank to improve their cost efficiencies. However, responsiveness of individual banks toward the changing business environment are quite different. In Figure 6, we present the technical progresses of different categories of banks.

Banks achieved an average 1.7% of reduction in cost after the deregulation. More important, technical progress seemed to be decreased with asset size of banks. It indicates that small banks experienced more technical progress and reaped more benefits from such changes as compare to the large banks. This is consistent with the hypothesis that the ability of bank in adapting to changes in business environment decrease with its operation size.

FIGURE 5
TECHNICAL PROGRESS OF ALL BANKS

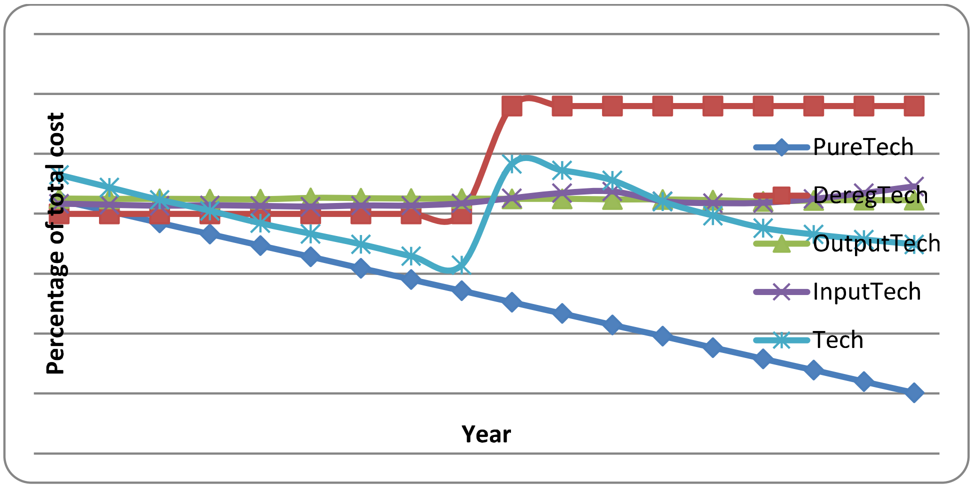
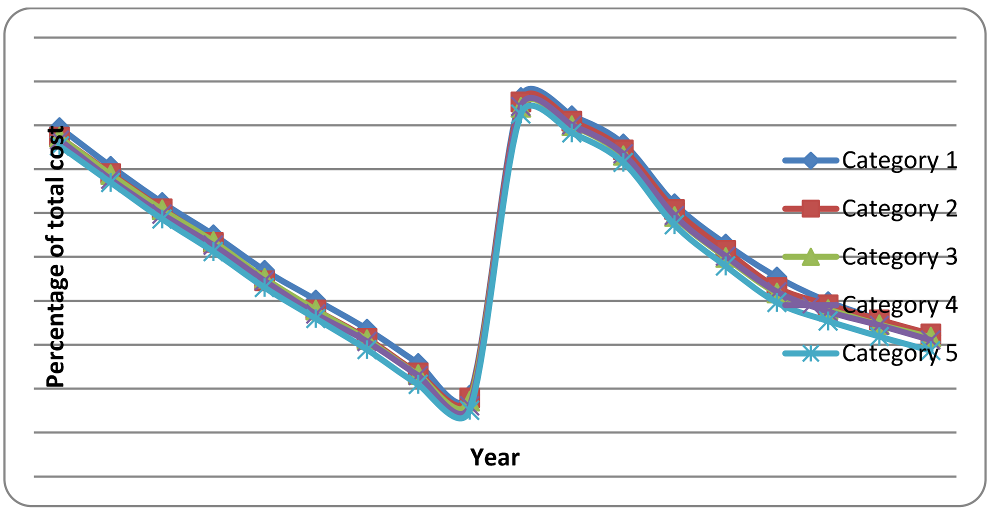


FIGURE 6
TECHNICAL PROGRESSES OF DIFFERENT CATEGORIES OF BANK



CONCLUSION

First, it is found that banks had to tolerate a higher cost in the first few years after the deregulation. Obviously, it was because the deregulation has created an unfavorable input environment for the banks. Second, the finding reflects the fact that banks adopted a business strategy of expanding fee-based financial services in order to reap a higher return on these activities, rather than concentrating on reducing operating cost by adjusting their input combinations or output combinations. Third, the deregulation did force banks to pursue active technical progress. Technical progress even enabled banks to reduce their costs to below pre-deregulation level four years after the deregulation. The uprising of Internet banking in recent years is a good example of using new cost-saving technology by banks. Fourth, individual bank's ability in adapting to changes in business environment may depend on its operation size. The finding indicates that larger banks were less adversely affected by the deregulation and they recovered at a faster rate. On the contrary, smaller banks were more affected by the deregulation and they recovered at a slower rate. Large banks are more capable of adapting to regulatory changes despite their sheer sizes and more bureaucratic organizations. On the other hand, small banks are not good at adapting to changes as they do not have the financial strength to implement all kinds of IT projects.

In summary, amendment of banking regulation may bring forward both merits and demerits to the society. In order to make best use of the advantages and bypass the disadvantages, a society has to conduct a thorough cost-benefit analysis before it implements any change in banking regulation.

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