CAHIERS DE RECHERCHE / WORKING PAPERS

07-01

Should we Abandon the Intermediation Approach for Analyzing Banking Performance?

Mario Fortin
André Leclerc

UNIVERSITÉ DE SHERBROOKE
Faculté d'administration
DÉPARTEMENT D'ÉCONOMIQUE

Should we Abandon the Intermediation Approach for Analyzing Banking Performance?

Mario Fortin[1] and André Leclerc[2]

January 2007

Abstract

The intermediation approach considers banks' liabilities as inputs to produce loans and other banking assets. We show that measures of banking efficiency and productivity are biased when there is an incomplete coverage of assets and liabilities. The bias can be eliminated with a complete coverage, but in this situation we show that banks are necessarily technically efficient. Moreover, the Malmquist decomposition of productivity growth becomes useless. The difficulties identified in this paper question the usefulness of the intermediation approach in assessing banks' performance.

Keywords : Intermediation approach, efficiency, Malmquist index.
JEL : G21, D24

[1] Département d'économique and GREDI, Université de Sherbrooke, 2500 Boul. de l'Université, Québec, Canada, J1K 2R1, Email : mario.fortin@usherbrooke.ca.
[2] Faculté d'administration and Chaire des caisses populaires acadiennes en gestion des coopératives, Université de Moncton, 165, boul. Hébert, Edmundston Nouveau Brunswick, Canada, E3V 2S8 and associate researcher, GREDI, Email: andre@umce.ca. Financing of this research by the *Schulich School of Business National Research Program in Financial Services and Public Policy* is gratefully acknowledged. We extend our thanks to Michel Goulet and Jean Ricard from the Fédération des caisses Desjardins and to Stéphane Cormier from the Fédération des caisses populaires acadiennes for the collaboration in providing us the data.

INTRODUCTION

It is hard to make sense of the large variability in estimates of banks' cost efficiency and productivity found in the literature. A good illustration of this perplexity can be illustrated by comparing some results reported in the recent survey about the effect of consolidation on banks' efficiency by Amel et all. (2004). They report that the average cost inefficiency in Japanese retail banks is around 10%, US and European operate with cost 10% to 25% higher than the best practice institutions while Australian banks have an average efficiency score lower than 60%. Yet, they fail to find significant improvement of cost efficiency following mergers in US while European or Australian evidence is mixed. The comparison between studies is made difficult by the various concepts of production or efficiency used. However, Tortosa-Ausina (2002) and Fortin and Leclerc (2004) demonstrated the importance of output definition in cost efficiency in banking by showing that depending of the model of banking production, a bank's efficiency score can differ completely.

Two main models of banking production compete in this literature. In the intermediation approach, banks use labour and capital in conjunction with financial liabilities, mostly deposits, to produce loans and other means of financing. The production approach takes rather the view that, in addition to loans, deposits are also a service offered to bank's customers, so that inputs comprise only labour and capital. Because the intermediation approach is better suited to capture the decisions taken to minimize the cost of the financing mix, it has become dominant to estimate the performance of whole banks. As to the production approach, it is recommended for analyzing the performance of branches where managers have limited control on the financing mix (Burger and Humphrey, 1997).

Since it is not possible to consider the hundreds of products banks offer simultaneously, modeling banking production requires to simplify by aggregating outputs. However, Lozano-

Vivas and Humphrey (2002) have shown that the simplifications taken in using the intermediation approach is a source of bias in measuring productivity growth in banking. They point out that the bias is " ... not due to the technique used but rather in how it is applied+[1], and arises when the coverage of assets and liabilities is incomplete. Although the bias can in principle be corrected by an adjustment factor, they show that all balance sheet inputs and outputs need to be included to completely prevent it. In addition, they provide many examples showing that the bias is substantial and can explain much of productivity changes measured in banking.[2]

By focusing on the ratio between the coverage of assets and liabilities, our paper identifies a more general problem of the intermediation approach that extends also to estimates of banks' efficiency and productivity. The problem is such that we question the usefulness of continuing to use this approach in any studies of banking performance. Indeed, we show that with an incomplete coverage, efficiency scores obtained from Data Envelopment Analysis (DEA) are biased. On the other hand, if all balance sheet items are included to correct the bias, then all banks are technically efficient. The approach it then unable to establish efficiency scores of bank. It also means that the Malmquist decomposition of productivity growth in banking cannot be done. Overall, our results imply that the intermediation approach is condemned to produce either biased or trivial measures of bank's performance. We suggest that the research should be directed towards value added approaches.

Our paper is organized as follows. In the next section we show how the bias identified by Lozano-Vivas and Humphrey (LH) extends also to efficiency scores. The second section shows

[1] Lozano-Vivas, A. & D.B. Humphrey, 2002. "Bias in Malmquist Index and Cost Function Productivity Measurement in Banking ", *International Journal of Production Economics*, 76(2), p. 177.

[2] Their illustration with Spanish banks shows that total factor productivity grew at an annual rate of 3.8% over the period 1986-1991 when only deposits are considered, but decreased by 0.2% annually when all balance sheets items are included.

that when all balance sheets components are integrated in the model, then all banks are technically efficient. A graphical representation with a single output illustrates that banks' performance differ only on their level of input slacks. Using banking data for two networks of Canadian credit unions, we illustrate in the third section how the efficiency score is affected by the coverage, and the close relationship between the efficiency score and the ratio of assets to liabilities. The fourth section shows that with a complete coverage of all assets and liabilities the Malmquist decomposition of productivity growth degenerates into a trivial solution. We conclude with a suggestion that, although it is more data intensive, a more promising approach to estimate productivity in banking should be based on value added.

1. THE SOURCE OF THE BIAS

Productivity studies in banking consider a large collection of outputs and inputs to measure multifactor productivity. With the exception of labour, outputs and inputs are usually taken from banks' balance sheet and measured in value. Stock measurements are used as proxies for the true outputs and inputs because adequate data on service flows are not available. These flows are considered to be proportional to the value of some assets taken in banks' balance sheets, such as loans, while physical and financial capital provide services also proportional to the value of some elements of assets or liabilities.

Because banks offer too many services simultaneously, it is necessary to aggregate different types of products into a limited number of components while some elements of assets are neglected. In the intermediation approach, liabilities are considered as financial inputs having an interest cost, and many types of deposits as well as borrowed funds can be used to finance banks' assets. The problem pointed out by LH arises when a gap is created between the value of assets and that of liabilities included in the model. As an example, let consider two banks having all the same assets, using also the same amount of physical capital and labour but who differ only because they have different proportions of deposits and borrowed funds. Let define bank production at time *t* as a sum of some assets $\Sigma A_{i,t}$ while financial inputs included in the model is a partial sum of liabilities. Let say here that only deposits are considered, whose value is $\Sigma L_{j,t}$. Because production is defined by $\Sigma A_{i,t}$ while $\Sigma L_{j,t}$ is seen as inputs, then the ratio of coverage $R_t = \Sigma A_{i,t} / \Sigma L_{i,t}$ directly influences the measure of productivity at time *t*. As to productivity growth, it will be affected by $(R_t - R_{t-1})/R_{t-1}$, that is, by the relative difference between $\Sigma A_{i,t} / \Sigma L_{j,t}$ and $\Sigma A_{i,t-1} / \Sigma L_{j,t-1}$. If, for example, deposits become a relatively less important source of funds between *t* and *t*-1 so that R_t is superior to R_{t-1}, then productivity growth seems boosted even if bank's real performance does not improve, thus the qualification of bias. Note also that since this impact is present no matter how the cost of borrowed funds evolves with respect to that of deposits, it provides no useful information about bank's management of financing cost.

LH documented that in most published studies, productivity growth estimated with the intermediation is largely explained by $(R_t - R_{t-1})/R_{t-1}$, so that it is an artefact of the changes in the ratio between the coverage of assets and that of liabilities. LH propose to correct the bias by including all balance sheet items, which is justified on the following economic basis:

> Thus, all balance sheet assets can be considered to be outputs since they all are presumed to earn the same marginal risk-adjusted return. Similarly, all liabilities are inputs since they all are presumed to incur the same maturity-adjusted interest and/or operating expense.[3]

Note that to respect the balance sheet identity, physical capital plays a dual role as it is at the same time an input and an asset.[4] Although this point is not discussed by LH, it is clear that efficiency studies are also affected by this bias since banks with higher R_t will tend to be

[3] Lozano-Vivas, A. & D.B. Humphrey, op. cit., p. 179.

[4] No justification is given in their paper for this dual role besides it is necessary to respect the balance sheet identity. We suggest here that physical capital can be considered as an asset produced by the bank that it uses itself for an implicit risk-adjusted return equivalent to the rental rate to a third party.

considered more efficient. We develop more on this in the third section. But before that, let us explore the consequence of the proposed correction for efficiency studies.

2. AN INADEQUATE CORRECTION FOR EFFICIENCY STUDIES

Following Farrell (1957), we can broadly define a score of efficiency as a measure of the distance between the actual outcome of a bank and an optimal outcome (Ex.: profit maximization, cost minimization). Let consider here that banks seek to minimize cost and assume that we observe K banks, each producing M outputs using N inputs, so that Y is a $K \times M$ output matrix and X a $K \times N$ input matrix. The scalar θ_k representing the DEA efficiency score as defined for the k-th bank is found by solving the familiar linear programming problem:

$$\min_{\{\theta, \lambda\}} \theta_k, \text{ subject to } x_k\theta - X\lambda \exists 0,\ Y\lambda \exists y_k,\ e{=}\lambda = 1,\ \lambda_k \exists 0,\ k = 1, 2, \ldots, K \qquad (1)$$

where x_k and y_k are the input and output vectors of bank k, λ is a K-components vector of non-negative weights and e is a vector of one. In this problem the efficiency score will satisfy $\theta_k \leq 1$, its value indicating the ratio between the efficient quantity of inputs and its actual use. A value of one happens when the actual use of factors is technically efficient, that is, the bank operates on the frontier. On an extensive form, in addition to the K non-negativity constraints on λ, the first equation defines the following N+M inequalities for the DMU k:

$$\theta_k x_{ik} \geq \sum_{k=1}^{K} x_{ik}\lambda_{jk}, \quad i = 1, \cdots, N \qquad (2)$$

$$\sum_{k=1}^{K} y_{jk}\lambda_k \geq y_{jk}, \quad j = 1, \cdots, M \qquad (3)$$

To see how the correction proposed by LH impacts on the efficiency score, we impose that all assets are outputs included in Y while all liabilities are inputs inserted as the N-1 first elements of X. If we sum the first N-1 inequalities in (2) and the M inequalities in (3), we obtain:

$$\theta_k \sum_{i=1}^{N-1} x_{ik} \geq \sum_{k=1}^{K} \lambda_k \sum_{i=1}^{N-1} x_{ik} \tag{4}$$

$$\sum_{k=1}^{K} \lambda_k \sum_{j=1}^{M} y_{jk} \geq \sum_{j=1}^{M} y_{jk} \tag{5}$$

By the balance sheet identity we know that $\sum_{j=1}^{M} y_{jk} = \sum_{i=1}^{N-1} x_{ik}$. Therefore, replacing $\sum_{i=1}^{N-1} x_{ik}$ by $\sum_{j=1}^{M} y_{jk}$ allows us to rewrite (4) as:

$$\theta_k \sum_{j=1}^{M} y_{jk} \geq \sum_{k=1}^{K} \lambda_k \sum_{j=1}^{M} y_{jk} \tag{4'}$$

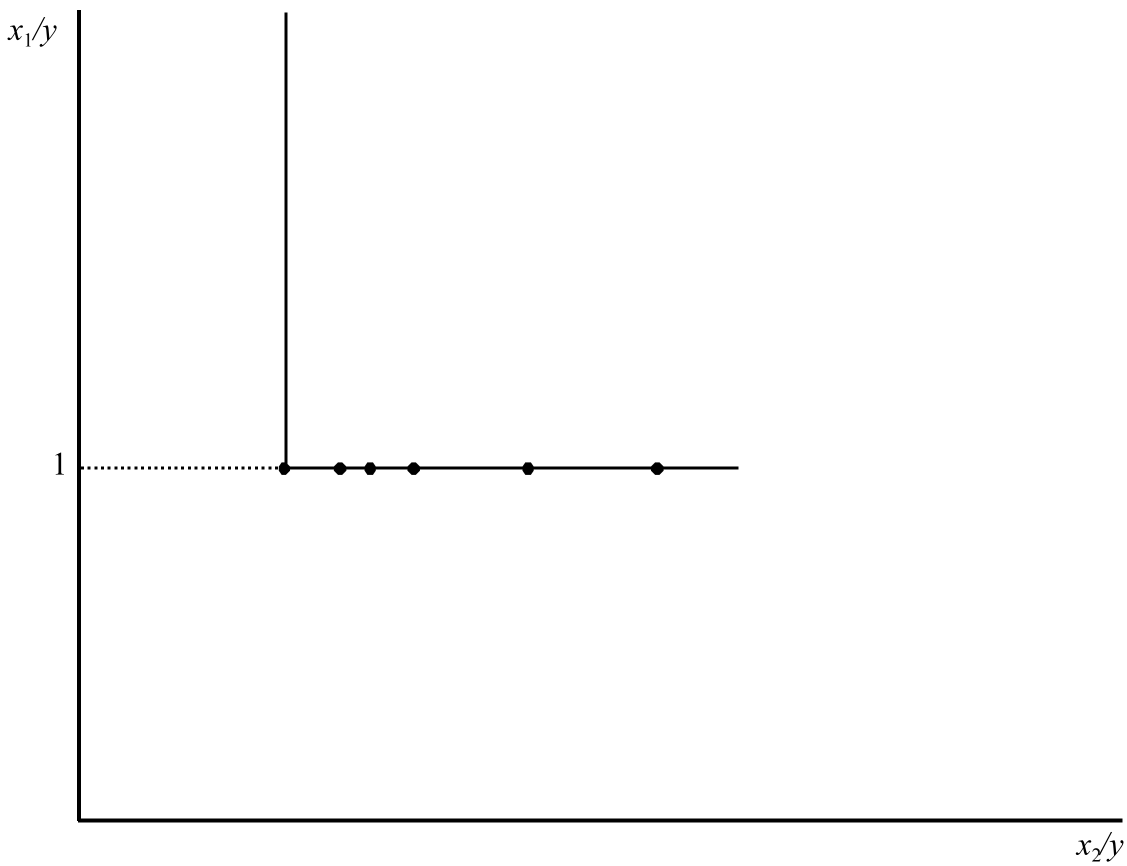
Since the left hand side of (5) is identical to the right hand side of (4'), the following inequality holds by transitivity:

$$\theta_k \sum_{j=1}^{M} y_{jk} \geq \sum_{j=1}^{M} y_{jk} \tag{6}$$

Removing $\sum_{j=1}^{M} y_{jk}$ in both sides simplifies (6) to $\theta_k \geq 1$. But since we know also that $\theta_k \leq 1$, then the only possibility to solve simultaneously both inequalities is that $\theta_k = 1$. Repeating the reasoning for all k implies that all banks are technically efficient.

The geometric representation of this result is as follows. Let suppose for the illustration that only two inputs x_1 and x_2 are needed to produce a single output y under the constraint $x_1 = y$. Because of this equality, it follows that there are constant returns to scale and, since $x_1 = y$, the production function $y = f(x_1, x_2)$ can be represented as $1 = f(x_1/y, x_2/y) = f(1, x_2/y)$. That means that all observations are on the line $x_1/y = 1$ in the space x_1/y and x_2/y, that is, are aligned horizontally if x_1/y is measured vertically (see Figure 1). The fact that all banks are technically efficient is obvious here since they are all on the horizontal part of the frontier. We can also observe that because banks differ on their use of the second input, their performance vary on their degree of input slacks. In the next section, we illustrate with real data how the efficiency score is affected by R_t when the coverage is incomplete.

Figure 1
The balance sheet identity and the technological frontier



3. INCOMPLETE COVERAGE AND THE EFFICIENCY SCORE

For the empirical application, we have built a panel of 580 annual observations about Canadian credit unions operated by two networks, *La Fédération des caisses populaires Desjardins du Québec* and *La Fédération des caisses populaires acadiennes* observed over a period of nine years between 1996 and 2004.[5] All financial data were extracted from the balance sheets and expressed in constant dollars of 1997 while labour was provided by the Human resources management and is measured in full-time equivalent employees.

To illustrate the impact on the efficiency scores of increasing the coverage of assets and liabilities, we took inspiration of LF's strategy which consists of beginning with a basic model having an incomplete coverage, then to add progressively more assets and liabilities until a final model incorporates all balance sheet items. The basic level of coverage considers only two outputs (*commercial loans* and *other types of loans*) covering 80.7% of assets and four inputs (*demand deposits*, *term deposits*, *labour* and *physical capital*) representing 81.6% of liabilities. This basic coverage level is similar to the list of inputs and outputs frequently included in published studies on banking performance using the intermediation approach. The second coverage level adds *investments* on the assets side and *borrowings and other deposits* as additional liabilities to significantly increase the coverage of assets (91.4%) and liabilities (87.9%).

Starting with the third model, we add financial inputs and outputs using two different methods. In a first, called *Addition of variables*, we continue to include new components as additional

[5] There was more than 1300 local credit unions in 1996 but starting in 1997, a wave of mergers have considerably reduced their numbers. To work with a balanced panel, we grouped the information about merging credit unions so that our final database reproduce for all years the administrative structure that existed at the end of 2004. Moreover, some credit unions that were in exceptional situations, such as operating in offices provided at no charge or having received grants, were removed from the sample. The identification of these special circumstances was made largely by representatives of the federations that helped us in building the database.

elements, a procedure more likely to be used in empirical studies. However, because increasing the number of inputs and outputs generally raises the technical efficiency,[6] it is hard to know if the rising score is due to a more complete coverage or a larger number of inputs and outputs. To better identify the effect of the coverage alone, we then use a second method named *aggregation*, in which the value of new assets and liabilities are added to that of components already included in the model while the number of variables is kept constant. The third model adds *other assets* and *other liabilities*. Taking into account *liquidity* and *owner's equity* pushes the coverage to 98.8% of assets and 100% of liabilities. Finally, adding *physical capital* as a final element of production raises asset coverage to 100%.[7] The different models with their respective coverage are presented in Table 1.

Table 1 : List of assets and liabilities by level of coverage

Level	Assets (outputs)	Liabilities (inputs)	Coverage level (%)	
			Assets	Liabilities
1	business loans other loans	demand deposits, term and tax sheltered deposits, labour and physical capital	80.7	81.6
2	+ investments	+ other deposits and borrowings	91.4	87.9
3	+ other assets	+ other liabilities	92.6	91.1
4	+ liquidities	+ owner's equity capital	98.8	100.0
5	+ physical capital		100.0	100.0

[6] This result had been noted in Farrell's first study: "the introduction of a new factor of production into the analysis cannot lower, and in general, raises the technical efficiency". (1957, p. 269-270)

[7] Most variables are self explaining except *other assets* which are accounts (including interest) receivable and deferred tax while *other liabilities* include other deposits and borrowings as well as accounts payable The Caisses populaires have a higher proportion of loans (81%) than the Spanish banks (56%) used by LH, but much less liquidity (respectively 6% vs 24%). This difference in the composition of asset changes the coverage associated with each model but does not alter the logic of the results.

Using a panel will allow us to estimate productivity growth in the next section. But to illustrate how efficiency is affected by the coverage, it is sufficient to look only to one year. To that effect we selected arbitrarily the year 2004. With the basic model the lowest efficiency score is 0.399, the average is 0.759 and 75 credit unions are efficient (12.9% of 580). With the second level of coverage, there is a significant increase in the efficiency scores, the lowest value being 0.845 while the average raises to 0.982 and 249 credit unions are efficient (42.3% of the total). Passing to the 3rd coverage level further increases the average score, which reaches 0.991 when adding new variables or 0.984 with the aggregation strategy. In the first case, 354 units (61.0%) have a score of one while 264 credits unions are technically efficient in the second case. When adding variables to the 4th level of coverage, the average score becomes 0.999 and 440 credit unions are technically efficient, a proportion of 75.8%. With aggregation, the average efficiency score attains 99.6%, continuing to rise although at a slower pace than with addition of variables, but the number of efficient units decreases slightly to 204. Finally, in the fifth model when a complete coverage is reached, all banks are technically efficient with both strategies, as demonstrated in the previous section.

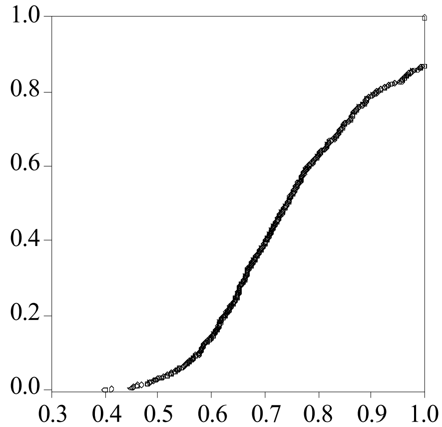
Not only does the average score rises with the coverage, but the range of the efficiency scores narrows. Figure 2 shows the cumulative distribution of efficiency scores for coverage levels 1 to 4, and for both strategies at the levels 3 and 4. It can easily be observed that, as the coverage becomes more complete, the cumulative distribution is pushed to the right. This figure illustrates the first main point of our results. The distribution of the efficiency scores is largely the consequence of the choices made when selecting which assets and liabilities are to be included. Opting for a low coverage opens the possibility for wide variations in the ratio of assets to liabilities, thus causing a dispersion of efficiency scores that, by definition, reduces the average efficiency. At the opposite, because since a more complete coverage ignores less components, R_t necessarily converges towards one, so that efficiency scores cannot have as much variability.

Although we do not have the ability to show how the coverage affects the distribution of efficiency scores in previously published papers using the intermediation approach, we have the conviction that the conclusion we reach with our sample apply to other studies as well and explains why so many researchers find high and variable X-inefficiency in banking (Berger and Mester, 1997).

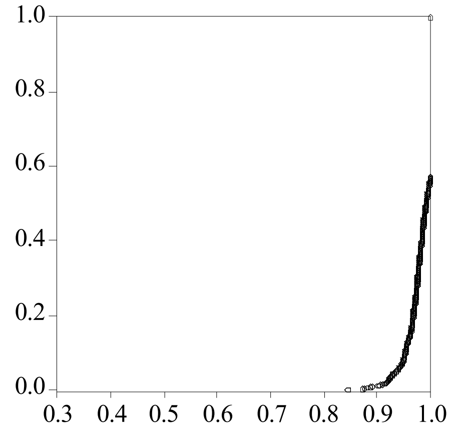
A second important conclusion can be developed, which concerns not the general distribution of efficiency but the link between the ratio of assets to liabilities and the score of technical efficiency. Using once again the year 2004, Figure 3 shows the scatter diagram between R_t on the horizontal axis and efficiency score on the vertical axis for coverage levels 1 to 4 and both estimation strategies. One can easily observe that R_t displays more variation with a more partial coverage (approximately between 50% and 150% with the basic model) and that this dispersion falls considerably when the coverage is expanded. With such a difference in the dispersion of the ratio of outputs to financial inputs, it is then understandable why the efficiency scores are more dispersed when less assets and liabilities are considered. It is also apparent that, for any coverage level, the lowest efficiency scores tend to be assigned to credit unions which have a lower ratio, and that increasing the ratio impacts positively on the score.[8] This figures clearly illustrates that efficiency scores are biased by the coverage of assets vs liabilities in the sample. Since this ratio does not inform on the quality of the management nor on other aspects of a bank's performance, it is valid to question the usefulness of the efficiency scores themselves is assessing banks' real efficiency.

[8] Because of the large number of efficient units, the link between both variables is not linear so that the correlation does not inform adequately on the dependence of the score on R_t.

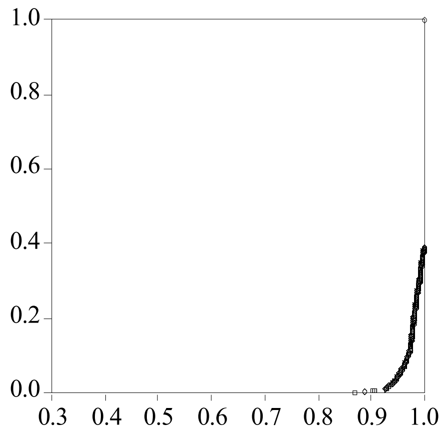
Figure 2
Cumulative distribution of efficiency scores
by coverage level, 2004



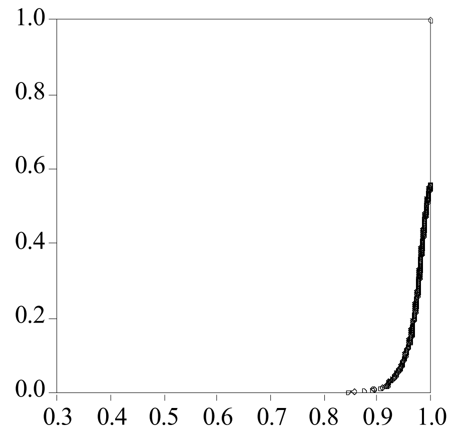
Efficiency scores for level 1



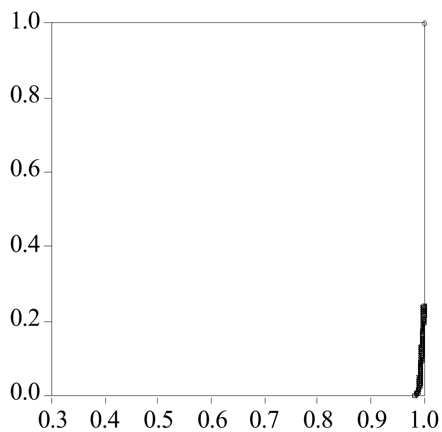
Efficiency scores for level 2



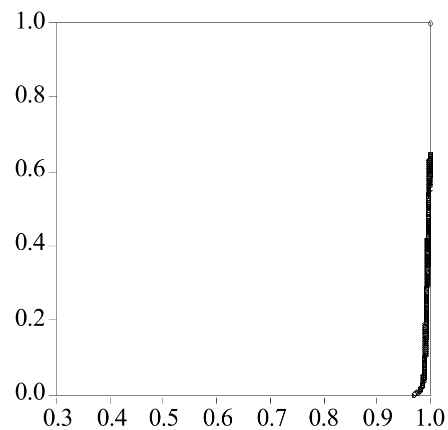
Efficiency scores for level 3 (addition)



Efficiency scores for level 3 (aggregation)

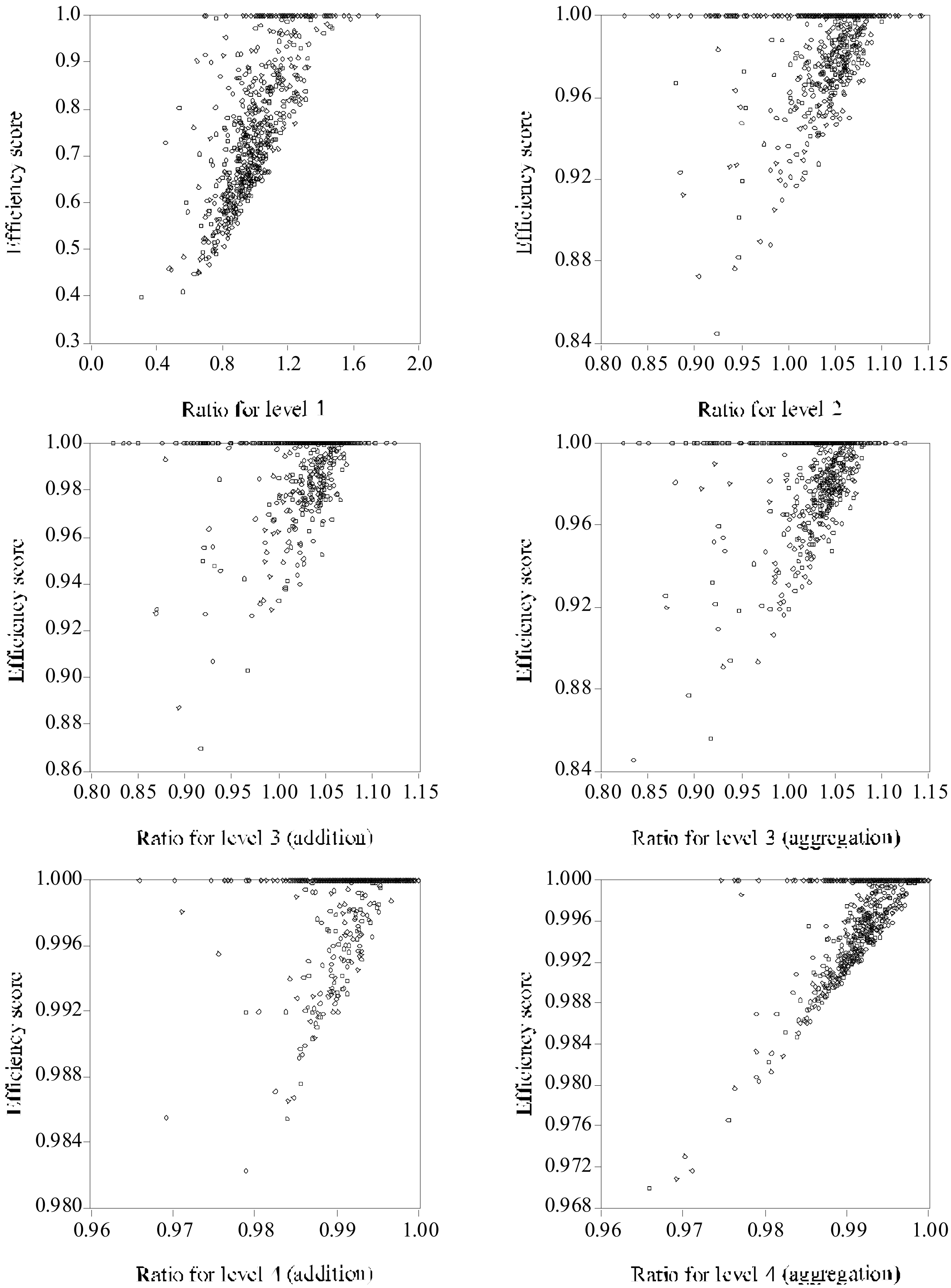


Efficiency scores for level 4 (addition)



Efficiency scores for level 4 (aggregation)

Figure 3
Efficiency score and ratio of asset to liabilities by coverage level, 2004



4. COMPLETE COVERAGE AND THE MALMQUIST DECOMPOSITION

We now return to the measurement of productivity growth and we show the impact on the Malmquist index developed by Färe & al. (1990, 1994) when the coverage is complete. The Malmquist index decomposes total factor productivity (TFP) growth into technological progress (TP), measured by the displacement of the frontier, and changes in technical efficiency (TE), often called the catch up because it happens when inefficient banks move closer to the frontier. In a variable-to-scale environment, TE can further be decomposed into scale efficiency (SE) and pure technical inefficiency (PTE). The former is the ratio between the maximum productivity at the cost-minimizing size and the highest possible productivity at the actual scale. As to the latter, it is the cost ratio between the efficient and the actual production without any change in the scale of production. We now use all nine years of the sample to show that when all banks are efficient the catch up cannot contribute to productivity growth and no estimation of the scale efficiency can be provided. In fact, the Malmquist decomposition degenerates into a trivial solution where only changes in the position of the frontier can alter productivity.

To see this, we follow the same strategies as in section 3 to add financial inputs and outputs. In the first (*Addition of variables*), new components are considered as separate elements. In the second strategy (*Aggregation*), the value of new assets and liabilities after model 2 are added to that of components already included in the model, so that the number of variables is kept stable for model 2 to 5. The results for the different coverage levels and strategies are reported in Table 2 which presents annually the different components of TFP, the number of technically efficient credit unions and the ratio of assets on liabilities.

Lets first concentrate on the results for the addition of variables strategy. When unstable variables are added to the model, large variations in the annual results on TFP are observed. These variations in fact reproduce the result established by LH that TFP growth is largely the consequence of change in the ratio of assets to liabilities.[9] Indeed, an increase in the coverage level and the number of variables lead to higher technical efficiency scores. At the end, that is at model 5, all credit unions are technically efficient and the technical efficiency index is equal to one. There is no catch up and TFP change is solely explained by technological progress. The estimation of productivity growth is reduced with the strategy of aggregation reported at the bottom of Table 2., with a reduction in the absolute average rate of TFP change is 1.24%. The results for technical efficiency change are similar on average for the three models. But once again in model 5, all 580 credit unions are technically efficient so that a frontier shift is still the only factor affecting inputs productivity.

Table 2 : Malmquist index components, average from 1996 to 2004 by coverage level

Coverage level	TE	TP	PTE	SE	TFP	Number of technically efficient units[a]	R_t
	Addition of variables						
1	1.0032	1.0248	1.0013	1.0019	1.0281	65	97.0%
2	1.0031	1.0050	1.0023	1.0009	1.0082	223	100.2%
3	1.0020	1.0128	1.0014	1.0006	1.0148	306	98.6%
4	1.0005	1.0158	1.0003	1.0002	1.0163	396	98.8%
5	1.0000	1.0138	1.0000	1.0000	1.0138	580	100.0%
	Aggregation of variables (3 outputs and 5 inputs)						
3	1.0021	1.0096	1.0014	1.0006	1.0117	224	98.6%
4	1.0006	1.0033	1.0004	1.0002	1.0039	182	98.8%
5	1.0000	1.0097	1.0000	1.0000	1.0097	580	100.0%

[a] Variable returns to scale.

[9] The most significant year-to-year changes in some components of the balance sheet were a decrease of liquidity from 8.7% to 3.7% between 1996 and 2004 while investments see their relative importance growing from 7.5% to 12.3%. On the liabilities side, borrowings are very unstable, with an average absolute year-to-year changes of 19.4%, suggesting that models that exclude borrowings are likely to produce large annual swings in the estimated productivity growth. To verify the impact of each input on TFP growth, we calculated in model 5 the correlation between TFP change and the annual variation of the ratio between total assets and each input for the years 2003-2004. The highest correlation is found with *physical capital* (0.299), *other liabilities* (0.285) and *other deposits and borrowings* (0.257), the three most unstable variables.

5. CONCLUSION

The title of this paper asks if we should consider to abandon the intermediation approach to measure banks performance. Most of our attention has been devoted to demonstrate with the non parametric method of DEA what is the impact of the coverage of assets and liabilities on the efficiency score. We showed that with an incomplete list of assets and liabilities, the ratio between assets and liabilities included in the model of banking production strongly influences the efficiency score. This is foremost revealed by the fact that the average score varies significantly according to the definition of inputs and products. Assessment of potential losses caused by inefficient banking measurements must then be interpreted with caution.

But we also showed that if one covers all assets and liabilities to remove the bias, it necessarily finds that all banks are efficient. This makes the analysis of efficiency as well as the Malmquist decomposition of productivity irrelevant. In essence, what the DEA finds is that, because of the strict correspondence between the value of assets and liabilities when all elements of balance sheet are considered, best practice requires to hold one dollar of liability to have one dollar of asset. But, obviously, all banks respect the balance sheet identity so they are all considered as best performers. And since other inputs, such as labour, are not as highly correlated with production as liabilities is, they are not considered essential in production, so a bank can have excess use of labour and still be considered as technically efficient. The researcher that wants to use the intermediation approach is then placed between a rock and a hard place. Either it has biased results with an incomplete coverage or finds all banks to be efficient. In light of this difficult choice, we believe it is more appropriate to rethink the way we estimate banks performance.

Some could be tempted to use slacks-based measures as developed by Tone (2001) to continue to use the intermediation approach with a complete coverage and rank banks with respect to their degree of input slacks. We do not believe such an approach would be fructuous since it would be highly bizarre to continue to include liabilities as inputs to deal with what is nothing more than a balance sheet identity. It seems more rational to simply ignore the role of financial inputs since we know that one dollar is needed to support each dollar of asset.

If the intermediation approach is discarded, two alternatives are open, the production approach and the value-added approach. It seems to us that the second one is more promising. In the production approach both credit and deposits services are included in the outputs of the banking firm but the high level of correlation between both types of services may lead to some specification problems. A value-added approach as developed by Fixler and Zieschang (1999) offers an alternative that takes into account the cost of funds to measure the average interest rate spread, so that it can take us out of this trap. Dealing adequately with the interest rate risk and selecting the appropriate reference rate (Fortin, Leclerc and Jean-Baptiste, 2006) will certainly be difficult but necessary steps to further develop this approach.

REFERENCE

Amel, D., C. Barnes, F. Panetta and C. Salleo, 2004. "Consolidation and efficiency in the financial sector: A review of the international evidence". *Journal of Banking and Finance* 28(10), 2493-2519.

Berger, A.N., Mester, L.J., 1997. "Inside the black box: What explains differences in the efficiencies of financial institutions". *Journal of Banking and Finance* 21, 895–974.

Casu, B., C. Girardone and P. Molyneux. 2004. "Productivity change in European banking: A comparison of parametric and non-parametric approaches". *Journal of Banking and Finance*, 28(10), 2521-2540.

Färe, R., S. Grosskopf, B. Lindgren & P. Roos, 1994. "Productivity developments in Swedish hospitals: a Malmquist output index approach", in A. Charnes, W. W. Cooper, A. Y. Lewin & L. M. Seiford (Eds.), *Data envelopment analysis: theory, metholodogy and applications*, Boston: Kluwer, 253-271.

Färe, R., S. Grosskopf, S.Yaisawarng, S.K. Li & Z. Wang, 1990. "Productivity growth in Illinois electricity utilities". *Resources and Energy* 12, 383-398.

Farrell, M. J., 1957. "The measurement of productive efficiency". *Journal of Royal Statistical Society* 120, 253-281.

Fixler, D. and K. Zieschang.(1999) "The productivity of the banking sector : integrating financial and production approaches to measuring financial service output", *Canadian Journal of Economics* 32, 547-569.

Fortin, M. and A. Leclerc, 2004. "Rationalization, automation and efficiency of Caisses Populaires Desjardins", *Proceedings of the Financial Services and Public Policy Conference*, Schulich School of Business, York University, Toronto, 251-288.

Fortin, M., A. Leclerc and N. Jean-Baptiste, 2006. "L=impact des opérations transactionnelles sur la croissance de la productivité dans le secteur bancaire [On line]". Sherbrooke: Université de Sherbrooke, département d=économique, cahier de recherche 06-01, http://www.usherbrooke.ca/adm/departements/economique/recherche/cahiers/2006/0601.pdf.

Lozano-Vivas, A. and D.B. Humphrey. 2002. "Bias in Malmquist index and cost function productivity measurement in banking". *International Journal of Production Economics*, 76, 177-188.

Tone, K. 2001. "A slacks-based measure of efficiency in data envelopment analysis", *European Journal of Operational Research* 130, 298-509.