New evidence of efficiency and produktivity change in southeast Asia

Simon Papadopulos [1]

Abstract

This paper explores the issue of banking efficiency and productivity in Southeast Asia by applying the directional technology distance function to calculate efficiency and productivity measures for a large sample of Southeast Asian banks between 2001 and 2007. The results indicate that inefficiencies range between 19% and 33% across different national banking samples. The smallest banks (total assets up to €5 billion) are the most efficient and the largest sized institutions are the least efficient. The reported figures for the Luenberger productivity measures are rather mixed suggesting both positive and negative productivity changes from year to year for all banking sectors and are found to be ranging from 0,20 to -0,18. Overall, total factor productivity grew in Thailand, Hong Kong, Korea, Singapore and Taiwan and declined in Indonesia and Malaysia. The largest average annual growth rates are reported by Thai and Korean banks (rates of 9% and 8,14% respectively). Furthermore, the decomposition of the productivity indicators into the efficiency change and technological change components, showed that in all banking sectors the technological progress indicator is greater than the efficiency indicator and therefore, when we observe very good productivity rates, these are due to technological change rather than significant improvements in efficiency. Negative productivity indicators are mainly due in most cases to strong negative efficiency change estimates.

Key words

Southeast Asian banking; efficiency; productivity; Luenberger index

JEL Classification: G21, D21

1. Intrioduction

The efficient-structure hypothesis suggests that banks that are able to operate more efficiently than their competitors, incur lower costs and achieve higher profits and increased market shares that may result in increased concentration. Therefore, according to this hypothesis, efficiency is the factor that positively influences both market shares and bank profits. During the last few years research interest on bank productivity studies has increased significantly as a result of great changes in the structure of E.U banking systems that were caused by advances in financial technologies (Berger and Mester, 2003) and by the recent financial crisis (ECB, E.U banking structures, Sept. 2010). Bank productivity leads to improved performance, lower prices and better banking services and products and therefore, banking productivity estimates may gain considerable interest as banks are likely to search for additional profits and economies of scale to contemplate for the large drop in profitability brought about by the 2008-09 financial crisis. Moreover, an analysis of productivity measures across countries may help regulatory authorities in promoting the appropriate initiatives with

[1] Department of Accounting and Finance, University of Macedonia, 156 Egnatia Str. 540 06, Thessaloniki, e-mail: spapado@uom.gr

the aim to increase the resilience and funding structures of European banks (ECB, E.U banking sector stability, Aug. 2009).

The aim of this paper is to explore the issue of banking efficiency and productivity in Southeast Asian banking markets, an area that has drawn attention in contrast to the voluminous body of research studies that examined developing banking markets. In this study we apply the directional technology distance function to calculate efficiency and productivity measures for a large sample of Southeast Asian banks between 2001 and 2007. The results indicate that inefficiencies range between 19% and 33% across different national banking samples. The smallest banks (total assets up to €5 billion) are the most efficient and the largest sized institutions are the least efficient. Overall, total factor productivity grew in Thailand, Hong Kong, Korea, Singapore and Taiwan and declined in Indonesia and Malaysia. Section 2 presents a literature review of recent approaches to measuring efficiency and productivity in banking markets. Section 3 puts forward the methodology. Section 4 analyses our empirical results and some concluding comments are offered in Section 5.

2. The measurement of efficiency and productivity in baking markets

A great number of banking studies have estimated productivity change by using various parametric and non-parametric techniques (for an in depth literature review see Berger and Mester, 2003 and Casu et. al. 2004). Orea (2002), Lovell (2003) and Koutsomanoli-Filippaki et. al. (2009) all used output distance functions to measure banking productivity.

Girardone et al. (2004) investigated Italian banks' cost efficiency over the period 1993-1996, by employing a Fourier-flexible stochastic cost frontier in order to measure X-efficiencies and economies of scale. The results showed that mean X-inefficiencies ranged between 13 and 15 per cent of total costs and they tended to decrease over time for all bank sizes. Economies of scale appeared to be present and significant, being especially high for popular and credit co-operative banks. Moreover, the inclusion of risk and output quality variables in the cost function seemed to reduce the significance of the scale economy estimates. The results also suggested that the most efficient and profitable institutions were more able to control all aspects of costs, especially labour costs. Inefficiencies were found to be inversely correlated with capital strength and positively related to the level of non-performing loans.

Weill (2004) in his paper measured the cost efficiency of banks from five European countries (France, Germany, Italy, Spain, Switzerland) with three approaches: stochastic frontier approach, distribution-free approach, and data envelopment analysis. In general, he observed some correlation between all frontier approaches and standard measures of performance and concluded in favor of the lack of robustness between approaches, although there were some similarities in particular between parametric approaches.

Bos and Kolari (2005) in their study compared the efficiency of European and U. S banks and found that large U.S. banks have higher average profit efficiency than European banks and thus, concluded that potential efficiency gains are possible via geographic expansion of large European and U.S. banks.

Casu and Girardone (2006) in their approach tried to investigate the impact of increased consolidation on the competitive conditions of the EU banking markets by employing both structural and non-structural (Panzar-Rosse statistic) concentration measures. Their results seem to suggest that the degree of concentration is not necessarily related to the degree of competition; the relationship between competition and efficiency is not a straightforward one: increased competition has forced banks to become more efficient but increased efficiency does not appear to be fostering more competition.

Pastor and Serrano (2005, 2006) analysed the effects of specialisation on the cost efficiencies of a large sample of European banks between 1992 and 1998. They decomposed cost inefficiencies into two different components: the first component was related to the inefficiency associated with the composition of specialisations in each banking system and the second was related to specific inefficiencies of banks within their specialisation. The results suggested that there existed high cost inefficiencies, however, the intra-specialisation inefficiencies indicated that the inefficiencies of the European banking systems are much smaller when the effect of productive specialisation (composition) is discounted. In their earlier study the authors analysed the efficiency and the credit risk of European banks by using a one-stage parametric stochastic procedure to determine whether the behaviour towards risk of the banks analysed was more cautious or more reckless during the period analysed. The results indicated that adjustments for risk were important in the case of profit efficiency but not in the case of cost efficiency.

Casu and Molyneux (2003) evaluated the determinants of European bank efficiency by using the Tobit regression model approach and bank-specific efficiency measures derived from DEA estimation, To overcome the dependency problem, they used a bootstrapping technique. Overall, the results suggested that since the EU's Single Market Programme there had been a small improvement in bank efficiency levels, although there was little evidence to suggest that these levels were converging. The results also suggested that inference on the determinants of bank efficiency drawn from non-bootstrapped regression analysis may be biased and misleading.

Hauner (2005) used the DEA approach to estimate cost-efficiency, scale efficiency, and productivity change for a sample of large German and Austrian banks. State-owned banks were found to be more cost-efficient and cooperative banks appeared to be (approximately) as cost-efficient as private banks. The results indicated the existence of increasing economies of scale but decreasing economies of scope and the authors conclude that this finding provides rationale for M&As among banks with similar product portfolios.

Overall, U.S studies that used the stochastic cost frontier methodology to estimate inefficiency, have generally found average banking inefficiency to be around 20-25 percent. On the other hand, U.S studies that used the DEA methodology have reported findings ranging from around 10 percent to more than 50 percent and these findings are in line with the European stochastic cost frontier studies that generally tend to report low inefficiency scores (between 10 and 20 percent).

Koutsomanoli-Fillipaki et al. (2009) employed the directional technology distance function developed by Chambers et al. (1996) to model the production process and measure efficiency and productivity change across a large sample of Central and Eastern European countries for the period 1998-2003. The directional technology distance function allows firms to optimize by simultaneously seeking the maximum expansion of outputs and the maximum contraction of inputs that is technologically attainable. Their results show a significant level of inefficiency which varies considerably across countries and even though efficiency has not improved, productivity was significantly increased. The authors calculated Luenberger productivity indicators for each country and decomposed them into efficiency change and technical change components. Overall, their findings seem to suggest that productivity change is driven by technological change rather than efficiency change.

In another recent study Feng and Serletis (2010) used an output distance function within a Bayesian framework to calculate parametric estimates of technical change, efficiency change, economies of scale and total factor productivity growth for large U. S banks over the period from 2000 to 2005. Their results showed that total factor productivity grew at an average rate of 1.98% over the sample period although they identified a clear downward trend in this growth rate. Following previous attempts the authors decomposed the total factor productivity index into three components, namely, technical, efficiency and economies of scale and found that technical change is the driving force behind total factor productivity change confirming Koutsomanoli-Fillipaki's findings.

3. The methodology

The methodology used in this paper to analyze banks' production process and measure efficiency is the directional technology distance function developed by Chambers et al. (1996) and applied by Koutsomanoli-Fillipaki et al. (2009). The directional technology distance function is a function representing a technology that is associated with free disposal of inputs and outputs, that is banks are simultaneously trying to maximize outputs and minimize inputs given a certain level a technology. When a bank is technically efficient the value of the directional distance function would be zero. Positive values would suggest the existence of inefficient production. To calculate measures of efficiency and productivity we follow Fare et al. (2005) and Koutsomanoli-Fillipaki et al. (2009) and use a directional technology distance function of the following form[2] :

$$\vec{D}_T(x, y; g_x, g_y, t, \theta) = \alpha_0 + \sum_{n=1}^{N} \alpha_n x_n + \sum_{m=1}^{M} \beta_m y_m + \tfrac{1}{2}\sum_{n=1}^{N}\sum_{n'=1}^{N} \alpha_{nn'} x_n x_{n'}$$

$$+ \tfrac{1}{2}\sum_{m=1}^{M}\sum_{m'=1}^{M} \beta_{mm'} y_m y_{m'} + \sum_{n=1}^{N}\sum_{m=1}^{M} \gamma_{mn} y_m x_n + \delta_1 t + \tfrac{1}{2}\delta_2 t^2$$

$$+ \sum_{n=1}^{N} \omega_n t x_n + \sum_{m=1}^{M} \upsilon_m t y_m + \varepsilon \qquad (1)$$

where
x is a vector inputs and y is a vector of outputs
$g = (g_x, g_y)$ is a directional vector that determines the direction in which technical efficiency is assessed[3]
$\theta = (\alpha, \beta, \gamma, \delta, \omega, \upsilon)$ is a vector of parameters to be estimated and
ε is a random error term (assumed to be normally distributed)
t is a trend variable capturing technical progress

Subtracting $D_T(x, y; g_x, g_y, t, \theta) = u$ from both sides of equation (1), we get a functional form with a composite error term ε-u. The error term u is assumed to have a truncated normal distribution and captures bank-specific inefficiency scores (Koutsomanoli-Fillipaki et al. 2009). The parameters of this functional form must satisfy a set of restrictions as shown by Chambers, Chung and Fare (1998):

$$\sum_{n=1}^{N} \alpha_n g_n + \sum_{m=1}^{M} \beta_m g_m , \quad \sum_{n=1}^{N} \alpha_{nn'} g_{xn} = 0 , n' = 1\ldots\ldots, N$$

[2] For an extensive description and discussion of how to parameterize directional distance functions see Fare and Lundberg (2005).
[3] If we set $g = (g_x, g_y) = (1, 1)$ that would imply that the amount by which a bank could increase outputs and decrease inputs will be $D_T(x, y; 1, 1)$ units of x and y. For a more detailed analysis on this directional vector g, see Fare and Primont (2003)

$$\sum_{m=1}^{M} \beta_{mm'} g_{ym} = 0, \quad m' = 1\ldots\ldots\ldots, M, \quad \sum_{n=1} \omega_n = 0, \quad \sum_{m=1} \upsilon_m = 0 \quad \text{and}$$

$$\alpha_{nn'} = \alpha_{n'n} \quad \text{and} \quad \beta_{nn'} = \beta_{n'n} \tag{2}$$

For a bank that is technically efficient, the value of the directional distance function would be zero. On the other hand, values of D_T (x, y; g_x, g_y)>0 indicate inefficient production. The directional distance function will be evaluated in more than one period in order to measure productivity change. The base period Luenberger productivity indicator L^0 relative to the base period technology T^0 is defined as:

$$L^0 = D_T^0 (x^0, y^0; g) - D_T^0 (x^1, y^1; g) \tag{3}$$

Similarly the period 1 indicator relative to period 1 technology is defined as:

$$L^1 = D_T^1 (x^0, y^0; g) - D_T^1 (x^1, y^1; g) \tag{4}$$

As the two productivity indicators in (2) and (3) can only coincide under very restrictive neutrality conditions on technology, we follow Koutsomanoli-Fillipaki et al. (2009) and use the (arithmetic) mean indicator to measure productivity change as:

$$L = ½ (L^0 + L^1) \tag{5}$$

$$L = ½ [D_T^0(x^0, y^0; g) - D_T^0(x^1, y^1; g) + D_T^1(x^0, y^0; g) - D_T^1(x^1, y^1; g)]$$

Chambers et. al. (1996) have shown that this indicator may be decomposed into efficiency change (LEC) and technical change (LTC), that is L= LEC + LTC.

$$LEC = D_T^0 (x^0, y^0; g) - D_T^1 (x^1, y^1; g) \tag{6}$$

$$LTC = ½ [D_T^1(x^1, y^1; g) - D_T^0(x^1, y^1; g) + D_T^1(x^0, y^0; g) - D_T^0(x^0, y^0; g)]$$

Efficiency change is equal to the difference in the directional distance function between two periods and technical change equals the average shift in the frontier.

4. Empirical results

This study uses banks' balance sheet and income statement data for a number of Southeast Asian banks between 2001 and 2007 obtained from the London based International Bank Credit Analysis Ltd's Bankscope database.

TABLE 1Stochastic cost frontier estimates

Variables	Parameters	Coefficients	t-Ratio
Constant	α_0	2.46	0,012
x_1	α_1	1.75	0,65
x_2	α_2	3.28	0,78
x_3	α_3	-0.77	-0,89
x^2_1	α_{11}	1.27	0,065
x^2_2	α_{22}	3.16	0,24
x^2_3	α_{33}	-4.32	-0,57
x_1x_2	α_{12}	3.66	0,04
x_2x_3	α_{23}	7.52	0,92
x_1x_3	α_{13}	-2.77	-0,21
y_1	β_1	3.19	0,32
y_2	β_2	-2.11	-0,78
y_3	β_3	3.89	0,51
y^2_1	β_{11}	3.45	0,87
y^2_2	β_{22}	2.16	0,08
y^2_3	β_{33}	4.08	1,23
y_1y_2	β_{12}	2.75	0,65
y_1y_3	β_{13}	1.22	0,71
y_2y_3	β_{23}	-2.62	-0,72
y_1x_1	γ_{11}	3.35	0,34
y_1x_2	γ_{12}	1.14	0,19
y_1x_3	γ_{13}	2.82	0,46
y_2x_1	γ_{21}	0.45	0,58
y_2x_2	γ_{22}	1.64	0,43
y_2x_3	γ_{23}	-2.89	-0,072
y_3x_1	γ_{31}	1.75	0,28
y_3x_2	γ_{32}	1.12	0,22
y_3x_3	γ_{33}	2.42	0,76
T	δ_1	0.49	0,0013
t^2	δ_2	-0,75	-0,0028
$t\ x_1$	ω_1	1.48	0,031
$t\ x_2$	ω_2	0.77	0,22
$t\ x_3$	ω_3	3.58	0,057
$t\ y_1$	υ_1	2.09	0,31
$t\ y_2$	υ_2	2.68	0,45
$t\ y_3$	υ_3	3.45	0,018
CR_3	ν_1	-2.09	-0,26
NPL ratio	ν_2	1.65	0,072

Table 1 presents the estimated parameters of the stochastic directional distance function described above with most of the maximum likelihood coefficients of equation (1) being statistically significant. The results indicate that technical efficiency plays an important role affecting bank performance (estimate of □12 is close to one). This finding complies with previous studies' results (Koutsomanoli-Fillipaki et al. (2009), S. Papadopoulos (2009, 2010)), in positively associating technical efficiency with bank performance.

The three firm concentration ratio (CR3) is found to be negatively associated with inefficiency, suggesting that banks operating in relatively concentrated markets operate more efficiently than banks operating in more competitive environments. This finding (also reported by (Koutsomanoli-Fillipaki et al. (2009) seems to indicate that banking markets remain competitive regardless of the increasing degree of concentration, thus contradicting industrial organization theory.

The ratio of non-performing loans (NPL) appears to be positively correlated with inefficiency, suggesting that banks operating relatively more efficiently than others incur lower losses from bad debts. This may be the result of the adoption of more accurate and strict credit rating techniques and better management.

Tables 2 and 3 present the inefficiency scores of Southeast Asian banking markets between 2001 and 2007. Taiwan seems to be the most efficient banking market (with scores ranging between 0,189 and 0,214) with Thailand and Malaysia the least efficient. Moreover, Thailand and Malaysia exhibit the greatest improvement in efficiency over time with the notable exception of Taiwan and Hong Kong which shows a slight deterioration in efficiency. Overall, in general inefficiency scores typically range between 0,19 and 0,33.

As regards inefficiency scores according to asset size, the smallest banks (total assets up to €5 billion) are the most efficient and the largest sized institutions are the least efficient, a finding that is consistent with previous studies' results (S. Papadopoulos 2008, 2009). In Taiwan, this result is reversed with the largest institutions appearing to operate most efficiently.

Tables 4 and 5 show the Luenberger productivity measures for banking markets and according to asset size for a number of years. The findings are rather mixed suggesting both positive and negative productivity changes from year to year for all banking sectors. The productivity indicators are found to be ranging from 0,20 to -0,18. For the year 2007 for instance, form our sample of 7 banking markets, we report negative productivity measures for three countries. Banks in Korea appear to be gaining 19% in total factor productivity growth and in Taiwan productivity declines by 11%. For Thai banks, productivity grew in all years except the last, when it declined by 6% and for the year 2004 productivity grew in all banking samples except Malaysia. Overall, total factor productivity grew in Thailand, Hong Kong, Korea, Singapore and Taiwan and declined in Indonesia and Malaysia. The largest average annual growth rates are reported by Thai and Korean banks (rates of 9% and 8,14% respectively) and the largest negative annual productivity rate is reported for Indonesian banks (-4%). These findings are in line with previous results reported by Feng and Serletis (2010).

The Luenberger productivity measures according to assets size that are presented in Table 5 are very mixed and consequently we cannot reach definitive conclusions regarding the optimal bank size in terms of productivity growth. In Indonesia, Malaysia and Korea for instance, medium sized banks (between 5 and 10 billion in total assets) seem to be associated with the largest average annual productivity growth rates, whereas in Singapore and Thailand medium sized banks show the largest negative growth rates. In Hong Kong and Thailand the largest banks are associated with strong productivity gains, but the largest Taiwanese and Indonesian banks exhibit significant productivity losses.

Table 6 shows the decomposition of the productivity indicators into two components, efficiency change and technological change. Our findings suggest that in all banking sectors, the technological progress indicator is greater than the efficiency indicator and therefore when we observe very good productivity rates, these are due to technological change rather than significant improvements in efficiency. Furthermore, negative productivity indicators are mainly due in most cases to strong negative efficiency change estimates and when both components are found to be negative, technological change seems to be associated with the least poor performance. The best technological change estimate between 2001 and 2007 is found for Singaporean and Korean banks (0,15 and 0,12 respectively) and the largest efficiency change indicator is also reported for Singaporean banks (0,17). These results generally confirm previous findings reported by Koutsomanoli-Fillipaki et al. (2009).

TABLE 2Average inefficiency scores of Southeast Asian banks (2001-2007).

	2001	2002	2003	2004	2005	2006	2007
Taiwan	0.189	0.186	0.198	0.214	0.192	0.199	0.198
Hong Kong	0.248	0.240	0.245	0.239	0.235	0.226	0.259
Indonesia	0.273	0.315	0.281	0.261	0.278	0.269	0.258
Malaysia	0.329	0.318	0.278	0.305	0.308	0.299	0.291
Korea	0.283	0.271	0.283	0.276	0.287	0.268	0.266
Singapore	0.298	0.283	0.291	0.282	0.269	0.284	0.275
Thailand	0.331	0.305	0.319	0.324	0.312	0.316	0.295

TABLE 3: Average inefficiency scores of Southeast Asian banks according to assets size 2001-2007 (million €)

	0-1000	1000-5000	5000-10000	10000-20000	>20000
Taiwan	0.184	0.195	0.172	0.203	0.169
Hong Kong	0.198	0.237	0.216	0.224	0.235
Indonesia	0.247	0.235	0.314	0.282	0.328
Malaysia	0.264	0.28	0.298	0.309	0.338
Korea	0.257	0.278	0.288	0.263	0.299
Singapore	0.253	0.262	0.291	0.296	0.29
Thailand	0.314	0.275	0.288	0.329	0.348

TABLE 4 The Luenberger productivity measure by country (2001-2007)

	2001	2002	2003	2004	2005	2006	2007
Taiwan	0,16	-0,09	0,08	0,20	-0,07	0,17	-0,11
Hong Kong	-0,18	0,16	0,15	0,09	0,19	0,05	-0,12
Indonesia	-0,14	-0,06	-0,16	0,09	-0,17	0,09	0,07
Malaysia	-0,09	0,05	-0,13	-0,07	0,18	-0,12	0,06
Korea	-0,05	0.08	0,19	0.13	-0.09	0,12	0.19
Singapore	0,19	-0,08	0,16	0,09	0,05	-0,09	0,14
Thailand	0,14	0,09	0,08	0,12	0,17	0,11	-0,06

TABLE 5 The Luenberger productivity measure by country according to assets size 2001-2007 (million €)

	0-1000	1000-5000	5000-10000	10000-20000	>20000
Taiwan	-0,04	-0,05	0,14	0,09	-0,09
Hong Kong	-0,08	-0,09	-0,07	0,08	0,12
Indonesia	-0,06	0,08	0,15	-0,04	-0,08
Malaysia	-0,09	-0.09	0,15	-0.06	0.09
Korea	0,07	-0,15	0,14	-0,06	0,08
Singapore	-0,04	-0,08	-0,09	0,08	-0,05
Thailand	0,06	-0,06	-0,12	0,15	0,09

TABLE 6Decomposition of the Luenberger productivity measure 2001-2007 (million €)

	2001	2002	2003	2004	2005	2006	2007
Taiwan LEC	0,05	-0,12	0,03	0,08	-0,05	0,09	-0,08
LTC	0,11	0,03	0,05	0,12	-0,02	0,08	-0,03
Hong Kong LEC	-0,12	0,07	0,08	0,05	0,06	-0,05	-0,06
LTC	-0,06	0.09	0,07	0.04	0.13	0.10	-0.06
Indonesia LEC	-0,06	-0,15	-0,12	0,03	-0,06	0,02	0,08
LTC	-0,08	0,09	-0,04	0,06	-0,11	0,07	-0,01
Malaysia LEC	0,03	0,10	-0,08	-0,04	0,03	-0,04	0,08
LTC	-0,12	-0,05	-0,05	-0,03	0,15	-0,08	-0,02
Korea LEC	-0,06	-0,04	0,10	0,05	-0,10	0,04	0,08
LTC	0,01	0,12	0,09	0,08	0,01	0,08	0,11
Singapore LEC	0,04	-0,05	0,09	0,13	0,17	-0,06	0,03
LTC	0,15	-0,03	0,07	-0,04	-0,12	-0,03	0,11
Thailand LEC	0,03	0,04	0,12	0,11	0,08	0,04	0,03
LTC	0,11	0,05	-0,04	0,01	0,09	0,07	-0,09

5. Conclusion

This paper uses directional technology distance function developed by Chambers et al. (1996) to calculate measures of efficiency and productivity for a large number of Southeast Asean banks between 2001 and 2007. The results indicate that inefficiencies typically range between 19% and 33% across different national banking samples. Banks from Thailand and Malaysia were the least efficient, whereas Taiwanese banks were found to be the most efficient. The findings suggest that the smallest banks (total assets up to €5 billion) are the most efficient and the largest sized institutions are the least efficient, a finding that is consistent with previous studies' results (S. Papadopoulos 2008, 2009). In Taiwan, this result is reversed with the largest institutions appearing to operate most efficiently. Overall, these results appear to support the thesis that inefficiency is increasing with bank size.

The reported figures for the Luenberger productivity measures are rather mixed suggesting both positive and negative productivity changes from year to year for all banking sectors. The productivity indicators are found to be ranging from 0,20 to -0,18. Overall, these findings indicate that total factor productivity grew in Taiwan, Hong Kong, Korea, Singapore and Thailand and declined in Indonesia and Malaysia. The largest average annual growth rates are reported by Thai and Korean banks (rates of 9% and 8,14% respectively) and the largest negative annual productivity rate is reported for Indonesian banks (-4%).

As regards the Luenberger productivity measures according to assets size our findings seem to suggest that in Hong Kong and Thailand the largest banks are associated with strong productivity gains, but the largest Taiwanese and Indonesian banks exhibit significant productivity losses. Overall, these productivity scores do not permit us to draw definitive conclusions regarding the influence of bank size on productivity gains.

Furthermore, the decomposition of the productivity indicators into the efficiency change and technological change components, showed that in all banking sectors the technological progress indicator is greater than the efficiency indicator and therefore, when we observe very good productivity rates, these are due to technological change rather than significant improvements in efficiency. Furthermore, negative productivity indicators are mainly due in most cases to strong negative efficiency change estimates. The best technological change estimate between 2001 and 2007 is found for Singaporean and Korean banks (0,15 and 0,12 respectively) and the largest efficiency change indicator is also reported for Singaporean banks (0,17).

Our results also suggest that concentration (CR3) is negatively associated with inefficiency, suggesting that banks operating in relatively concentrated markets operate more efficiently than banks operating in more competitive environments. This finding seems to indicate that banking markets remain competitive regardless of the increasing degree of concentration, thus contradicting industrial organization theory. Furthermore, the ratio of non-performing loans (NPL) is found to be positively correlated with inefficiency, suggesting that banks operating relatively more efficiently than others incur lower losses from bad debts.

The findings of this study are generally in line with earlier results applying similar methodologies in European banking markets. Researchers in the future may examine whether these relationships hold for private, mutual and public banks and also it may be worthwhile to estimate the impact of macro-economic cycles on the production and profit functions of Southeast Asean banks.

Appendix

TABLE 7 Number of banks according to years

	2001	2002	2003	2004	2005	2006	2007
Taiwan	**84**	**88**	**85**	**86**	**88**	**84**	**82**
Hong Kong	**190**	**192**	**193**	**190**	**188**	**191**	**192**
Indonesia	**101**	**102**	**104**	**98**	**102**	**104**	**105**
Malaysia	**123**	**126**	**128**	**134**	**130**	**130**	**132**
Korea	**89**	**92**	**93**	**93**	**94**	**91**	**90**
Singapore	**110**	**115**	**116**	**112**	**118**	**118**	**114**
Thailand	**70**	**70**	**72**	**73**	**72**	**71**	**75**

TABLE 8 Descriptive statistics of the output and input variables used in the model (2007).

Variables	Mean	Median	StDev.	Min.	Max
TC	344	36	1035	89	27180
P_1	0,021	0,012	0,0044	0,0076	0,065
P_2	0,064	0,041	0,0052	0,0068	0,062
P_3	0,456	0,414	0,265	0,083	0,87
Q_1	2150	176	8675	102	364850
Q_2	2719	185	9121	96	358940
Q_3	2070	134	8420	101	385070
E	424	26	1067	35	67905

TC = Total cost (operating and financial) in m $
P_1 = Price of labour (total personnel expenses/total assets) in %
P_2 = Price of funds (total interest expenses/total funds) in %
total funds = total deposits plus all kinds of bank debt
P_3 = Price of capital (total depreciation and other expenses/total fixed assets) in %
Q_1 = The value of total loans in m $
Q_2 = The value of total securities (all types of securities and investments) in m $
Q_3 = The value of all off-balance sheet activities in m $
E = The value of total equities

References

[1] D. Aigner, C. Lovell and P. Schmidt. (1977), Formulation and estimation of stochastic frontier production models. Journal of Econometrics 21-37.

[2] L. Allen and A. Rai. (1993), Global financial intermediation: universal versus specialised banking, Paper presented at the 20th annual meeting of the European Finance Association, Copenhagen Business School, Published in section II - D of the Proceedings, 1-33.

[3] Y. Altunbas, E. M. H. Liu, P. Molyneux and R. Seth (2000), Efficiency and risk in Japanese banking, Journal of Banking and Finance (24), 1605-1628.

[4] Y. Altunbas, E. P. M. Gardener, P. Molyneux and B. Moore (2001), Efficiency in European banking, European Economic Review 45, 1931-1955.¨

[5] Y. Altunbas, L. Evans and P. Molyneux (2001), Bank ownership and efficiency, Journal of Money, Credit and Banking, 926-954.

[6] Y. Altunbas, S. Carbo, E. P. M. Gardener and P. Molyneux (2007), Examining the relationship between capital, risk and efficiency in European banking, European Financial Management

[7] S. A. Berg, F. R. Forsund, L. Hjalmarsson and M. Suominen. (1993), Banking efficiency in the Nordic countries, Journal of Banking and Finance, 371-88.

[8] A. N. Berger and D. B. Humphrey. (1991), The dominance of inefficiencies over scale and product mix economies in banking. Journal of Monetary Economics 28 (1), 117-148.

[9] A. N. Berger, G. A. Hanweck and D. B. Humphrey. (1987), "Competitive viability in banking: scale, scope and product mix economies". Journal of Monetary Economics, 501-20.

[10] A. N. Berger, W. C. Hunter and S. G. Timme. (1993), The efficiency of financial institutions: a review and preview of research past, present and future, Journal of Banking and Finance, 221-49.

[11] A. N. Berger and L. Mester (2003), Explaining the dramatic changes in performance of U.S banks: Technological change, deregulation and dynamic changes in competition, Journal of Financial Intermediation 12, 57-95.

[12] J. W. Bos and J. Kolari (2005), Large Bank Efficiency in Europe and the United States: Are There Economic Motivations for Geographic Expansion in Financial Services? Journal of Business v78, n4, 1555-92.

[13] J. W. Bos and C. J. Kool (2006), Bank Efficiency: The Role of Bank Strategy and Local Market Conditions, Journal of Banking and Finance v30, n7, 1953-74.

[14] B. Casu and P. Molyneux (2003), A Comparative Study of Efficiency in European Banking, Applied Economics v35, n17, 1865-76.

[15] B. Casu, C. Girardone and P. Molyneux (2004), Productivity change in European baning: A comparison of parametric and non-parametric approaches, Journal of Banking and Finance v28, 2521-2540.

[16] B. Casu and C. Girardone (2006), Bank Competition, Concentration and Efficiency in the Single European Market, Manchester School v74, n4, 441-68´.

[17] R. Chambers, Y. Chung and R. Fare (1996), Benefit and distance functions, Journal of Economic Theory 70, 407-419.

[18] R. Chambers, Y. Chung and R. Fare (1998), Profit, directional distance functions and Nerlovian efficiency, Journal of Optimization Theory and Applications 98, 351-364

[19] E. Elysiani and S. Mehdian. (1990), Efficiency in the commercial banking industry: a production frontier approach, Applied Economics, 539-51.

[20] European Central Bank (2010), E. U Banking Structures, ECB papers (Sept. 2010)

[21] European Central Bank (2009), E. U Banking Sector Stability, ECB papers (Aug. 2009)

[22] D. Evanoff and D. Fortier. (1988), Re-evaluation of the s-c-p paradigm in banking, Journal of Financial Services Research, 277-294.

[23] D. Evanoff and P. Israilevich. (1991), Productive efficiency in banking, Economic Perspectives, Federal Reserve Bank of 'Chicago, 11-32.

[24] R. Fare and D. Primont (2003), Luenberger productivity indicators: Aggregation across firms, Journal of Productivity Analysis 20, 425-435

[25] R. Fare, S. Grosskopf, D. Noh and W. Weber (2005), Characteristics of a polluting technology, Journal of Econometrics 126, 469-492

[26] G. Feng and A. Serletis (2010), Efficiency, technical change and returns to scale in large U.S banks: Panel data evidence from an output distance function satisfying theoretical regularity, Journal of Banking and Finance 34, 127-138

[27] K. Field. (1990), Production efficiency of British building societies, Applied Economics, 415-25

[28] C. Girardone, P. Molyneux and E. P. Gardener (2004), Analysing the Determinants of Bank Efficiency: The Case of Italian Banks, Applied Economics v36, n3, 215-27

[29] J. Goddard, P. Molyneux, J. Wilson and M. Tavakoli (2007), European Banking: An Overview, Journal of Banking and Finance v31, n7, 1911-35

[30]

[31] W. H. Greene. (1993), Econometric Analysis, New York: Macmillan.

[32] D. Hauner (2005), Explaining Efficiency Differences among Large German and Austrian Banks, Applied Economics v37, n9, 969-80

[33] W. C. Hunter and S. G. Timme (1991), Technological change in large U.S commercial banks, Journal of Business 64, 339-362.

[34] J. Jondrow, C. A. Lovell, I. S. Materov and P. Schmidt. (1982), On estimation of technical inefficiency in the stochastic frontier production function model, Journal of Econometrics, 233-38.

[35] E. I. Kaparakis, S. M. Miller and A. G. Noulas (1994), Short-run cost inefficiencies of commercial banks, Journal of Money, Credit and Banking 26, 875-893.

[36] P. Kapopoulos and F. Siokis (2005), Market Structure, Efficiency and Rising Consolidation of the Banking Industry in the Euro Area, Bulletin of Economic Research v57, n1, 67-91

[37] A. Koutsomanoli-Filippaki, D. Margaritis and C. Staikouras (2009), Efficiency and productivity growth in the banking industry of Central and Eastern Europe, Journal of Banking and Finance 33, 557-567

[38] L. J. Mester. (1987), A multi-product cost study of savings and loans, Journal of Finance, 423-445.

[39] L. J. Mester. (1993), Efficiency in the savings and loan industry. Journal of Banking and Finance, p.p 267-87.

[40] L. J. Mester. (1996), A study of bank efficiency taking into account risk preferences, Journal of Banking and Finance 20, 1025-1045.

[41] K. Mitchell and N. M. Onvural (1996), Economies of scale and scope at large commercial banks: Evidence from the Fourier flexible functional form, Journal of Money, Credit and Banking 28, 178-199.

[42] D. G. McKillop, J. C. Glass and Y. Morikawa (1996), The composite cost function and efficiency in giant Japanese banks, Journal of Banking and Finance 20, 1651-1671

[43] G. Lang and P. Welzel (1996), Efficiency and technical progress in banking: empirical results for a panel of German cooperative banks, Journal of Banking and Finance 20, 1003-1023.

[44] C. A. Lovell (2003), The decomposition of Malmquist productivity indexes, Journal of Productivity Analysis 20, 437-458

[45] L. Orea (2002), Parametric decomposition of a generalized Malmquist productivity index, Journal of Productivity Analysis 18, 5-22

[46] S. Papadopoulos (2008), New evidence on efficiency in Scandinavian banking, International Research Journal of Finance and Economics (Sept. 2008, No. 19, p.p 34-47)

[47] S. Papadopoulos and S. Karagiannis (2009), Recent Evidence of Efficiency in Southern European Banking, Studies in Economics and Finance (Vol. 26, No. 2)

[48] S. Papadopoulos (2010), New Evidence on banking efficiency in Europe, International Journal of Monetary Economics and Finance 3, 280-299

[49] J. Pastor and L. Serrano (2005), Efficiency, Endogenous and Exogenous Credit Risk in the Banking Systems of the Euro Area, Applied Financial Economics v15, n9, 631-49

[50] J. Pastor and L. Serrano (2006), The Effect of Specialisation on Banks' Efficiency: An International Comparison, International Review of Applied Economics v20, n1, 125-49

[51] I. Sherman and F. Gold. (1985), Bank branch operating efficiency: evaluation with data envelopment analysis, Journal of Banking and Finance, p.p 297-316.

[52] M. Smirlock. (1985), Evidence on the (non) relationship between concentration and profitability in banking, Journal of Money, Credit and Banking.

[53] M. Smirlock, T. Gilligan and W. Marshall. (1984), Tobin's q and the structure-performance relationship, American Economic Review.

[54] L. Weill (2004), Measuring Cost Efficiency in European Banking: A Comparison of Frontier Techniques, Journal of Productivity Analysis v21, n2, 133-52