London Metropolitan University

Centre for International Capital Markets

Discussion Papers ISSN 1749-3412

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No 2009-4

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February 2009

Abstract

In this paper, the productivity of Baltic banks over 2000-2006 is analysed with a Malmquist index and the input technological bias is investigated. Baltic banks on average became more efficient and experienced technological improvment. Our results indicate that the traditional growth accounting method, which assumes Hicks neutral technological change, is not appropriate for analyzing changes in productivity for Baltic banks.

Key words: Baltic banks; productivity, technological change, policy implications.

JEL Classification : C43, G21, P21

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1. Introduction

Since the new millennium Baltic banking markets have undergone an expansive period. The dynamic growth of lending, including mortgage, and deposits growth contributed to an increase in banks assets by 35% on average. Estonia, Latvia and Lithuania have been among most growing banking markets in Central and Eastern Europe. Commercial banks have also significantly improved their efficiency by investing in infrastructure and technologies.

However, the banking sector has remained vulnerable to domestic and external economic shocks. The Baltic countries face an uncertain period as a result of the current global financial crisis. The Latvian Government, for example, has recently been forced to take over the second largest bank after a run on its deposits. This measure significantly undermines the confidence in the banking sector as a whole. The current problems are very similar to the collapse of Baltija Bank in May 1995.[1]

Therefore it is vital not only for banking regulators but also for market analysts to have sufficient relevant information that aids in the identification of actual or potential problems in the banking systems and individual banks. Such information is also valuable in order to compare competitiveness and efficiency of banking systems across EU countries. If there is significant inefficiency in the sector, in general, and in different groups of banks, in particular, there may be room for structural changes, increased competition, mergers and acquisitions.

Efficiency at the unit level has become a contemporary major issue, due to the increasingly intense competition experienced at world level related to the effects of globalization, technological innovation and increase regulation (Dietsch and Weill,

[1] Baltija Bank was the country's largest commercial bank. Its collapse disclosed severe shortcomings within the banking sector that was considered to be stable.

2000; Molyneux and Williams, 2005; Alam, 2001; Berger and Mester, 2003, Bonin et al., 2005, Fries and Taci 2005).

This research study analyses productivity change in Baltic banks using a data envelopment analysis (DEA) model, the Malmquist Index with biased technology change. The Malmquist index, was previously used in banking, for example, by Guzmán and Reverte (2007), Casu *et al.* (2004), Sturm and Williams (2004), without biased technology, therefore the present research innovates in banking context.

Whereas productivity may be estimated by parametric techniques, the most popular approach employs non-parametric methods – DEA and the Malmquist productivity index. The advantage of using non-parametric frontier techniques is that they impose no *a priori* functional form on technology, nor any restrictive assumptions regarding input remuneration. Furthermore, the frontier nature of these methods allows any productive inefficiency to be captured and offers a ‘‘benchmarking’’ perspective.

The research objective of our analysis is to evaluate productivity growth in the banking sector in Estonia, Latvia and Lithuania. There are three motivations for our research. First, at European level achieving an integrated market for banks and financial conglomerates is a core component of the European policy in the area of financial services. Therefore productivity comparisons among neighbours are a way to evaluate this integration. Second, small countries have small economies of scale and therefore their banks tend to be small which limits the competition at European level. Internal growth is based in productivity improvement. Third, as the productivity measure used in the present research are relative to the sample, the multi country productivity comparison, restricts the possibility that the sample could be globally inefficient, but the relative measure will give a positive relative view of some units. Moreover, the present paper analyses technological change bias, concluding that Hicks neutral technological change, is not appropriate for analyzing changes in productivity for Baltic banks.

The remainder of this paper is organised as follows. Section 2 presents the contextual setting. Section 3 presets the literature survey. Section 4 presets details the methodology. Section 5 presents the data and the results. Section 6 concludes.

2. Banking Sector in the Baltic Countries

The banking sector has been the economy's dominant financial channel for most transition economies. The accession agreement to the European Union and later removal of entry barriers within the EU banking market catalysed necessary consolidation of banking in all transition economies.

The Baltic countries underwent the rapid deregulation process of their banking sectors in the 1990s. The transformation was painful and brought inevitably banking crises when a large number of newly established banks were forced to close their business operations. Baltic countries started banking reform in 1991 after regaining independence from former Soviet Union. Estonia and Lithuania inherited the specilised Soviet banks that were in the first instance reconstituted as state banks and gradually or partially privatised. Latvia, for example, sold and privatised former branches of specialised banks (Fleming *et al* 1996).

The Baltic banking system relied on private banks from the beginning of transition. All three countries adopted liberal licensing policies. Liberal barriers to entry and low minimum capital requirements led to an uncontrolled growth in small and medium sized commercial banks. Restrictions on foreign commercial banks activities were also kept to minimum.

The Estonia banking sector exhibited, in the early 1990s, a rapid increase in the number of small private banks. However, the authority recognised that the contribution of these banks to financial intermediation is rather marginal. Regulators threfore tightened licensing policy and imposed strict prudential regulation. The gradual increase of minimum capital requirements, in early 1993, has also helped to reduce the number of banks from 42 to 23 in Latvia (De Castello et al., 1996). The dependency of the business sector on credits led to a situation in which some economies showed symptoms of over-borrowing and over-indebtedness. The first banking crisis occurred in Estonia in 1992, in Latvia and Lithuania in 1995. The crises led to a fundamental revision of the imposed regulatory policies and banks management practices.

3. Literature Review

There have recently been a large number of studies focusing on the efficiency analysis in EU countries. The empirical studies apply either parametric or nonparametric estimation techniques (see, for example, Altunbas et al. (2001), Goddard et al., (2001), Bikker and Haaf, (2002) and Maudos et al. (2002), Schure et al. (2004), Bos and Schmiedel (2007), Kuosmanen et al. (2007) Barros et al. (2007) and Williams et al. (2008).

Factors such as legal tradition, accounting conventions, regulatory structures, property rights, culture and religion have been suggested as possible explanations for cross-border variations in financial development and economic growth (Beck et al., 2003a, b; Beck and Levine, 2004; La Porta et al., 1997, 1998; Levine, 2003, 2004; Levine et al., 2000; Stulz and Williamson, 2003). In addition, market dynamics have also been considered, as bank profits have been found to be procyclical (Arpa et al, 2001; Bikker and Haff, 2002), similarly to provisions for loan losses, which can exert a negative impact on the level of economic activity (see, for example, Cortavarria et al., 2000; Cavallo and Majnoni, 2002; Laeven and Majnoni, 2003).

Another strand of literature emphasises the importance of market structure and bank-specific variables in explaining performance heterogeneities across banks. This strand developed around the structure-conduct-performance (SCP) paradigm and has been extended to contestable markets, firm-level efficiency and the roles of ownership and governance in explaining bank performance (see, for example, Berger, 1995; Berger and Humphrey, 1997; Bikker and Haaf, 2002; Goddard et al., 2001; Molyneux et al., 1996).

Empirical research on the efficiency of commercial banks in transition economies have been intensive in the last decade.

Two recent studies that employes the stochastic frontier approach cover a large sample of countries. Bonin et al. (2005) analyse the effects of bank ownership on bank efficiency and conclude that foreign banks are more cost-efficient than other banks. The results of Fries and Taci (2005) who analyse efficiency in 15 transition countries suggest that foreign banks show higher cost efficiency compared with domestic banks and that state-owned commercial banks exhibit the lowest efficiency among the group analysed. They stress that cost efficiency of small- and medium- sized domestic banks differ significantly from foreign and state-owned banks. De Hass and van Lelyveld (2006) find that foreign banks have had a stabilising effect on total credit supply in CEE countries. Mamatzakis et al (2008) find that banks show low level of cost and lower level of profit efficiency. They also support findings by de Hass and van Lelyveld (2006) that foreign banks outperform both state-owned and domestic private-owned banks profit efficiency.

In general, the extensive empirical evidence does not provide conclusive proof that bank performance is explained either by concentrated market structures and collusive price-setting behaviour or superior management and production techniques. Bank efficiency levels are found to vary widely across European banks and banking sectors (see Altunbaş et al., 2001; Maudos et al., 2002; Schure et al., 2004, Fries and Taci, 2005).

4. The Model

We apply Data Envelopment Analysis (DEA) to individual commercial banks in order to measure changes in productivity for the time period from 2000 through 2006. We separate measures of productivity change into various component parts to better understand the nature of technological advance. Total factor productivity (TFP) includes all categories of productivity change, which can be decomposed into two components: 1) technological change (shifts in the production frontier) and 2) efficiency change (movement of inefficient production units relative to the frontier) (e.g., Färe *et al*. 1994). Production frontier analysis provides the Malmquist indexes (e.g., Malmquist, 1953; Caves *et al*, 1982), which can be used to quantify productivity change and can be decomposed into various constituents, as described below. Malmquist Total Factor Productivity is a specific output-based measure of TFP. It measures the TFP change between two data points by calculating the ratio of two associated distance functions (e.g., Caves *et al*. 1982). A key advantage of the distance function approach is that it provides a convenient way to describe a multi-input, multi-output production technology without the need to specify functional forms or behavioral objectives, such as cost-minimization or profit-maximization.

The DEA method has been widely used to estimate the reciprocal of the Shephard (1970) input distance function. The reciprocal of this distance function serves as a measure of Farrell (1957) input efficiency and equals the proportional contraction in all inputs that can be feasibly accomplished given output, if the DMU adopts best-practice methods. We link input efficiency indexes across time in order to estimate the Malmquist productivity index. This index estimates the change in resource use over time that is attributable to efficiency change and due to technological change. Furthermore, we use the approach of Färe and Grosskopf (1996) and decompose technological change into an index of output biased technological change, an index of input biased technological change, and an index of the magnitude of technological change.

Holding outputs constant, the reciprocal of the input distance function gives the ratio of minimum inputs required to produce a given level of outputs to actual inputs employed, and serves as a measure of technical efficiency. Let $x^t = (x_1^t, \ldots, x_N^t)$ represent a vector of *N* non-negative inputs in period *t* and let $y^t = (y_1^t, \ldots, y_M^t)$ represent a vector of *M* non-negative outputs produced in period *t*. The input requirement set in period *t* represents the feasible input combinations that can produce outputs and is represented as

$$L^t(y) \quad = \quad \{x: \quad x \text{ can produce } y\}. \tag{1}$$

The isoquant for the input requirement set is defined as

$$ISOQ\ L^t(y) = \{x: \quad \frac{x}{\lambda} \notin L^t(y), \ \text{for } \lambda > 1\}. \tag{2}$$

The Shephard input distance function is defined as

$$D_i^t(y,x) \quad = \quad \max\{\lambda: \quad \frac{x}{\lambda} \in L^t(y)\}. \tag{3}$$

The reciprocal of the Shephard input distance function equals the ratio of minimum inputs to actual inputs employed and serves as a measure of Farrell input technical efficiency. Efficient DMUs use inputs that are part of the *ISOQ* $L^t(y)$ and have $D_i^t(y,x)=1$. Inefficient DMUs have $D_i^t(y,x)>1$.

We assume that there are k=1,…,K DMUs. The DEA piece-wise linear constant returns to scale input requirement set takes the form:

$$L^t(y)=\{x:\sum_{k=1}^{K} z_k^t x_{kn}^t \le x_n,\, n=1,...,N,\, \sum_{k=1}^{K} z_k^t y_{km}^t \ge y_m,\, m=1,...,M, z_k^t \ge 0,\, k=1,...,K\}. \quad (4)$$

The DEA input requirement set takes linear combinations of the observed inputs and outputs of the K DMUs using the K intensity variables, z_k^t, to construct a best-practice technology. The N+M inequality constraints associated with inputs and outputs imply that no less input can be used to produce no more output than a linear combination of observed inputs and outputs of the K DMUs. Constraining the K intensity variables to be non-negative allows for constant returns to scale.

To compute input technical efficiency for DMU "o" we solve the following linear programming problem:

$$\begin{aligned} 1/D_i^t(y_o^t,x_o^t) = \max_{z,\lambda}\{\lambda^{-1} : \sum_{k=1}^{K} z_k^t x_{kn}^t \le \lambda^{-1} x_{on}^t,\, n=1,...,N, \\ \sum_{k=1}^{K} z_k^t y_{km}^t \ge y_{om}^t, m=1,...,M,\, z_k^t \ge 0, k=1,...,K\}. \end{aligned} \quad (5)$$

Following Färe and Grosskopf (1996) total factor productivity growth can be estimated using the Malmquist input-based index of total factor productivity growth. This index can be decomposed into separate indexes measuring efficiency change and technological change. Efficiency change measures "catching up" to the frontier isoquant while technological change measures the shift in the frontier isoquant from one period to another. Dropping the subscript "o" the Malmquist input-based productivity index (*MALM*) takes the form

$$MALM = \sqrt{\frac{D_i^{t+1}(y^{t+1}, x^{t+1})}{D_i^{t+1}(y^t, x^t)} \times \frac{D_i^t(y^{t+1}, x^{t+1})}{D_i^t(y^t, x^t)}}\,. \tag{6}$$

Rearranging (6) yields

$$MALM = \frac{D_i^{t+1}(y^{t+1}, x^{t+1})}{D_i^t(y^t, x^t)} \times \sqrt{\frac{D_i^t(y^t, x^t)}{D_i^{t+1}(y^t, x^t)} \times \frac{D_i^t(y^{t+1}, x^{t+1})}{D_i^{t+1}(y^{t+1}, x^{t+1})}}\,, \tag{7}$$

where efficiency change is represented by $EFFCH = \frac{D_i^{t+1}(y^{t+1}, x^{t+1})}{D_i^t(y^t, x^t)}$ and technological progress is represented by $TECH = \sqrt{\frac{D_i^t(y^t, x^t)}{D_i^{t+1}(y^t, x^t)} \times \frac{D_i^t(y^{t+1}, x^{t+1})}{D_i^{t+1}(y^{t+1}, x^{t+1})}}$. Values of *MALM*, *EFFCH*, or *TECH* (greater) than one indicate productivity (growth) in efficiency, and technological progress (progress).

Färe and Grosskopf (1996) show how the technological change index can be further decomposed into the product of three separate indexes of output biased technological change (*OBTECH*), input biased technological change (*IBTECH*), and the magnitude of technological change (*MATECH*). These indexes take the form:

$$OBTECH = \sqrt{\frac{D_i^t(y^{t+1}, x^{t+1})}{D_i^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D_i^{t+1}(y^t, x^{t+1})}{D_i^t(y^t, x^{t+1})}},$$

$$IBTECH = \sqrt{\frac{D_i^{t+1}(y^t, x^t)}{D_i^t(y^t, x^t)} \times \frac{D_i^t(y^t, x^{t+1})}{D_i^{t+1}(y^t, x^{t+1})}}, \tag{8}$$

$$\text{and } MATECH = \frac{D_i^t(y^t, x^t)}{D_i^{t+1}(y^t, x^t)},$$

where $TECH = OBTECH \times IBTECH \times MATECH$.

Figure 1 illustrates the construction of the input distance function and the components of the Malmquist input based productivity index. The input requirement set in period 1 includes all points to the northeast of the isoquant $L^1(y)$. We assume that technological progress occurs from period 1 to period 2 with the input requirement set in period 2 including all points to the northeast of the isoquant $L^2(y)$. The DMU for which we calculate efficiency and productivity change employs input vector. In period 1 and in period 2 it employs input vector E. In both periods the DMU produces the same level of output (*y*), but uses excessive inputs and is technically inefficient. The input distance function in period 1 is $D_i^1(y,x^1)=\frac{0A}{0B}$ and in period 2 the input distance function is $D_i^2(y,x^2)=0E/0D$. The two inter-period input distance functions are calculated as $D_i^1(y,x^2)=\frac{0E}{0F}$ and $D_i^2(y,x^1)=\frac{0A}{0C}$. The Malmquist index is calculated as $MALM=\sqrt{\left(\frac{0E/0D}{0A/0C}\right)\times\left(\frac{0E/0F}{0A/0B}\right)}$. Efficiency change is calculated as $EFFCH=\frac{0E/0D}{0A/0B}$ and technological change is calculated as $TECH=\sqrt{\left(\frac{0A/0B}{0A/0C}\right)\times\left(\frac{0E/0F}{0E/0D}\right)}=\sqrt{\frac{0C}{0B}\times\frac{0D}{0F}}$.

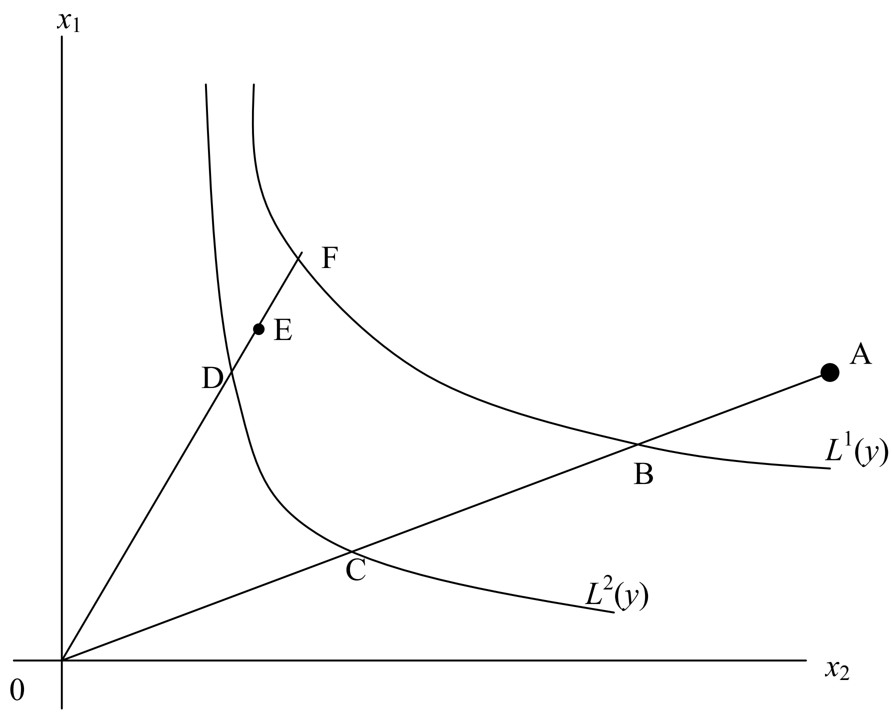

Figure 1. Input requirement sets and the Malmquist input based productivity index.

Figure 2 illustrates the construction of the index of input biased technological change. The isoquant in period 1 is represented by $L^1(y)$. We again assume technological progress and draw two alternative isoquants represented by $L^{21}(y)$ and $L^{22}(y)$. Technological progress is Hicks' neutral if the MRS (marginal rate of substitution) between two inputs remains constant, holding the input mix constant. Hicks' neutral technological change is given by the parallel shift in the input requirement set to $L^{HN}(y)$. Technological progress is x_1-saving and x_2-using if the MRS between the two inputs increases, holding the input mix constant. Technological progress is x_1-using and x_2-saving if the MRS between the two inputs decreases, holding the input mix constant. The isoquant $L^{21}(y)$ represents an x_1-saving and x_2-using bias. The isoquant $L^{22}(y)$ represent an x_1-using and x_2-saving bias. From period 1 to period 2 the ratio of the two inputs changed such that $\left(\frac{x_1}{x_2}\right)^{t+1} > \left(\frac{x_1}{x_2}\right)^{t}$. If technological progress shifts the isoquant to $L^{21}(y)$ in period 2 the index of input bias is $IBTECH = \sqrt{\frac{0B}{0C} \times \frac{0D}{0F}} = \sqrt{\frac{0B/0C}{0F/0D}}$. Therefore, by construction we have $0B/0C > 0F/0D$ implying that *IBTECH*>1. Therefore, x_1-saving and x_2-using bias is indicated by $\left(\frac{x_1}{x_2}\right)^{t+1} > \left(\frac{x_1}{x_2}\right)^{t}$ and IBTECH>1. If instead, technological progress shifted the isoquant to $L^{22}(y)$ in period 2, the index of input bias would be $IBTECH = \sqrt{\frac{0B}{0C} \times \frac{0G}{0F}} = \sqrt{\frac{0B/0C}{0F/0G}}$. In this case, we have $0B/0C < 0F/0G$ so that *IBTECH*<1 and the technology exhibits an x_1-using and x_2-saving bias.

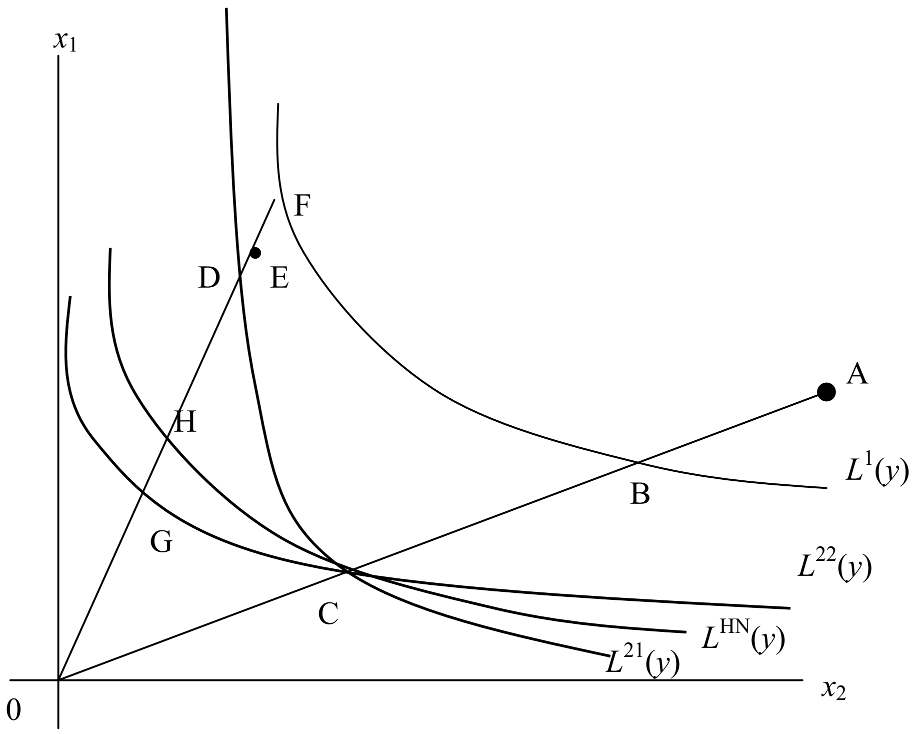

Figure 2. Input Requirement Sets ($L(y)$) and Input Biased Technological Change

To investigate output biased technological change we represent the technology by the output possibility set: $P^t(x) = \{y: \quad x \text{ can produce } y\}$. The output possibility set is an alternative to the input requirement set for representing the technology since $x \in L^t(y)$ if and only if $y \in P^t(x)$. The Shephard output distance function takes the form:

$$D_o^t(x^t, y^t) = \min\{\theta: \quad (y/\theta) \in P^t(x)\}. \tag{9}$$

Under constant returns to scale the Shephard input distance function equals the reciprocal of the Shephard output distance function. (Färe and Primont, 1995) That is, $D_i^t(y^t, x^t) = D_o^t(x^t, y^t)^{-1}$. Therefore, given constant returns to scale we can write the index of output biased technological change as

$$OBTECH = \sqrt{\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^{t+1}, y^{t+1})} \times \frac{D_o^t(x^{t+1}, y^t)}{D_o^{t+1}(x^{t+1}, y^t)}}. \tag{10}$$

Figure 3 illustrates the construction of the index of output biased technological change assuming technological progress between period 1 and 2. The output possibility set in period 1 is given by $P^1(x)$. Technological progress with respect to outputs is Hicks' neutral if the marginal rate of transformation between two outputs is constant, holding the mix of outputs constant. Hicks' neutral technological progress is illustrated by the parallel shift of the production possibility set to $P^{HN}(x)$. Technological progress is biased in favor of output 1 (y_1-producing) if the marginal rate of transformation between outputs 1 and 2 increases, holding the mix of outputs constant. Technological progress is biased in favor of output 2 (y_2-producing), if the marginal rate of transformation between the two outputs is less in period 2 holding the output mix constant. The output possibility set given by $P^{21}(x)$ illustrates a y_1-producing output bias and the output possibility set given by $P^{22}(x)$ illustrates a y_2-producing output bias.

In period 1 a DMU is observed to produce an output vector represented by point A. The output distance function is calculated as $D_o^1(x, y^1) = \frac{0A}{0B}$. In period 2, the DMU is observed to produce output vector E. If the technology shifts to $P^{21}(x)$ in period 2, the output distance function in period 2 is $D_o^2(x, y^2) = \frac{0E}{0F}$ and the index of output biased technological change is $OBTECH = \sqrt{\frac{0E/0F}{0E/0D} \times \frac{0A/0B}{0A/0C}} = \sqrt{\frac{0D/0F}{0B/0C}} > 1$. Thus, since $\frac{y_1^{t+1}}{y_2^{t+1}} < \frac{y_1^t}{y_2^t}$ and $OBTECH>1$, the technology is y_1-producing, relative to y_2. If the technology shifted to $P^{22}(x)$ in period 2, the output distance function would be calculated as $D_o^2(x, y^2) = \frac{0E}{0G}$ and output biased technological change is $OBTECH = \sqrt{\frac{0E/0G}{0E/0D} \times \frac{0A/0B}{0A/0C}} = \sqrt{\frac{0D/0G}{0B/0C}} < 1$. Given that $\frac{y_1^{t+1}}{y_2^{t+1}} < \frac{y_1^t}{y_2^t}$ and $OBTECH<1$, the technology is y_2-producing.

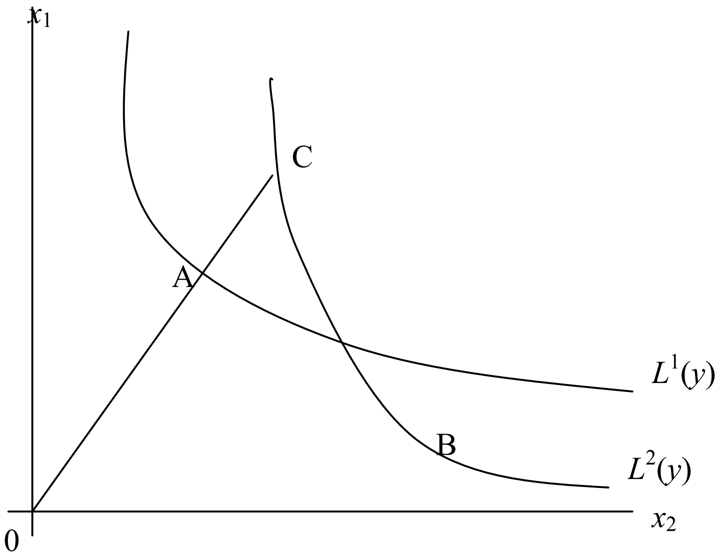

Figure 3. Illustration of Technological Regress for Frontier oil blocks.

In the next section we calculate input technical efficiency and the components of the Malmquist input-based productivity index for Angola oil blocks and examine the bias in the use of inputs and production of outputs found in the technological change index.

5. Data and Results

We compiled our dataset on the financial statements of thirty commercial banks in Estonia, Latvia and Lithuania from BankScope between 2000 and 2006. Our sample includes 210 observations.

Two approaches to measure bank outputs and costs are applied in banking (Berger and Humphrey, 1997). The production approach considers that banks produce accounts of various size by processing deposits and loans, incurring in capital and labour costs. Inputs are measured as operating costs and output is measured as number of deposits and loans accounts. The intermediation approach considers banks as transforming deposits and purchased funds into loans and other assets. Inputs are expressed as total operating plus interest cost and deposits and output is measured in money units. These two approaches have been applied in different ways depending on the availability of data and the purpose of the study. The intermediation approach is applied in our study.

We measure and decompose productivity change over time in the Baltic banks. We measure outputs by, first, post tax profit and second, total nonearning assets plus total fixed assets. We measure inputs by, first, total deposits; second, personal expenses, Third, other administrative expenses and fourth, other operating expenses. This input and output choice was based in the data availability and literature survey.

Table 2 and 3 presents results for the malmquist productivity index (Malm), efficiency change (EFFCH), technological change (TECH), output bias (OBTECH), input bias (IBTECH), the product of output times input bias (MATECH), ISC which is the difference of efficiency change under VRS and CRS, (i..e, (score in CRS) / (socer in VRS)) and PTC the pure technological efficiency change (i.e., measure of efficiency). In PTC, we assume VRS. Efficiency change score (CRS) =PTC*ISC).

Banks with Malm equal one experienced no change in efficiency. Those with Malm > 1 experienced productivity regress. While those with Malm < 1 experienced productivity improvement. Table 3 indicates that foreign banks have on the average Malm lower than domestic banks. It means that foreign banks experienced over the analysed period productivity improvement while domestic banks showed productivity regress.

The Malmquist index is further decomposed in technical efficiency change (EFFCH) and technological change (TECH). The change in the technical efficiency score is defined as the diffusion of best-practice technology in the management of the activity and is attributed to investment planning, technical experience, and management and organization in the banks. There are individual banks that experienced improvement in efficiency (*EFFCH*<1), while others experienced regress (EFFCH>1). Our findings show that both domestic and foreign banks exhibits technical efficiency progress. If the arithmetic mean is applied then only foreign banks show the negative value of EFFCH. The arithmetic mean, instead of adding the set of numbers and then dividing the sum by the count of numbers in the set, as do the arithmietic mean, multiplies the numbers and then the *n*th root of the resulting product is taken. Geometric mean is adopted when the distribution of the data is assumes not to be normal, as in financial variables, but rather a log-normal distribution.

Technological change is a consequence of innovation, i.e. the adoption of new technologies by best-practice banks. The technological change index is lower than one for some banks, which indicates technological improvement (TECH<1), while others experienced technological regress (*TECH*>1). We obtained the similar results as for EFFCH. The foreign banks show technological improvement if the geometric mean is applied. However, the arithmetic mean indicates technological regress. Technological improvement for foreign banks may be explained by the fact that foreign banks take advantage of implementing new technologies faster than domestic banks.

Technological efficiency change is decomposed in output bias (OBTECH) and input bias (IBTECH), which sum up on Malmquist bias (MATECH). Values of these indices lower than one indicate technological progress. The technological progress is Hicks neutral if the MRS (marginal rate of substitution) between two inputs remains constant, corresponding to a parallel shift in the input requirements. Technological progress is x1-using and x2-saving if the MRS between the two inputs decreases, holding input mix constant. The same logic applies to output bias. Based on the results of table and as there are two outputs values of (OBTECH >1) means that the technology is y1-producing relative to y2, signifying in the present case progress with bias in favor of profits, while (OBTECH<1) means that the technology is y2 producing relative to y1, signifying bias in favor of non-earning assets. The estimation shows that both group behaves in the similar manner, i.e., OBTECH is lower than one.

Relative to input bias, using four inputs, when (IBTECH>1) the technology is x1-using and x2-saving using and when (IBTECH<1) the technology is x1-saving and x2-using bias. Therefore savings increase is represented by (IBTECH<1) and labour cost increase by (IBTECH>1). Table 4,5 and 6 display the evolution of productivity indicators along the period by domestic and foreign banks.

The productivity scores of domestic and foreign banks are similar,s ignifying that the contextual setiing influences the average productivity of the banks. Therefore relative productivity changes can only be observed at country level. Looking at country levels we observe from Table 2 that only foreign banks, in Latvia, show productivity improvement over the analysed period caused mainly by an improvement in technical efficiency. Surprisingly no banks in Estonia and Lithuania show productivity improvement over the analysed peiod.

5. Discussion and Conclusion

The present paper analyses changes in productivity in Baltic banks between 2000 and 2006, a period of dramatic expansions after the period of instability in the late 1990s. This instability within the sector was the combination of several factors. Banking sectors in all three countries were significantly destabilised in the late 1990s because of domestic factors but also the economies was significantly affected by the financial crisis in Russia in 1997. Since the new millennium banks dramatically expanded their activities and profitability.

We emphasize several implications of our findings for economic policy. Firstly, Baltic banks, on average, have positive productivity growth during the analysed period. Moreover, the productivity increasing is decomposed into improvement in technical efficiency change and improvement in technological efficiency change.

Secondly, regarding the inefficient banks, management adjustments are necessary above all in domestic banks. These must be based on the improvement of technical efficiency or/and technological change, emulating the procedures of the best-practice banks, i.e., those banks with Malmquist productivity scores lower than one.

Third, while recognizing that national markets contributed to the average level of efficiency, it is verified that there are differences among countries. Latvian's bank shows better results compared to Estonia and Lithuania. This may be explained by the fact that Latvian's banking sector underwent much more radical consolidation and recapitalisation process in late 90s than its geographical neighbours. Other factor that one may consider is that the Latvian's banking sector is larger and more competitive compared to Estonia and Lithuania. Last but not least important aspect is that foreign banks have even a stronger position in the market than in Estonia and Lithuania.

Finally, technical change in the majority Baltic banks is captured by the output bias (OBTECH) and input biased variable (IBTECH), which suggests there is not a global neutral shift in the best practice frontier between 2000 and 2006. Therefore, on average, the marginal rate of substitution between outputs is affected by technical change, which in the present case is the marginal rate of substitution between profits and non-earning assets. Similarly, the average, the marginal rate of substitution between inputs is affected by technical change, which in the present case is the marginal rate of substitution between Deposits, personnel expenses, other administrative expenses and other operating expenditures. Therefore the assumption of parallel neutrality is also rejected for inputs.

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Table 1: Descriptive Statistics (2000-2006)

Varia bles	Minimum	Maximum	Mean	Stand.dev.
Outputs				
Post tax profit	323478	-16414.6	15890.21	35431.26
Total nonearning assets theur + Total fixed assets	1.75E+07	7363.292	924758.3	1773578
Inputs				
Total deposits	5595.582	1.00E+07	721098.2	1246610
Personnel expenses	189.6807	167372.2	11264.6	19449.21
Other admin expenses	142.946	61964.1	5854.859	10046.31
Other operating expenses	-28.89697	136493.5	9439.719	17509.49

Table 2. Average Technical Efficiency Change and Technological Change for the of Baltic Banks

	Ownership	Country	Banks	MALM	EFFCH	TECH	OBTECH	IBTECH	MATECH	ISC	PTC
1	0	Estonia	AS Sampo Pank	1.1374	1.0643	1.0800	0.9953	1.0084	1.0771	1.0001	1.0989
2	1	Estonia	HansaPank-HansaBank	1.0629	1.1350	1.0603	0.9916	1.0232	1.0603	1.1350	1.0000
3	1	Estonia	SEB Eesti Ühispank	1.0676	1.1030	1.0017	0.9856	1.0016	1.0154	0.9597	1.1667
4	0	Estonia	Tallinna Äripanga AS	1.2555	1.1541	1.1766	0.9964	1.0032	1.2006	1.1541	1.0000
5	0	Estonia	Eesti Pank-Bank of Estonia	1.0326	1.0000	1.0326	1.1982	1.1093	0.8067	1.0000	1.0000
6	0	Latvia	Aizkraukles Banka A/S	1.1175	1.0939	1.0837	1.0059	1.0241	1.0579	1.0145	1.0827
7	0	Latvia	Baltic International Bank	1.2044	1.0876	1.1006	1.0331	0.9718	1.1058	1.0387	1.0300
8	1	Latvia	Hansabanka	1.1996	1.1114	1.0742	1.0088	1.0238	1.0402	1.0219	1.1036
9	1	Latvia	Latvian Business Bank JSC	0.9582	0.9407	1.0206	0.9411	1.0339	1.0550	0.9591	0.9747
10	0	Latvia	Mortgage and Land Bank of Latvia	1.0826	0.9726	1.1163	0.9990	0.9938	1.1249	1.0037	0.9686
11	0	Latvia	Latvian Trade Bank	1.3612	1.0361	1.3204	1.1996	1.1399	0.9763	1.0332	1.0023
12	1	Latvia	Multibanka	0.8849	0.8467	1.0690	1.0017	0.9865	1.0829	0.8777	1.0080
13	1	Latvia	Ogres Komercbanka A/S	0.9310	0.9267	1.0114	1.0025	1.1041	0.9464	0.9990	0.9296
14	0	Latvia	Parekss Banka-JSC Parex Bank	1.0555	0.9787	1.0925	0.9888	1.0068	1.0977	1.0453	0.9636
15	0	Latvia	Regional Investment Bank	1.2228	1.1045	1.1029	1.0580	1.0153	1.0326	1.1045	1.0000
16	0	Latvia	Rietumu Banka	1.1214	1.0245	1.1169	1.0284	1.0591	1.0247	1.0140	1.0231
17	1	Latvia	SEB banka AS	1.0308	0.9690	1.0710	1.0199	1.0003	1.0532	0.9703	1.0312
18	0	Latvia	Trasta Komercbanka	1.1473	1.0189	1.1190	1.0155	1.0127	1.0913	1.0069	1.0101
19	0	Latvia	VEF Banka	1.2101	1.0433	1.1410	1.0022	0.9763	1.1639	0.9303	1.1111
20	0	Latvia	Latvijas KrajBanka	1.0043	0.9673	1.0484	0.9910	1.0017	1.0562	0.9988	0.9688
21	0	Latvia	UniCredit Bank AS	1.1937	1.0393	1.1538	1.0129	1.0567	1.0798	1.0033	1.0339
22	1	Lithuania	Danske Bank A/S	1.1603	1.0874	1.0479	1.0239	0.9868	1.0309	1.0874	1.0000
23	1	Lithuania	AB Bankas Hansabankas	1.2104	1.1229	1.0867	0.9827	1.0130	1.0943	0.9750	1.1898
24	1	Lithuania	AB DnB NORD Bankas	1.2481	1.1389	1.1112	1.0000	0.9747	1.1408	1.0051	1.1324
25	1	Lithuania	AB Ukio Bankas	1.3403	1.1979	1.1211	0.9914	1.0013	1.1312	1.1160	1.1088
26	0	Lithuania	Bankas Snoras	1.1538	1.0546	1.1037	1.0017	0.9925	1.1140	1.0079	1.0628
27	1	Lithuania	SEB Bankas	1.0790	1.1009	0.9974	1.0243	1.0247	0.9543	1.0198	1.1284
28	0	Lithuania	Siauliu Bankas	1.3555	1.2695	1.0589	1.0419	0.9921	1.0270	1.0208	1.2339
29	0	Lithuania	UAB Medicinos Bankas	1.0734	1.0624	1.0293	0.9952	0.9992	1.0347	1.1279	0.9701
30	1	Lithuania	Danske Bank A/S	1.1699	1.0578	1.1306	1.0000	1.0426	1.0937	1.1015	0.9744

Notes: 1. *MALM = EFFCH* x *TECH,* 2. *TECH = OBTECH* x *IBTECH* x *MATECH, 3.* Efficiency change socre (CRS) =PTC*ISC. Numbers may not multiply because of rounding error.
Ownership: 0 – domestic bank, 1 – foreign bank

Table 3. Average Technical Efficiency Change and Technological Change

		MALM	EFFCH	TECH	OBTECH	IBTECH	MATECH	ISC	PTC
All Banks	Geometric mean	1.1297	1.0536	1.0877	1.0166	1.0186	1.0563	1.0225	1.0410
	Arithmetic Mean	1.1357	1.0570	1.0893	1.0179	1.0193	1.0590	1.0244	1.0436
	Median	1.1423	1.0601	1.0852	1.0020	1.0076	1.0591	1.0110	1.0166
	Std. Dev.	0.1179	0.0860	0.0627	0.0535	0.0400	0.0742	0.0627	0.0755
Domestic Banks	Geometric mean	1.0491	0.9611	0.9887	0.9159	0.9092	0.9693	0.9246	0.9487
	Arithmetic Mean	1.1049	1.0176	1.0570	0.9814	0.9834	1.0296	0.9863	1.0075
	Median	1.1423	1.0546	1.0877	1.0025	1.0076	1.0579	1.0140	1.0231
	Std. Dev.	0.2217	0.1974	0.1998	0.1832	0.1851	0.1907	0.1854	0.1929
Foreign Banks	Geometric mean	0.9875	0.9005	0.9248	0.8566	0.8485	0.9024	0.8647	0.8874
	Arithmetic Mean	1.0713	0.9834	1.0211	0.9484	0.9485	0.9901	0.9527	0.9725
	Median	1.1390	1.0484	1.0872	1.0021	1.0042	1.0562	1.0095	1.0133
	Std. Dev.	0.2781	0.2515	0.2593	0.2392	0.2406	0.2484	0.2412	0.2477

Table 4: Average productivity indexes by year

year average	MALM	EFFCH	TECH	OBTECH	IBTECH	MATECH	ISC	PTC
2000/01	1.05905	0.86233	1.239472	1.01861	1.011231	1.214804	0.917985	0.944081
2001/02	1.028634	1.008078	1.022109	1.003403	1.004063	1.017561	0.993578	1.030631
2002/03	1.119936	1.232807	0.928991	1.021519	1.040701	0.891148	1.171068	1.069925
2003/04	1.129824	1.030278	1.101942	1.005331	1.03848	1.065935	0.990631	1.051764
2004/05	1.214254	1.12313	1.069295	1.039203	1.019325	1.014389	1.061332	1.082057
2005/06	1.248906	1.077781	1.166685	1.021629	1.020827	1.121586	1.008625	1.074734

Table5: Average productivity indexes by year (Domestic Bank)

year average	MALM	OTEC	TECH	OBTECH	IBTECH	MATECH	ISC	PTC
2000/01	1.064805	0.844142	1.268747	1.025707	1.016458	1.235225	0.906284	0.939716
2001/02	1.051078	1.025386	1.025781	1.006408	1.001232	1.022472	1.028296	1.002684
2002/03	1.125639	1.220408	0.935692	1.043643	1.029753	0.900911	1.150033	1.075429
2003/04	1.155533	0.99863	1.163047	1.019849	1.037725	1.102484	0.96688	1.043888
2004/05	1.310433	1.184666	1.090833	1.068662	1.020874	1.00469	1.150345	1.050145
2005/06	1.255688	1.069684	1.178234	1.034438	1.022067	1.112308	0.97609	1.085774

Table6: Average productivity indexes by year (Foreign Bank)

year average	MALM	OTEC	TECH	OBTECH	IBTECH	MATECH	ISC	PTC
2000/01	1.049331	0.878962	1.209357	1.009397	1.004491	1.197276	0.924948	0.951512
2001/02	0.993645	0.985448	1.011968	0.99506	1.006346	1.012009	0.945909	1.07193
2002/03	1.107393	1.271238	0.897251	0.995899	1.0401	0.871374	1.217747	1.067582
2003/04	1.112168	1.083416	1.025728	0.98606	1.032817	1.028401	1.038352	1.055629
2004/05	1.10153	1.036579	1.056074	0.998983	1.012208	1.046777	0.934041	1.132696
2005/06	1.255733	1.085073	1.170264	1.002355	1.004075	1.166567	1.043972	1.065728