TALLINN UNIVERSITY OF TECHNOLOGY

Productivity, the Malmquist Index and the Empirical Study of Banks in Estonia

LY KIRIKAL

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THESIS ON ECONOMICS H9

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Declaration:

Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any degree or examination.

Ly Kirikal

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VÄITEKIRI MAJANDUSTEADUSTES H9

Tootlikkus ja Malmquist indeks – Eesti pankade näitel

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Tallinn, May 2005

Ly Kirikal

[1] 28.12.1941-22.12.2004

CONTENTS

INTRODUCTION

In Estonia the financial sector has been developing and growing very fast in close connection with the whole economy since 1988[2]. The performance of the financial institution is crucial for the well being of the whole economy and therefore, studies of financial sector development and analyses of performance are interesting to owners, regulators, customers and management. The performance analyses of banking have also attracted the attention of many researchers. The experts have identified objectives that a bank should strive to follow. One of several appointed goals was productivity. Therefore, the main motivation for this study accrues from the need to provide a review of productivity, present productivity ratios and to find productivity change differences in Estonian banking.

Due to the importance of the financial sector and its impact to the whole economy, financial sector development study and performance analysis is necessary. Every new analysis provides an additional picture of the banking sector. Changes in productivity are of great importance at all levels – national, industrial, company and personal (Kendrick 1993). The ever popular "Come in early, stay late and work through lunch" is the old-school instruction for increasing productivity. Today there are several books that provide a methodology for the successful application of productivity management and increasing productivity - Christopher, W. F. ed. (1993), Sumanth, D. J. (1998), Belasco, K. S. (1990). The construction of productivity ratios and indices may be easy when a single output is produced using a single input, but economic entities usually produce many outputs from many inputs. The academic literature has adopted the Malmquist productivity index approach for measuring productivity change in multiple input/output cases. **The first goal of this study** was to analyse the productivity change of banks in Estonia using the Malmquist productivity index. The productivity analysis includes the data of six domestic Estonian banks. The time period under study is from 1999 to 2003, during which there was the steady development of financial institutions and stabilization in the Estonian banking market.

The main point of productivity management is to identify areas of potential productivity improvement. The Malmquist index can be decomposed into technical efficiency and technical change components. This decomposition made it possible to examine the causes of productivity change and to see whether the economic entities have improved their productivity: through a more efficient use of existing technology or through technological progress. **The second goal of this study** was to research the causes of productivity change using the Malmquist productivity index components.

Productivity is one important detail of the monitoring, analysing and supervising of bank performance. Over recent years, bank performance analysis has received increasing attention in Estonia. The most widely applied measures

[2] In the Soviet Union the permission for the establishment of commercial banks was determined in 1988.

for evaluating banks include various financial ratio measures, which provide the tools for managing information in order to analyse the financial condition and performance of a bank. The most commonly used financial ratios, such as *Return on Shareholders' Equity* (ROE), *Return on Assets* (ROA), *Profit Margin* (PM), *Net Interest Margin* (NIM), *Cost to Income ratio* (CTI) and *Earnings per Share* (EPS), are used to characterize the performance of banks and are also presented in the annual reports of banks. While the banks' performance represents the complexity of many outputs and inputs, there are some limitations to financial ratios as performance measures. The fundamental limitation of traditional ratio analysis is that the choice of a single ratio does not provide enough information about the various dimensions of the performance of a bank. To exceed the single-ratio problem in financial analysis, alternative techniques to measure performance have been developed. One alternative method of performance measurement discussed in this thesis is the Malmquist index. **The third goal of this study** was to compare the Malmquist total factor productivity indices and three standard measures of performance indices, *Return on Shareholders' Equity* (ROE), *Net Interest Margin* (NIM) and *Cost to Income ratio* (CTI), for six Estonian banks.

All of these banks have a number of outputs and inputs. The construction of classical productivity ratios may be easy when it is defined as a ratio of aggregate output to the sum of inputs. The classical productivity ratios, presented in the third essay, are partial productivity (PP), total factor productivity (TFP) and total productivity (TP)[3]. Since the mix of outputs can change over time and the amount of input may differ, the classical productivity ratios and indexes are not ideal for performance analysis. In these cases, productivity change can be computed using a newer method to measure productivity change – the Malmquist productivity change index. **The fourth goal of this study** was to analyse the partial productivity (labour productivity) of banks in Estonia next to the Malmquist productivity change index.

3 Partial productivity (PP) is the ratio of output to a single input. Total factor productivity (TFP) takes the ratio of output to capital and labour services. Total productivity (TP) is the ratio of output to all combined inputs including labour, materials, capital, energy and others inputs.

1. STRUCTURE OF THE THESIS and MAIN RESEARCH GOALS

The structure of the thesis is as follows. The present thesis consists of six chapters and three essays. The first chapter presents the structure of the thesis and the main research goals. The next chapter provides a review of banks in Estonia and productivity. Chapter three provides a review of previous literature on the Malmquist index of productivity change application to banking in Europe. In chapter four are presented the Malmquist productivity index and its decomposition. The fifth chapter presents choice of data. The sixth chapter provides a review of main findings and ideas for future research. Following the six chapters of the thesis there are three essays presented on productivity and the Malmquist index. The thesis concludes with an abstract in Estonian, Curriculum Vitae of the author and list of publications.

The **main motivation for this study** is to provide a review of productivity, present productivity ratios and to find productivity change differences in Estonian banking. The main research goals in the thesis are:

(1) To measure the productivity change of banks in Estonia using the Malmquist productivity index.

> **Hypothesis 1:** The size of a bank by total assets is positively related to the value of productivity change.
>
> **Hypothesis 2:** The average annual productivity growth rate indicated retardation for banks over the studied period in Estonia.

(2) To research the causes of productivity change using the Malmquist productivity index components.

> **Hypothesis 3:** Estonian banks experienced high productivity change due to contemporary technology.

(3) To compare the Malmquist indexes and standard measures of performance (Return on Shareholders' Equity, Net Interest Margin, Cost to Income ratio) used by banks.

> **Hypothesis 4:** The standard measures of performance indexes are not related to Malmquist indexes for six Estonian banks.

(4) To analyse the partial productivity of banks in Estonia.

> **Hypothesis 5:** The high level of productivity is not related to the high productivity change of banks in Estonia.

The first essay is published in co-operation with Professor Mart Sõrg from the University of Tartu and Professor Vello Vensel from Tallinn University of Technology. The contribution of the author, of the present thesis, to the first essay is the research concerning the Estonian banking productivity changes utilising the Malmquist productivity index. The author of the present thesis is also the author for the second and third sections of the first essay and the co-author of the introduction (the first section) and concluding remarks (the sixth section). This essay was presented at the Applied Business Research Conference in the spring of 2004 in Puerto Rico, where it has obtained the title "Best Paper Award".

2. BACKGROUND

2.1. Estonian banking sector

The Estonian position is unique due to a late start, which has enabled Estonia to learn from the mistakes made by countries with historically strong banking traditions. Today's situation in banking is the result of rapid development since the 1990s. The first commercial bank (Tartu Commercial Bank) on the territory of the former Soviet Union was established in Estonia in 1988. There was a great demand for banking services by the emerging private sector. The largest number of commercial banks operating simultaneously in the small Estonian banking market was 42 in 1992. A period of rapid change was followed by crisis in the financial sector that led to mergers and bankruptcy in the banking sector. Estonia has experienced two serious banking crises during a 12-year period, in 1992-1994 and in 1998-1999.

In 1998, a wave of mergers and restructuring took place in the Estonian banking sector. After the completion of these mergers, Scandinavian banks started to show greater interest in the Estonian banking market. Due to the opening of financial markets the majority owners of two major banks in Estonia - Hansabank and Eesti Ühispank[4], are from Sweden - *Swedbank* and *Skandinaviska Enskilda Banken* (SEB) respectively. As a result, the share of foreign capital in the banks' total share capital is about 97 percent in Estonia. This means that Scandinavian-owned banks currently control the Estonian banking market.

Since 1999, the institutional division of the Estonian banking market has achieved stability. During the period from 1999 to 2003, there was the steady development of financial institutions and stabilization in the banking market. There are six commercial banks operating in Estonia (Estonian Branch of Nordea Bank Finland excluded) during this period - Eesti Krediidipank (Estonian Credit Bank), Preatoni Pank[5], Hansapank, Eesti Ühispank, Sampo Pank and Tallinna Äripank (Tallinn Business Bank). The period from 1999 to 2003 is also interesting for the current study because it was the pre-European Union-membership period for Estonia. From the 1st of May 2004 Estonia became an official member of the European Union.

[4] Since the 11th of April 2005 the new business name of Eesti Ühispank is SEB Eesti Ühispank.

[5] The Supervisory Board of Eesti Pank extended a banking license to Preatoni Pank on 28 September 1999. Preatoni Pank has focused on the intermediation of foreign capital into the Estonian economy, real estate financing and asset management. Since the 18th of June 2004 the new business name of Preatoni Pank is SBM Pank.

2.2. Productivity

Special banks' analyses are interesting from the viewpoint of different audiences: owners, regulators, customers and management. The performance of the financial institution is crucial for the well being of the whole economy, and it has attracted the attention of many researchers. Many researchers have identified objectives that a company should strive to follow. One of several appointed goals was productivity. Productivity is one important component of the monitoring, analysis and supervision of company performance. The term productivity was probably first mentioned by the French mathematician Quesnay in an article in 1766 (Sumanth 1998). Changes in productivity are of great importance at all levels – national, industrial, company and personal (Kendrick 1993). Several books and articles provide a methodology for the successful application of productivity management and increasing productivity[6].

In productivity and efficiency analysis the aim is to evaluate the performance of economic entities that convert inputs into outputs. Input is the resources (labor, capital, materials, energy) going into the production of product and service output. Output is the product and service, meeting quality requirements, provided by a process using resources, and delivered to the customer. Productivity is the efficiency in the use of resources, measured as output in relation to inputs. The customer is the user of the product and/or service produced. (Christopher 1993).

The terms - productivity and efficiency are often discussed. They are frequently used interchangeably, but this is unfortunate because they are not precisely the same things. Efficiency improvement does not guarantee productivity improvement. People often think that if you improve efficiency, you are more productive. Efficiency is a necessary but not a sufficient condition for productivity. Commonly used measures of efficiency and productivity are (Sumanth 1998):

$$\text{Efficency} = \frac{\text{Actual output}}{\text{Standard output}} \qquad \text{Pr oductivity} = \frac{\text{Actual output}}{\text{Inputs consumed}}$$

Therefore, efficiency is the ratio of actual output generated to the standard output prescribed, but the classic measure of productivity is the ratio of output produced per unit of input expended.

Productivity measurement is usually conducted from two perspectives – according to the level of productivity and trends in the productivity. The productivity ratio refers to the productivity level at a given point in time expressed as output units delivered per unit of input expended. Productivity measures may be classified into several major groups, where none of the measures or groups is considered to be the best. The most commonly used

[6] See the list of references at the end of present thesis.

productivity ratio groups are (Christopher, W. F. ed. (1993), Sumanth, D. J. (1998)):

- Partial productivity - the ratio of output to a single input;
- Total factor productivity - the ratio of output to capital and labour services;
- Total productivity - the ratio of output to all combined inputs including labour, materials, capital, energy and other inputs.

More detailed information about classical productivity measures is presented in part three of essay 3 in the present thesis.

Productivity trends are defined by following the development of the productivity level over time. Productivity trend ratios are commonly converted into an index. Indices make it possible to show the input, output and productivity rates on the same graph. The productivity indices can provide some information on the causes of productivity changes – are the input or the output dimensions bringing on the changes.

There is an output-oriented and an input-oriented measure of change in productivity. The output-oriented productivity indices define the index as a measurement of increased outputs derived from the inputs' net growth. Therefore, to measure the change in productivity for the output-oriented approach is to see how much more output has been produced, using a given level of inputs and the present state of technology, relative to what could be produced under a given reference technology using the same level of inputs. An alternative is to measure change in productivity by examining the reduction in input use, which is feasible given the need to produce a given level of output under a reference technology. This approach is referred to as the input-oriented measure of change in productivity (Coelli, Rao and Battase (1998)).

The discussion of productivity may be elementary when a single output is produced using a single input. But economic entities such as banks usually produce many outputs from many inputs. There is the Malmquist productivity index approach for measuring productivity change for multiple input/output cases. Detailed information of the Malmquist productivity index is presented in chapter four. Next there is a review of literature on the Malmquist index of productivity change in Europe.

3. LITERATURE

3.1. A review of the literature on the Malmquist index of productivity change application to European banking

The aim of this chapter is to introduce the studies of the Malmquist index of productivity change as applied to the banking industry in Europe. The limitation on the presented literature is made by reasons for the need to provide a review of the empirical literature that is related to the present thesis.

There are two basic approaches to the measurement of productivity change: the econometric estimation of a production, cost, or some other function, and the construction of index numbers using non-parametric methods. Pastor (1995) refers to the advantages and disadvantages of both methods. Berger, Humphrey and Mester review applications of this literature to banking (Berger and Humphrey (1997), Berger and Mester (1997)). The present thesis has adopted the construction of index numbers using non-parametric methods, because it does not require the imposition of a possibly unwarranted functional form on the structure of production technology[7] as required by the econometric approach. The productivity change in the banking industry has been examined using the Malmquist productivity index.

In 1953, Sten Malmquist, a Swedish economist and statistician, published in *Trabajos de Estadistica* (Malmquist 1953) a quantity index for use in consumption analysis. Sten Malmquist had proposed constructing input quantity indexes as ratios of distance functions[8]. Caves, Christensen and Divert (1982)[9] adapted Malmquist's idea for production analysis and they named their productivity change indices after Sten Malmquist. Caves et al, 1982 presented Malmquist firm-specific productivity indexes and showed how distance functions can be used to define Malmquist indices of productivity change. The Malmquist productivity index can be used in order to identify productivity differences between two firms or one firm over two time periods.

There are several papers by Caves et al. (1982), Färe et al. (1997), Førsund (1997), Balk (1997) and Coelli et al. (1998), which provide a theoretical framework for measurement of productivity change. Different indexes can be used for productivity change measurements - these are the Fischer, Törnqvist and Malmquist indexes. Respectively to Grifell-Tatjé and Lovell (1996 and 1997), the Malmquist index has a number of desirable features relative to the Fischer and Tornqvist indexes. They do not require input prices or output prices in their construction, which makes them particularly useful in situations in which prices are distorted or non-existent. They do not require a behavioural assumption such as cost minimization or profit maximization, which makes them useful in situations in which producers' objectives differ, or are unknown or are

[7] However, it does require monotonicity and convexity of the underlying technology.
[8] The definition of distance function is given in chapter four.
[9] Important developments in this field have also been presented by the work of Diewert (1976, 1978, 1981) and Färe et al. (1985, 1994a)

unachieved. They are easy to compute, as Färe, Grosskopf, Lindgren and Roos (1995) have demonstrated. Under certain conditions the Malmquist index can be related to the Törnqvist (1936) and Fisher (1922) quantity indexes, as Caves, Christensen and Diewert (1982), Färe and Grosskopf (1992) and Balk (1993) have shown.

An attractive feature of the Malmquist productivity index is that it decomposes into sub-components. The first study was by Nishimizu and Page (1982), which attempted to explicitly decompose productivity growth into technical change and change in efficiency. This decomposition was largely ignored until the non-parametric work by Färe et al. (1989). Färe et al. showed that the Malmquist productivity index could be decomposed into two components - technical efficiency change and technical change. This decomposition of the Malmquist index will be discussed in chapter four of the present thesis. The value of this decomposition is that it provides insight into the sources of productivity change. Therefore it is possible to examine the causes of productivity change and to see whether the productivity has improved: through a more efficient use of existing technology or through technological progress. The main disadvantage of the Malmquist index is the necessity to compute the distance function. There are many different methods that could be used to measure the distance function needed for the Malmquist productivity index, for example, the Stochastic Frontiers method[10] and the Data Envelopment Analysis method[11]. One of the most widely used methods has been the DEA-like linear programming method suggested by Färe et al. (1994b). In this study the DEAP computer program is used to construct Malmquist TFP indexes using DEA-like methods (Coelli, Rao and Battase (1998)). DEAP is a data envelopment analysis computer program (Coelli (1996).

Table 1 presented some empirical studies of banking productivity using the Malmquist productivity index in Europe – banks of the Nordic countries (Berg, Forsund, Jansen (1992), Berg et al. (1993), Berg, Bukh, Forsund (1995), Mlima (1999)); Spanish banks (Grifell-Tatje, Lovell (1997)); Portuguese banks (Rebelo, Mendes (2000)); French, German, Italian and Spanish banks (Chaffai et al. (2001)); Turkish banks (Isik, Hassan (2003)); German banks (Chu-Fen (2004)); French, German, Italian, Spanish and United Kingdom banks (Casu, Girardone, Molyneux (2004)). The present three essays, made by the author of this thesis, are the first productivity analysis of Estonian banks using the Malmquist productivity index (Kirikal, Sõrg, Vensel (2004), Kirikal (2004a), Kirikal (2004b)). First are presented empirical studies of banking productivity using the Malmquist productivity index in Norwegian, Spanish, Portuguese, Turkish and German banks and followed by European cross-country bank comparisons.

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[10] Sometimes referred to as the econometric frontier method.

[11] Stochastic Frontiers is a parametric method and Data Envelopment Analysis is a non-parametric method.

Table 1.

A review of the literature on Malmquist index of productivity change application to Europe banking

Authors and year	**Study**	**Inputs**	**Outputs**
Berg, Forsund, Jansen (1992)	Malmquist Indices of Productivity Growth during the Deregulation of Norwegian Banking, 1980-89	Labour (measured in man-hours); Materials (operating expenses from the annual accounts divided by a materials price index).	Short-term loans (in value terms and deflated); Long-term loans (in value terms and deflated); Non-bank deposit (in value terms and deflated).
Berg, Førsund, Hjalmarsson and Suominen (1993)	Efficiency and Productivity (Nordic countries)	Labour (man-hours per year); Capital (book value of machinery and equipment).	Loans (total loans to other than financial institutions, measured in value terms); Deposits (total deposits from other than financial institution, measured in value terms); Number of branches.
Grifell-Tatje and Lovell (1997)	The sources of productivity change in Spanish banking	Labour (the number of employees); Expense (the sum of non-labor operating expenses, direct expenditure on buildings, amortization expense in value terms and deflated).	Loan (the aggregate number of loan accounts in value terms and deflated); Deposits (the aggregate number of savings accounts in value terms and deflated); Checking accounts (the aggregate number of checking accounts in value terms and deflated).

Table 1 continued

Mlima (1999)	Productivity change in Swedish banks: A comparison of Malmquist productivity indexes.	Labour (measured in hours worked); Inventories (measured by book value and deflated); Number of branches.	Loan (loan to the public, measured in value terms and deflated); Deposits (measured in value terms and deflated); Guarantees (measured in value terms and deflated).
Rebelo and Mendes (2000)	Malmquist Indices of Productivity Change in Portuguese Banking: The Deregulation Period	Deposits (deposits from clients plus deposits from the public sector plus certificates of deposit plus deposits from other banks); Labour (number of employees); Asset (fixed assets net of depreciation).	Loan (loan to clients, net of provisions); Financial applications (loan to credit institutions plus bonds plus other financial applications, net of provisions); Other bank services (commissions received plus net profit from financial operations).
Chaffai, Dietsch, Lozano-Vivas, (2001)	Technological and environmental differences in the European banking industries	Labour (measured by expenses in labour inputs); Physical capital (measured by the book value of the banks fixed assets); Financial inputs (measured by the interest paid by the banks).	Loans (in value terms); Other assets (in value terms); Deposits (in value terms).
Isik and Hassan (2003)	Financial deregulation and total factor productivity change: An empirical study of Turkish commercial banks	Labour (measured by the number of full-time employees on the payroll); Capital (measured by the book value of premised and fixed assets); Loanable funds (measured by the sum of deposits and non-deposits funds).	Short-term loans (loans with less than a year maturity); Long-term loans (loans with more than a year maturity); Off-balance sheet items (risk-adjusted guarantees and warranties, commitments and other off-balance sheet activities); Other earning assets (loans to special sectors, inter-bank funds sold and investment securities).

Table 1 continued

Chu-Fen (2004)	Inefficiency, technical progress and productivity change in German banking: a category-based empirical study.	Labour (the number of full-time employees on the payroll at the end of each year, excluding temporary personnel); Capital (measured by the book value of premised and fixed assets, capital and revenue reserves, capital represented by participation rights, funds for general banking risk and so forth); Loanable funds (measured by the sum of time deposits, savings deposits, CDs, bank savings bonds, foreign currency bonds and other borrowed funds from banks and non-banks).	Total lending (measured by short-term and long-term loans, advances, bills, discounted, securities and others).
Casu, Girardone and Molyneux (2004)	Productivity change in European banking: A comparison of parametric and non-parametric approaches.	Labour (the average cost of labour, personnel expenses/total assets); Deposits (interest expenses/customer and short-term funding); Capital (total capital expenses/total fixed assets).	Loans (total loans); Securities; Off-balance sheet items (letters of credit, derivatives and other types of non-traditional).

Source: Author's compositions using studies: Berg, Forsund, Jansen (1992), Berg et al. (1993), Grifell-Tatje, Lovell (1997), Mlima (1999), Rebelo, Mendes (2000), Chaffai et al. (2001), Isik, Hassan (2003), Chu-Fen (2004), Casu, Girardone and Molyneux (2004).

Berg, Forsund, Jansen (1992) investigated productivity growth during the deregulation of the Norwegian banking industry. They employed Malmquist indices for productivity growth in Norwegian banking during the years 1980–89 and found that productivity regressed at the average bank prior to deregulation, but grew rapidly when deregulation took place. Grifell-Tatje and Lovell (1997) examined the productivity change in Spanish banking over the period 1986-1993 using a generalised Malmquist productivity index. Comparing commercial banks with savings banks, they found that the commercial banks had a slightly lower rate of productivity growth. Mlima (1999) analysed the productivity change in Swedish banking industry by applying the Malmquist index. The data used in this study covers the period from 1984 to 1995, during which time there was the Swedish banking reform and the Swedish banking crisis. After the introduction of deregulation there was productivity improvement for commercial banks. The effect on savings banks was less obvious. Most Swedish banks experienced a productivity regress in the year of crisis, followed by a strong recovery. Rebelo and Mendes (2000) have evaluated productivity in Portuguese banking using the Malmquist productivity index. The results showed that Portuguese banks have increased productivity as a result of technological progress during 1990 to 1997. In addition they have investigated the correlation of the asset per employee ratio with the productivity score. The positive correlation between variables has suggested that the asset per employee ratio index is a good proxy for productivity. Applying a DEA-type Malmquist TFP productivity change index, Isik and Hassan (2003) investigated the impact of financial reforms presented in the 1980s on the productivity of Turkish commercial banks between 1981 and 1990. The results suggest that the performance of Turkish banks after deregulation recorded significant productivity gains driven mostly by efficiency increases rather than technical progress. Chu-Fen (2004) investigated the pattern and source of productivity change of banks in Germany during 1992-2001. The results indicate that foreign banks' productivity growth was the highest due to the rapid improvement in technology and efficiency. By contrast, the most rapid productivity regress occurred within private bankers.

Next there are presented some empirical cross-country studies of banking using the Malmquist productivity index. The cross-country studies can provide valuable information regarding the competitiveness of banks in the global European financial market. However, the data collection techniques, regulatory and economic environments are relatively different across countries. Also the level and quality of bank services in different countries may differ in ways that are difficult to measure. Therefore these cross-country comparisons are usually difficult to complete and interpret.

Berg, Forsund, Hjalmarsson and Souminen (1993) have made an empirical study of banking productivity using the Malmquist productivity index in Nordic countries. An input-based Malmquist index was used to characterise the productivity differences between banks of Finland, Norway and Sweden. Table 1 shows how the three outputs and two inputs were defined for banks.

Money market funding was ignored in this study, and was in contrast to the recommendations of Berger and Humphrey (1992), but in accordance with the view represented by Benston et al. (1982). The average Swedish bank was more productive than the average Norwegian bank followed by the average Finnish bank. The study indicated 1990 as the best average Swedish bank position. Berg, Bukh and Forsund (1995) did a follow-up study of Berg, Forsund, Hjalmarsson and Souminen (1993), adding Denmark to the sample. Chaffai et al. (2001) are used a Malmquist type index that allowed for inter-country productivity differences to be broken down into pure technological and environmental effects. This index is used to calculate productivity gaps across four main European Union countries – France, Germany, Italy and Spain. The results show that environmental conditions play a major role in the explanation. On average, the differences due to environmental conditions always are larger than the differences in banking technology among the European banking industries. Casu, Girardone and Molyneux (2004) examined productivity change in European banking (France, Germany, Italy, Spain and United Kingdom banks) between 1994 and 2000. They compared parametric and non-parametric estimates of productivity change in their paper. The findings suggested clear productivity growth in the Italian and Spanish banking sectors, with mixed results for French and German banking. The results that were found also suggest that productivity growth has mainly been brought about by improvements in technological change.

4. THE CONCEPT OF MODEL

4.1. Production and intermediation approach

The exact definition of input and output variables in banking is a disputable issue (Berger, Humphrey 1997). There are two main approaches to the choice of how to measure the flow of services provided by banks. The majority of banking studies can be categorized as users of the intermediation model or of the production model. The intermediation approach characterizes banks as financial intermediaries whose function is to collect funds in the form of deposits and other lendable funds and to offer them as loans or other assets that earn income (Figure 1). With this approach the data is typically assumed to be in the numbers of dollars of loans, deposits, or insurance in force (Berger, Humphrey (1991)).

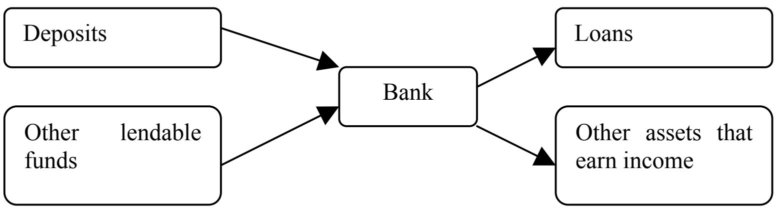

Figure 1. Intermediation model (Source: Author's compositions)

Under the alternative production approach, banks are the institutions providing fee based products and services to customers. Products and services such as loans and deposits are outputs in this model, and the resources consumed such as labour, capital and operating expenses are inputs (Figure 2). Under this approach, output is best measured by the number and type of transactions or documents processed over a given time period (Kuussaari, Vesala (1995); Berger, Humphery (1997)). Unfortunately, such data are typically not available. Thereby, in production models the number of deposit or loan accounts or insurance policies data can also be used (Ferrier, Lovell (1990), Ferrier, Grosskopf, Hayes, Yaisawarng (1993)).

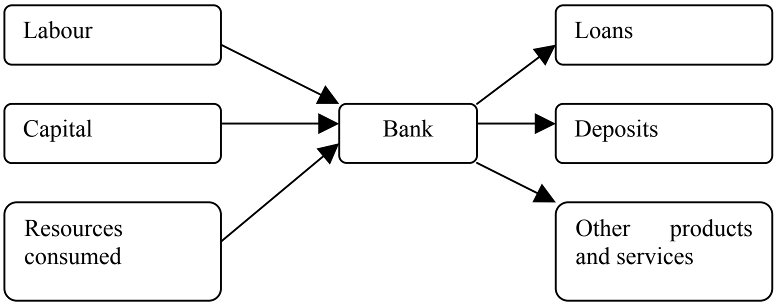

Figure 2. Production model (Source: Author's compositions)

These two approaches, production and intermediation approach have both advantage and disadvantages, and cannot fully capture the role of banks. The selection of model, input and output data is essential because they have a direct influence on the results of empirical analysis. The final choice of model depends upon the concept of what banks do, the stated problem and the availability of data.

4.2. Output Distance Function

The Malmquist index is defined using the distance function in present thesis. An alternative definition of Malmquist total factor productivity index can be presented as the ratio of the Malmquist output-quantity index to the Malmquist input-quantity index (Mlima (1999)). The distance function makes it possible to describe a multi-input, multi-output production technology and does not require the profit maximization or cost minimization assumption.

The distance function can be presented as an input distance function or an output distance function. In the present thesis the Malmquist productivity index will be defined using the output distance function. An input distance function describes the production technology by looking at a minimal proportional decrease of the input vector, given an output vector. An output distance function using the given input vector describes a maximal proportional increase of the output vector.

To define an output distance function, there is considered a sample of K firms using $x^t \in \Re_+^N$ inputs in the production of $y^t \in \Re_+^M$ outputs in the time period $t = 1,...,T$. Multiple input and multiple output production technology may be defined using the output set, P, which represents the set of all output vectors, $y^t=(y^t_1,\dots,y^t_m)$, which can be produced using the input vector, $x^t = (x^t_1,\dots, x^t_n)$ in the time period $t = 1,...,T$. That is:

$$P^t(x^t) = \{y^t : x^t \text{ can produce } y^t \text{ at time } t\} \qquad t=1\dots T.$$

In an output-based approach, the production technology is completely characterized by the output distance function (Shephard, 1970), defined on the output set $P^t(x^t)$ as:

$$D^t(y,x) = \min\{\delta \in (0,1] : (y/\delta) \in P^t(x)\} \qquad t=1\ldots T.$$

The distance function is less than or equal to one (i.e. $D(y,x) \leq 1$), if and only if output y belongs to the production possibility set of x (i.e. $y \in P(x)$). Note that the distance function is equal to the unit (i.e. $D(y,x) = 1$) if y belongs to the "frontier" of the production possibility set. A firm is considered technically efficient if the distance function equals one.

The next example presented the output distance function and production possibility set on the simple one-input, two-output case.

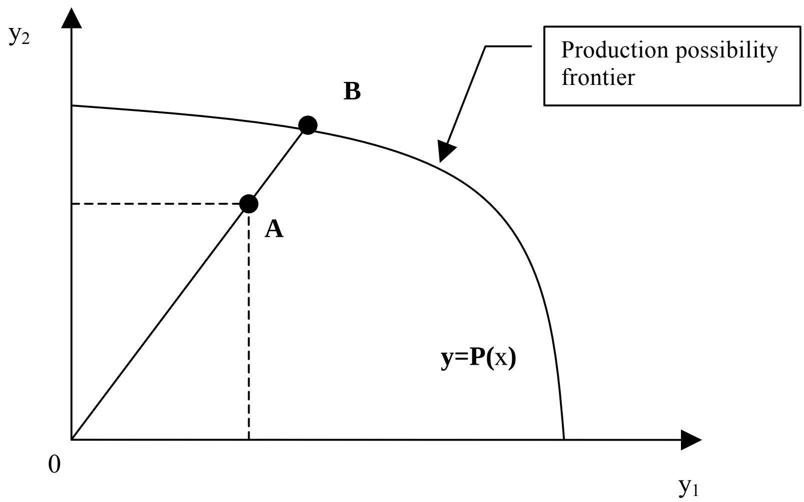

Figure 3. Output distance function and production possibility set (Source: Modified from Coelli, Rao, and Battese (1998))

An example of production possibility set P(x) is represented on a two dimensional diagram in Figure 3, where two outputs – y_1 and y_2 are produced using one input x. The production possibility set P(x) is bounded by the production possibility frontier. The value of output distance function for the firm A is equal to the ratio $\delta = \frac{0A}{0B}$ and the firm B is considered technically efficient, as the distance function equals one ($\delta = 1$).

4.3. The Malmquist Productivity Index

The Malmquist productivity index can be used to identify productivity differences between two firms or one firm over two-time periods. In this chapter the thesis will be concentrated on one firm over two period's output-oriented Malmquist productivity index. The output-orientated productivity change measures will use an output distance function, which addresses the maximal proportional expansion feasible without altering the input quantities (Coelli, Rao, and Battese (1998)). To estimate technical efficiency changes and technical changes over the period in question, the decomposed Malmquist productivity index was used.

Caves et al. (1982) proposed that output-based Malmquist productivity index between time period's *t* and *(t + 1)* can be defined as:

$$M_{t,t+1}\left(y^{t}, y^{t+1}, x^{t}, x^{t+1}\right) = \left[\frac{D^{t}(y^{t+1}, x^{t+1})}{D^{t}(y^{t}, x^{t})} \times \frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t}, x^{t})}\right]^{1/2}, \quad (1)$$

where the notation D represents the distance function and the value of M is the Malmquist productivity index. The first ratio represents the period t Malmquist index. It measures productivity change from period t to period (t+1) using period t technology as a benchmark. The second ratio is the period (t + 1) Malmquist index and measures productivity change from period t to period (t + 1) using period (t + 1) technology as a benchmark. A value of M greater then one (i.e. M >1) denotes productivity growth, while a value less than one (M < 1) indicates productivity decline, and M= 1 corresponds to stagnation.

According to Färe et al. (1989) the output-based Malmquist productivity index between time periods t and (t + 1) can be decomposed into two components, which is an equivalent of index (1), as (Färe et al. (1994a), Coelli (1996), Grifell-Tatjé and Lovell (1996, 1997)):

$$M_{t,t+1}\left(y^{t}, y^{t+1}, x^{t}, x^{t+1}\right) = \underbrace{\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^{t}(y^{t}, x^{t})}}_{\text{EFFCH}} \underbrace{\left[\frac{D^{t}(y^{t}, x^{t})}{D^{t+1}(y^{t}, x^{t})} \times \frac{D^{t}(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t+1}, x^{t+1})}\right]^{1/2}}_{\text{TECHCH}} \quad (2)$$

In equation (2) the term outside the brackets (EFFCH) is a ratio of two distance functions, which measures the change in the output-oriented measure of the Farell technical efficiency between period t and t+1. The square root term (TECHCH) is a measure of the technical change in the production technology. It is an indicator of the distance covered by the efficient frontier from one period to another and thus a measure of technological improvements between the periods. The term (EFFCH) is greater than, equal to or less than one if the producer is moving closer to, unchanging or diverging from the production frontier, respectively. The square root term (TECHCH) is greater than, equal to or less than one when the technological best practice is improving, unchanged, or deteriorating, respectively.

The next example illustrates the construction of the Malmquist index on the simple one-input, one-output case for firm A.

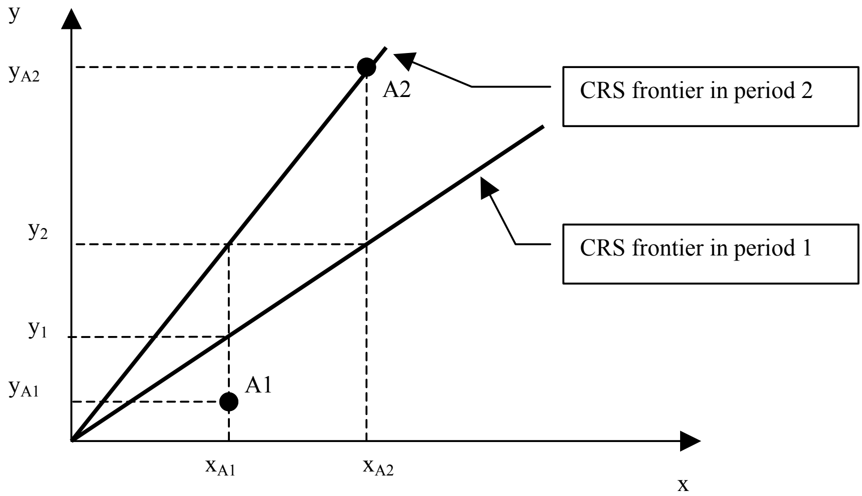

Figure 4. Malmquist Productivity Index (Source: Modified from Coelli, Rao, and Battese (1998))

In Figure 4 the calculation of Malmquist productivity index is illustrated, where a single output *y* is produced using a single input *x*. There is assumed the constant returns to scale (CRS) technology[12]. The firm A produces at the point A1 in the first period and at the point A2 in the second period. The firm A is **technically inefficient** in the first period as the point A1 is below the frontier for that period. In the second period the point A2 is on the frontier and thereby firm A is **technically efficient**. The **technical change** includes a time component and involves advances in technology, which is represented by an upward shift in the production frontier from first period to the second period. Using equation (2) it is:

$$M_{1,2}(y_{A1}, y_{A2}, x_{A1}, x_{A2}) = \underbrace{\frac{y_{A2}/y_{A2}}{y_{A1}/y_1}}_{\text{EFFCH}} \underbrace{\left[\frac{y_{A1}/y_1}{y_{A1}/y_2} \times \frac{y_{A2}/y_2}{y_{A2}/y_{A2}} \right]^{1/2}}_{\text{TECHCH}} , \qquad (3)$$

[12] Malmquist TFP index may not correctly measure TFP change when variable returns to scale (VRS) is assumed for technology (Grifell-Tatje and Lovell 1995).

where the value of *M* is the Malmquist productivity index between two time periods. It is easy to calculate that the value of *M* is greater than one (i.e. $M > 1$), which implies productivity growth. In equation (3) the terms *EFFCH* and *TECHCH* are also greater than one (i.e. $EFFCH > 1$ and $TECHCH > 1$). Therefore the firm A experienced the positive technical efficiency change and technological change from one period to another.

To construct the Malmquist index for adjacent periods, it is needed to calculate four different distance functions - $D^t(y^t, x^t)$, $D^t(y^{t+1}, x^{t+1})$, $D^{t+1}(y^t, x^t)$ *and* $D^{t+1}(y^{t+1}, x^{t+1})$. There are many different methods that could be used to measure the distance function, which makes up the Malmquist productivity index. These required distance functions can be calculated using either mathematical programming or econometric techniques. The DEAP computer program to construct Malmquist indices using DEA-like methods was used in the empirical part of this study (Coelli, Rao and Battase, 1998). DEAP is a data envelopment analysis computer program (Coelli, 1996).

4.4. Constant and variable returns to scale

One issue that must be emphasised is that the returns to scale properties of the technology are very important in TFP measurement. The most widely used DEA formulations are the constant returns to scale (CRS) by Charnes, Cooper and Rhodes (1978), and the variable returns to scale (VRS) by Banker, Charnes and Cooper (1984)[13]. As the names indicate, these two models differ with respect to their assumptions on returns to scale. Figure 5 illustrates the assumption on constant and variable returns to scale in model. With constant returns to scale it is assumed that each additional unit of input produces the same amount of output. With this assumption only firm B is efficient. The firms operating on the frontier are efficient and those operating beneath it are inefficient. The assumption on variable returns to scale in model allows the additional output produced by a unit of additional input to vary (i.e. first increase and then decrease) according to scale size. With this assumption all four firms on Figure 5 are efficient.

[13] In productivity analysis literature some authors use CCR (Charnes, Cooper and Rhodes) and BCC (Banker, Charnes and Cooper) and some CRS and VRS abbreviations when referring to different scale assumptions.

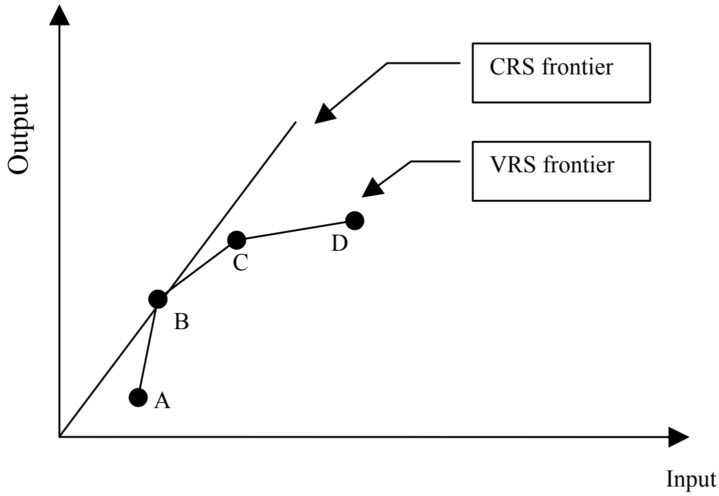

Figure 5. Constant and Variable Returns to Scale (Source: Modified from Färe, Grosskopf, Lovell (1994a))

The CRS technology was used in this thesis. The argument for the use of a CRS technology is practicable ness to firm-level and aggregate data. Grifell-Tatjé and Lovell (1995) use a simple one-input, one-output example to illustrate that a Malmquist TFP index may not correctly measure total factor of productivity changes when VRS is assumed for the technology. Hence it is important that CRS be implemented to any technology that is used to estimate distance functions for the calculation of a Malmquist TFP index. Otherwise the resulting measures may not properly reflect the TFP gains or losses resulting from scale effects.

4.5. Data Envelopment Analysis

Data Envelopment Analysis (DEA) involves the use of linear programming methods to construct a non-linear piece-wise frontier over the data. Efficiency measures are then calculated relative to this frontier. The method has received attention since the paper by Charnes, Cooper and Rhodes (1978), in which the term *data envelopment analysis* (DEA) was firs used. They proposed a model that had an input orientation and assumed constant return to scale (CRS). Subsequent papers have considered alternative sets of assumptions, such as Banker, Carnes and Cooper (1984), in which a variable return to scale (VRS) model was proposed (Coelli, Rao and Battase (1998)).

In the present thesis the output distance functions that constitute the Malmquist index are calculated using DEA-like linear programming methods. The linear programming problems must be solved K times, once for each firm in the sample. For each firm four distance functions are calculated - $D^t(y^t, x^t)$, $D^t(y^{t+1}, x^{t+1})$, $D^{t+1}(y^t, x^t)$ and $D^{t+1}(y^{t+1}, x^{t+1})$, to measure the total factor of productivity change between two periods. This requires the solving of four linear programming problems. Assuming CRS, the required linear programming problem for distance functions can be calculated by solving the following linear programming problems:

$$\left[D^t(y^t, x^t)\right]^{-1} = \max_{\phi,\lambda} \phi,$$
$$\text{st}$$
$$-\phi y^t + Y^t\lambda \geq 0,$$
$$x^t - X^t\lambda \geq 0,$$
$$\lambda \geq 0$$

$$\left[D^t(y^{t+1}, x^{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi,$$
$$\text{st}$$
$$-\phi y^{t+1} + Y^t\lambda \geq 0,$$
$$x^{t+1} - X^t\lambda \geq 0,$$
$$\lambda \geq 0$$

$$\left[D^{t+1}(y^t, x^t)\right]^{-1} = \max_{\phi,\lambda} \phi,$$
$$\text{st}$$
$$-\phi y^t + Y^{t+1}\lambda \geq 0,$$
$$x^t - X^{t+1}\lambda \geq 0,$$
$$\lambda \geq 0$$

$$\left[D^{t+1}(y^{t+1}, x^{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi,$$
$$\text{st}$$
$$-\phi y^{t+1} + Y^{t+1}\lambda \geq 0,$$
$$x^{t+1} - X^{t+1}\lambda \geq 0,$$
$$\lambda \geq 0$$

where y' is the output vector and x^t is the input vector in the time period t = 1,...,T; λ is a solution value of weight and $1 \leq \phi < \infty$ is the proportional increase in outputs that could be achieved by the firm, with input quantities held constant. The value $\frac{1}{\phi}(=\delta)$ defines a technical efficiency score that varies between zero and one. The radial expansion of the output vector produces a projected point $(X\lambda; Y\lambda)$ on the surface of this technology. This projected point is on the frontier and it is a linear combination of these observed data points (Coelli, Rao and Battase (1998)).

The next example illustrates the construction of projected point $(X\lambda; Y\lambda)$ and the calculation of distance functions - $D^t(y^t, x^t)$ on the simple one-input, one-output case for firm A in Figure 4. This figure illustrates the calculation of the Malmquist productivity index, where one output *y* is produced using one input *x* and CRS technology is assumed. The firm A has produced at the point A1 $(x_{A1}; y_{A1})$ in first period $(t=1)$. The projected point for firm A is $(x_{A1}\lambda_1; y_{A1}\lambda_2) = (x_{A1}; y_1)$ for first period, where $\lambda_1 = 1$ and $\lambda_2 = \frac{y_1}{y_{A1}}$. The distance function $D^1(y^1, x^1)$ for firm A is equal to the value $\frac{y_{A1}}{y_1}$ for first period.

Comprehensive reviews of the DEA methodology are presented by Seiford and Thrall (1990), Lovell (1993), Ali and Seiford (1993), Lovell (1994), Charnes et al (1997), Seiford (1996) and Coelli et al. (1998).

5. DATA

The purpose of the next chapter is to present the empirical variable of banks in Estonia and to describe the choice procedure of data for modelling. The data used in this study covers the period from 1999 to 2003 (except the first essay, where the period is from 1999 to 2002). This data is from annual balance sheets and income statements of the banks involved.

The Central Bank of Estonia has regularly collected the public reports by individual banks. This data was used as a database for the present thesis (Central Bank of Estonia homepage). All variables, with the exception of labour and offices, are reported in millions of Euros and corrected to the 1999 price level using the consumer price index (with the exception of the first essay of the present thesis in which all variables are in millions of Estonian crowns at original prices). The example includes all six domestic commercial banks operating in Estonia (the Estonian Branch of Finnish Nordea Bank was excluded) during this period - Eesti Krediidipank (*Estonian Credit Bank*), Preatoni Pank[14], Hansapank (*Hansabank*), Eesti Ühispank, Sampo Pank and Tallinna Äripank (*Tallinn Business Bank*).

To evaluate the productivity performance of banks in Estonia, the essential element is the selection of input and output variables. The first selection of model variables was on the basis of the research aim, which focuses on productivity of banks performance, and on the availability of data. There are eleven possible groups of data for the productivity model selected by the author of this thesis. They are as follows:

- Loan to clients, net of provisions
- Deposits from clients
- Other bank services/Commissions received
- Commissions received, net profit/loss on financial operations
- Tangible fixed assets
- Net interest profit/loss
- Profit/loss of the reporting period
- Loan to credit institutions, net of provisions
- Liabilities/Deposits to credit institutions
- Number of employees
- Number of offices

These data groups, with the exception of employees and offices, are from the banks balance sheets and income statements. For each essay/ model were selected two or three output and input variables. The selection was made on the basis of correlation matrix. The correlation matrix displays the correlation coefficients for every possible pair of variables in the analysis. Table 2 shows correlation between the variables.

[14] The Council of the Bank of Estonia extended a banking license to Preatoni Pank on 28 September 1999. Preatoni Pank has focused on the intermediation of foreign capital into the Estonian economy, real estate financing and asset management.

Table 2.

Correlation Matrix for the Variables

	Loan to clients, net of provisions	Deposits from clients	Other bank services/ Comissions received	Comissions received, net profit/loss on financial operations	Tangible fixed assets	Net interest profit/loss	Profit/loss of the reporting period	Loan to credit institutions, net of provisions	Liabilities/Deposits to credit institutions	Number of employees	Number of offices
Loan to clients, net of provisions	1.0000										
Deposits from clients	0.9582	1.0000									
Other bank services/ Commissions received	0.9161	0.9213	1.0000								
Commissions received, net profit/loss on financial operations	0.7131	0.6975	0.8481	1.0000							
Tangible fixed assets	-0.9607	-0.9714	-0.9084	-0.6524	1.0000						
Net interest profit/loss	0.6680	0.8085	0.8141	0.6857	-0.7577	1.0000					
Profit/loss of the reporting period	0.7221	0.7924	0.6442	0.3523	-0.7217	0.6293	1.0000				
Loan to credit institutions, net of provisions	0.7673	0.8241	0.7283	0.5369	-0.8088	0.6226	0.6923	1.0000			
Liabilities/Deposits to credit institutions	0.8959	0.7877	0.7476	0.5977	-0.7875	0.3405	0.5483	0.6155	1.0000		
Number of employees	0.9458	0.8822	0.8045	0.5551	-0.9062	0.5000	0.7277	0.6665	0.8853	1.0000	
Number of offices	-0.8823	-0.9630	-0.9182	-0.7267	0.9153	-0.9020	-0.7582	-0.7934	-0.6712	-0.7474	1.0000

Source: Author's calculations.

Various goals of bank performance can be presented. For instance, the bank is devoted to increasing employee motivation, while only dedicated employees can create value to bank customers and thus to bank shareholders (Hansapank annual report 2001). For selection of input and output variables it was presumed that the goal of bank performance is to receive profit. Therefore, the first step in correlation analysis was to determine the relationship between profit/loss of the reporting period and other ratios. The data is represented in Table 2. The strongest correlation appeared between profit/loss of the reporting period and the following variables – Loan to clients, net of provisions (0.7221), Deposits from clients (0.7924), Other bank services/Commissions received (0.6442), Tangible fixed assets (-0.7217), Net interest profit/loss (0.6293), Loan to credit institutions, net of provisions (0.6923), Number of employees (0.7277) and Number of offices (-0.7582). Table 2 shows remarkably weak correlation between profit/loss of the reporting period and the following data set: Commissions received, net profit/loss on financial operations (0.3523) and Liabilities/Deposits to credit institutions (0.5483). Based on weak correlation these are excluded from the data of the first productivity model. Also loan to credit institutions and net of provisions are not included in the model. Thereby, the aspect of the credit institutions was excluded from the model, this aspect is important when interpreting the results. The net interest profit / loss are not included in the model, since they are generally a function of the market and difficult to control. The Estonian banks' productivity cases described are calculated on the basis of non-interest income and expense data, since the banks themselves monitor this data on a large scale.

Based on previous correlation analysis results, the author of this thesis has selected the input and output data for productivity analysis for the present thesis. In the first essay the production approach was used and the variables were defined as follows (Kirikal, Sõrg, Vensel (2004)):

- For the inputs: x1 is the number of employees and x2 is the number of offices;
- For the outputs: y1 are loans (loans to clients, net provisions), y2 are deposits (deposits from clients) and y3 are other bank services (commissions received).

The production model was based on the assumption that banks are multi-product organizations and have been increasing their role as service/production providers. The input variables must represent the bank's production input, and the output variables must represent the possible output set produced by the bank. Therefore, the number of employees and the number of offices were selected for the production model. This data also illustrated the accessibility of the bank's services and they were strongly related with the profit/loss data set of the reporting period. At first, two classical banks products were selected for the outputs - loans (loans to clients, net provisions) and deposits (deposits from clients). Since the service fee along with interest income is very important for the banks, the third output measure was added for the model - other bank services (commissions received).

In the second essay, the Malmquist indices of productivity change and their components for the intermediation model and for the production model were researched (Kirikal 2004). The second essay has made some changes in input and output variables for comparisons of the first empirical case. At first, there the book values of tangible assets were used instead of the number of bank offices. These changes were made since there was no quarterly data for number of bank offices. The tangible asset is likewise a physical input for banks and it also had a strong inversely proportional correlation with profit/loss of the reporting period (-0.7217). The second change was made based on the decision to enlarge the concept of bank services. The output "bank services" was replaced with the output "bank services, net profit from financial operations". In the intermediation model the deposits (deposits from clients) are input and for the production model deposits (deposits from clients) are output, in this case this is the only difference between the two models.

5.1. Information on the output and input variables

The descriptive statistics are founded over the quarterly summed data of six banks in Estonia. Hereby there were 17 time periods between December, 31 of 1999 and December, 31 of 2003. Table 3 contains some information on the variables used. The first column of Table 3 lists the variables and the following columns show the minimum, maximum, sum, mean, median, standard deviation and sample variance of variables in the time series for five years.

Most of the variables: loans, deposits, commissions and number of employees consistently increase between 1999 and 2003. The largest increase is loans (122%), but the smallest increase is the number of employees (16%). Two measures that do not follow this pattern are tangible fixed asset (-99%) and number of offices (-26%). For tangible fixed asset the 2003 quarterly summed value is approximately two times lower than in 1999. The data in Table 3 allows an increase in productivity, while the value of bank outputs (loans and commissions received) has increased more than the bank inputs (number of employees and physical capital).

Table 3.

Descriptive Statistics to the Variables

	Minimum	Maximum	Increase/ decrease	Sum	Mean	Median	Standard Deviation	Sample Variance
Loan to clients, net of provisions	1554.1	3458.9	122%	38655.9	2273.9	2188.9	519.0	269323.2
Deposits from clients	1613.8	2844.1	76%	38956.5	2291.6	2340.1	384.5	147872.1
Other bank services/ Commissions received	7.2	14.5	102%	196.8	11.6	11.7	1.7	3.0
Commissions received, net profit/loss on financial operations	12.1	20.2	67%	299.6	17.6	17.9	2.1	4.3
Tangible fixed assets	43.6	86.6	-99%	1079.8	63.5	60.7	12.9	166.9
Number of employees	3537.0	4119.0	16%	63999.0	3764.6	3772.0	185.0	34208.1
Number of offices	188.0	237.0	-26%	3442.0	202.5	203.0	15.1	227.0

Source: Author’s calculations.

6. RESULTS

The present thesis has four goals and in the beginning of this thesis were suggested five hypotheses for examining the productivity of banks in Estonia. The last chapter of this thesis will present a short review of research results.

(1) To measure the productivity change of banks in Estonia using Malmquist productivity index.

This goal was the first and the main motivator for this thesis. The research conception accrues from the need to find productivity change differences in Estonian banking. The present thesis was the first productivity analysis of banks in Estonia by applying the Malmquist productivity index.

Productivity is one of the major responsibilities of management. By attaining productivity increase, several other management goals are automatically achieved. An increase in the productivity has the positive impact to the quality of products and service, to the production costs as well as to the market share and profit. Therefore, productivity is one important component of the monitoring, analysis and supervision of banks performance. The importance of productivity in management was considered in the third essay.

Hypothesis 1: The size of a bank by total asset is positively related to the value of productivity change.

This hypothesis was not supported in the present thesis. Table 4 shows productivity change scores by different banks (the data is from the first essay) and the range number of bank size. The two largest banks by total asset – Hansapank and Eesti Ühispank have not obtained the highest value of Malmquist productivity change index for the period of 1999-2002 in Estonia. The newest and smallest bank in Estonia – Preatoni Pank – exhibited the highest productivity change during the studied period.

Table 4.

Malmquist index summary of bank means (1999-2002)

Bank	Malmquist Productivity Index	The range number of bank size by total asset
Preatoni Pank	1,631	6
Eesti Krediidipank	1,371	4
Hansapank	1,251	1
Eesti Ühispank	1,161	2
Tallinna Äripanga AS	1,127	5
Sampo Pank	1,071	3
Geometric Average	1,256	

Note: All indexes are geometric averages.
Source: Author's calculations.

Therefore, as a result it cannot be said that the size of bank by total asset is positively related to the value of productivity change.

> **Hypothesis 2:** The average annual productivity growth rate indicated retardation for banks over the studied period in Estonia.

This hypothesis found proof in the second essay. The cumulative geometric average of Malmquist productivity indexes indicated retardation in the changes from 1999 to 2003 in Estonia. The productivity regression during these years was mainly the result of the fierce competition in the banking market, especially in the loans market. Since 2002 clear features – rapidly declining loan margins and luring away clients – have indicated certain market saturation (Bank of Estonia (2003)). Therefore, the high annual productivity growth rate indicated retardation over the studied period for bank in Estonia.

(2) To research the causes of productivity change using the Malmquist productivity index components.

This research goal was presented through the present thesis. The Malmquist productivity index approach has a number of desirable features. This index can be implemented for measuring productivity change in many input/output cases and it can be decomposed into technical efficiency and technical change components. This kind of decomposition made possible to examine the causes of productivity change and to see whether the banks have improved their productivity.

> **Hypothesis 3:** Estonian banks experienced a high productivity change due to the contemporary technology.

This hypothesis was confirmed in the present thesis. The banks and their customers are quite innovative in Estonia. They are in the process of intensively introducing new technology-based products and services. The main influence that helps to produce the high value of Malmquist productivity index was the component of technical change in production technology. The results of the first and second essay show that Estonian banks experienced a high annual productivity growth rate during 1999-2003 as the result of technological progress.

(3) To compare the Malmquist indexes and standard measures of performance (*Return on Shareholders' Equity, Net Interest Margin, Cost to Income ratio*) used by banks.

In essay two productivity changes in Estonian banking were estimated using the Malmquist productivity index and compared the received results with standard measures of performance used by banks. The quarterly data used in this study covered the period from 1999 to 2003, during which there was the steady development of financial institutions and stabilization in the Estonian banking market.

Hypothesis 4: The standard measures of performance indexes are not related to Malmquist indexes for six Estonian banks.

To analyse the relation between Malmquist productivity indexes and most commonly used standard measures of performance indexes (*Return on Shareholders' Equity* (ROE), the *Net Interest Margin* (NIM) and the *Cost to Income ratio* (CTI)) the correlation analysis was introduced in the second essay.

Table 5.

Correlation coefficients for the Malmquist indices, their components and standard measures of performance indexes (ROE, NIM, CTI)

	Malmquist TFP Index		Technical Efficiency Change		Technological Change	
	Inter-mediation approach	Production approach	Inter-mediation approach	Production approach	Inter-mediation approach	Production approach
ROE	-0.281	-0.180	0.120	0.142	-0.309	**-0.555**
NIM	**0.554**	0.353	-0.093	**0.515**	**0.531**	-0.072
CTI	0.325	0.301	**-0.499**	0.151	**0.515**	0.348

Source: Author's calculations.

Table 5 shows that the strongest inversely proportional correlation (-0.555) appeared between ROE and Malmquist indexes technological change components for production approach. Correlation was weak between ROE and other Malmquist index components. Remarkably related were Malmquist index and its technological change component part with values NIM for intermediation approach. Therefore, the correlation between Malmquist indexes and standard measures of performance gives the result, which proves that there is not a strong correlation between these values. This means that all the calculated classical productivity change indexes and the Malmquist productivity change index characterise productivity change of banks from a different viewpoint and therefore, all these indexes are important for performance analysis of banks in Estonia.

(4) To analyse the partial productivity of banks in Estonia.

A partial productivity measure is the ratio of output to a single input. The weakness of partial productivity measures is that they tend to overstate increases in productivity. The advantage of partial productivity measures is that they are not a difficult ratio to understand and measure. The most widely used measure of partial productivity is labour productivity. The calculation of labour productivity in Estonian banks shows that next to the productivity index it is also important to know the productivity level of the base year. Comparing productivity trends alone, without the productivity level, can be misleading.

Hypothesis 5: The high level of productivity is not related to the high productivity change of banks in Estonia.

This hypothesis found proof in the third essay. Table 6 contains information about the labour productivity levels and indices of Estonian banks.

Table 6.

Labour productivity levels and indices for Estonian banks

Labour productivity = Loans per employee	**Labour productivity levels 1999**	**Labour productivity levels 2003**	**Labour productivity index 1999-2003**
Eesti Krediidipank	0.09	0.18	2.08
Eesti Ühispank	0.45	0.99	2.19
Hansapank	0.46	0.89	1.91
Sampo Pank	0.38	0.60	1.61
Preatoni Pank	0.08	0.28	3.29
Tallinna Äripank	0.13	0.20	1.58

Source: Author's calculations.

Three banks - Eesti Krediidipank, Eesti Ühispank and Preatoni Pank obtained the highest labour productivity index during the period 1999-2003. The productivity levels for Eesti Krediidipank and Preatoni Pank were not the highest. But Eesti Ühispank has obtained next to the highest labour productivity index also the highest labour productivity level in 2003. Therefore, the high level of productivity is not related to the high productivity change of banks in Estonia.

Based on the results of the presented thesis, the author of the thesis can conclude that all four goals of the thesis are obtained and all suggested hypothesis are inspected. The results, presented in this thesis will provide a useful basis for future research in the field of productivity, efficiency, the financial market and banking. In future work, the aim is to research more thoroughly the relationship between the Malmquist productivity index, standard measures of performance and management decisions.

The author of the present thesis has presented the results of the following essays at conferences in Estonia, Sweden, Great Britain and Finland. The results are published in conference proceedings, journals and books.

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The Estonian Banking Sector Performance Analysis Using Malmquist Indexes and DuPont Financial Ratio Analysis

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Abstract

Banks and other financial institutions are a unique set of business firms whose assets and liabilities, regulatory restrictions, economic functions and operating make them an important subject of research. Banks' performance monitoring, analysis and control needs special analysis in respect to their operation, productivity and performance results from the viewpoint of different audiences:

investors/owners, regulators, customers/clients, and management themselves. In this paper, productivity change in Estonian banking is estimated using the Malmquist productivity index. The data used in this study covers the period from 1999 to 2002. One purpose of this research is to introduce the Malmquist productivity index, which is used for the first time for productivity analysis of Estonian banks. The present study shows that Estonian banks experienced on average a 25.6 percent annual productivity growth rate during 1999-2002, that was the result of technological progress. Generally, all Estonian banks have increased productivity as a result of technological progress on this period. Some historical notes on the development of the Estonian banking system and the capital structure of banks are presented in this article. Different versions of financial ratio analysis are used for the bank performance analysis using financial statement items as initial data sources. The usage of a modified version of DuPont financial ratio analysis is also discussed in the article. Empirical results (1994-2002) of the Estonian commercial banking system performance analysis are presented in the article.

Introduction

The problem of banking and financial system soundness has become more important in all countries over the last years. In transition countries, the weakness of the banking system is the major factor of delaying expected economic growth. Rapid financial sector reforms and drastic restructuring has been characteristic for all Central and Eastern European transition countries.

Based on a newly constructed cross-country database of financial liberalization, Abiad and Mody (2003) examined the experience of 35 countries over the period 1973-1996 to analyze underlying causes of financial sector reforms. They found that liberalization is a combination of discrete changes in response to economic and political "shocks", reinforced by a self-sustaining dynamic (referred to as "learning"). They draw five specific conclusions about what produces change (reform):

- Countries whose financial sectors are fully repressed (non-liberalized) are the ones with the strongest tendency to maintain their policy stance and hence remain closed and highly regulated. But, initial reforms cause changes that make further reforms necessary.
- Regional diffusion effects appear to be important – the further a country's stage of liberalization is from that of the regional leader, the greater is the pressure to liberalize.
- Shocks to the economic environment (a new government; decline in US interest rates) play an important role in weakening the *status quo* and making reforms possible.
- Crises do trigger action, but not always is the direction of reform – balance of payments crises raise the likelihood of reform; banking crises have the opposite effect.
- Among variables representing ideology and structure, only trade openness appears related to the pace of reform. Presidential or parliamentary regimes are not important, right- or left-wing governments, and the legal system prove not to be influential as well.

It is evident that to study results of financial sector reform and restructuring, a profound performance analysis is needed. The traditional financial ratio analysis is mainly used for the bank performance analysis. We can find different versions of this approach from various textbooks about banking and financial institutions. Different versions of DuPont financial ratio analysis (see Cole (1973)) seem to be more perspective for banks' and other financial institutions' performance analysis (see, for example, Dietrich (1996)). Recent studies of banks' efficiency and productivity analysis in different countries can be taken as lessons for the Estonian case – see, for example, Hardy and di Patti, 2001 (Pakistan lessons); Spiegel, 1999 (Japanese experience); Berger and Mester, 1999; Stiroh, 2000 (US experience); Rebelo and Mendes, 2000 (Portuguese experience); Hasan and Marton, 2000 (Hungarian lessons); Andersen et al., 2000 (Finnish experience); ECB, 1999 and 2000 (EU banks' experience); Kwan, 2003 (Asian countries experience). Different financial ratios are used as predictors of bank failures (Estrella et al. (2000)). Berger and Humphrey (1997) presented a review of 122 studies in 21 countries about the efficiency and productivity of financial institutions.

There are two basic approaches to the measurement of productivity change: the econometric estimation of a production, cost, or some other function, and the construction of index numbers using non-parametric methods. Pastor (1995) refers to the advantages and disadvantages of both methods. Berger and Humphrey (1997) and Berger and Mester (1997) review applications of this literature to banking. In this case the construction of index numbers using non-parametric methods was adopted because it does not require the imposition of a possibly unwarranted functional form on the structure of production technology as required by the econometric approach. To examine productivity change in the banking industry, we used the Malmquist productivity index.

Malmquist firm-specific productivity indexes were introduced by Caves et al, 1982. They named these indexes after Malmquist, who had earlier proposed constructing input quantity indexes as ratios of distance functions (see Malmquist, 1953). There are output-oriented and input-oriented measures of change in productivity. In this study we concentrated on the output-oriented Malmquist productivity index, while the output-orientated productivity measures focus on the maximum level of outputs that could be produced using a given input vector and a given production technology relative to the observed level of outputs.

Different indexes can be used for productivity measurements – Fischer, Törnqvist and Malmquist indexes. According to Grifell-Tatjé and Lovell (1996 and 1997), the Malmquist index has some advantages relative to the Fischer and Tornqvist indexes. First, it does not require the profit maximization, or cost minimization, assumption and information on the input and output prices. Also, if the researcher has panel data, it allows the decomposition of productivity changes into two components (technical efficiency change or catching up, technical change or changes in the best practice). The Malmquist index's main disadvantage is the necessity to compute distance function. It can be mentioned that the Malmquist index is deterministic and does not permit statistical analysis. This problem has been partially solved using bootstrapping techniques to construct confidence intervals (Simar, Wilson (1996), Lothgren, (1997)). However, the data envelopment analysis (DEA) technique can be used to solve this problem.

There are various methods that could be used to measure the distance function which make up the Malmquist TFP index. One of the more popular methods has been the DEA-like linear programming methods suggested by Färe et al. (1994b). In this study the DEAP computer program was used to construct Malmquist TFP indexes using DEA-like methods. DEAP is a data envelopment analysis computer program (Coelli (1996), Coelli, Roa, Battase (1998)). There have been few studies on banking productivity analysis of Nordic countries (Berg et.al (1992, 1993), Bukh et al. (1995), Mlima (1999). The current study is the first productivity analysis of Estonian banks, using the Malmquist productivity index.

The focus of financial analysis for the management of any bank (or the banking sector as a whole) should be on the efficiency of performance of the bank measured from the viewpoint of investors/owners' income maximization. Various measures of rates of return are used mainly for that purpose. In this article, we present one of the possible approaches to such financial analysis using the modified version of DuPont analysis (Cole, 1973), which is similar to Dietrich's (1996) approach.

The paper is organized as follows. A short review of the Estonian banking system recent developments is presented in Section 1. Section 2 presents the methodology of the Malmquist productivity index. Section 3 presents the data and empirical results from the analysis of Estonian banks using Malmquist indexes. Section 4 describes the methodology of DuPont financial ratio analysis. Section 5 presents the data and empirical results from the analysis of Estonian banks using Dupont financial ratio analysis. The final section offers some concluding remarks.

1. Development of the Estonian Banking System

1.1. Some Historical Notes

The first commercial bank (Tartu Commercial Bank) on the territory of the former Soviet Union was established in Estonia in 1988. This bank went bankrupt and was liquidated in 1992-1993. Due to the great demand for banking services by the emerging private sector, the maximum number of commercial banks operating simultaneously in the small Estonian banking market was 42 in 1992. Some of them were liquidated during the banking crises in 1992-1994 and in 1998-1999, and some of them were merged into larger commercial banks. A short history of the Estonian contemporary banking system is presented in Table 1.

Table 1.

History of the Estonian Banking Sector (Only Operating Banks, 2003)

	Bank	Established	Organizational Changes
A. Large Banks			
1.	Hansapank	01.07.1991	Merged with the Estonian Savings Bank (which was established 14.04.92 on the basis of former state-owned savings offices and merged with the Estonian Industrial Bank in 1996) in 1998
2.	Union Bank of Estonia	15.12.1992	Established on the basis of 11 smaller regional banks, merged with North-Estonia Bank in 1997 and with the Bank of Tallinn (which was established 21.12.92) in 1998
B. Medium-Sized Banks			
3.	Nordea Bank Plc, branch	20.06.1995	Established on the basis of merging KOP and SYP (Finnish banks) offices
4.	Sampo Bank	30.06.1992	Previous Optiva Pank, former Forexbank, merged with Raepank in 1995 and with Estonian Investment Bank (established 30.06.92) in 1998, Finnish Sampo-owned since 2000
C. Small Banks			
5.	Estonian Credit Bank	10.04.1992	Small niche bank, majority owned by non-resident legal persons
6.	Tallinn Business Bank	09.12.1991	Small niche bank, majority owned by Estonian legal persons
7.	Preatoni Bank	23.09.1999	Oriented to foreign investments, real estate financing and asset management

Source: Bank of Estonia.

Up until 1997, the development of the Estonian banking sector was characterized by a rapid nominal growth of total assets and loan portfolios. 1997 was also the beginning of a new stage in the development of the Estonian financial sector, especially in the international context, which is confirmed by investment grade credit ratings assigned to Estonia: Standard and Poor's BBB+ and Moody's Investors Service's Baa1. It has to be added that from 2001-2002 Estonia has the following credit ratings by rating agencies (Leemets, Reedik (2003)): Moody's foreign currency and Estonian crown (EEK) ratings both A1 (from 12.11.2002); Standard&Poor's rating both A- (from 20.11.2001); Fitch foreign currency rating A- and EEK rating A+ (from 30.08.2001). The rapidly growing economy (GDP growth rate in 1997 about 11%) boosted credit demand, and non-banking financial inter-mediation also accelerated. However, implementation of the expected Estonian banks expansion to the other Baltic countries and Russia was only partly realized due to the tightened market situation both in Estonia and internationally. Negative results of the overoptimistic and risky attitude towards the opportunities of the Eastern market and consequences of the bursting of the 1997 stock exchange bubble in Estonia became clearly evident during 1998-1999.

The rapid nominal growth both in the real and financial sectors, the deepening dependence on international financial markets and financial problems in the emerging markets in South-East Asia dictated several steps of precaution by the government and the central bank. The most important long-term regulatory measures included raising of the banks' minimum capital adequacy ratio from 8% to 10%, increasing the risk-weight of local governments' liabilities from 50% to 100%, and a decision to introduce a market risk component to the capital adequacy ratio. The intermediate steps included the introduction of reserve requirements to the net liabilities of domestic banks' *vis-à-vis* non-resident banks and additional liquidity requirement to restrain capital inflow.

Compared to previous years, the growth rate of nominal indicators in the banking sector slowed down during 1998-2000, partly due to the changes in the external environment. With the deterioration of the economic environment in 1998, wrong economic and management decisions that had been made already earlier, surfaced in 1998 and resulted, for example, in the dropout of three banks from the banking market in July-October. Some of the more important interrelated systematic factors behind wrong management decisions were: the expansive development in previous years, lack of experience in doing business in the changing market conditions, insufficient transparency of the market, owners' weak control over the activities of executive management, tightened competition in the banking market, insufficient risk hedging and management, and external shocks.

In 1998, a wave of mergers and restructuring took place in the Estonian banking sector. After the completion of these mergers, Scandinavian banks started to show greater interest in the Estonian banking market. As a result, *Swedbank* acquired 56% of *Hansapank* and *Skandinaviska Enskilda Banken* (SEB) acquired 32% of the Union Bank of Estonia. We may conclude that the Estonian banking sector became healthier when Swedish banks and other Nordic investors joined the circle of bank owners, improving the future outlook of the banking system. During the first banking crises, in 1992-1994, Estonia had to resolve the problems by itself, then during the second banking crises, in 1998-1999, foreign banks also helped and supported Estonia to get through the crises.

Smaller banks in Estonia were also affected by the negative developments in Russia. The liquidation of some banks continued in 1999, accompanied by the declaration of bankruptcy of *EVEA Pank* and *ERA Pank*. On the other hand, the first new banking licence issued since 1993 was granted to the new *Preatoni Pank* in September 1999. *Preatoni Pank* has focused mainly on intermediation of foreign capital into Estonian economy, real estate financing and asset management. During 1999, Swedish banks – SEB and *Swedbank* – increased their participation in the equity capital of the Union Bank of Estonia and in *Hansapank* over 50%.

1.2. Banking Crises and Bank Rehabilitation

Estonia has experienced two serious banking crises during the 12-year period of its banking sector development and restructuring, the first crisis in 1992-1994 and the second in 1998-1999. The first banking crisis occurred during the difficult period of starting drastic economic reconstruction when production output was reducing dramatically and the country underwent a period of hyperinflation. The characteristic feature of the first banking crisis in Estonia was that it was caused by internal reasons and it was overcome with Estonia's own resources and management skills. The main causes of this banking crisis were severe problems in the whole economy, poor bank management and lack of professional skills, weak supervision both from the side of the central bank and owners. The depositors' losses in the banking crisis were large, the money supply decreased, many loans were depreciated, and the trustworthiness of the banking system fell significantly.

The central bank acted quite quickly and resolutely to overcome the banking crisis. The Bank of Estonia brought the prudential requirements into its operation on the basis of international experience for protecting creditors' and clients' interests beginning from January 1993. In April 1993, the Bank of Estonia announced a stabilization period in the banking system, during which the issuance of new banking licenses was frozen and for the existing banks it established a schedule of gradual rise in minimum equity capital. After that, the Bank of Estonia did not renew licenses of 8 banks, 10 banks merged into one larger bank, and a moratorium was declared on 3 banks.

Looking back, it is possible to establish some signs that lead up to the banking crisis of 1998-1999:

- Estonian banks took extraordinary high financial risks through investment companies and their subsidiary companies to get big profits via speculating in securities market – rapid fall in prices on the share market in autumn 1997 reduced significantly banks' profits and at the end of 1997 and in 1998 almost all banks operated in losses;
- Banks held a very high negative level of gap (interest rate sensitive liabilities exceeded significantly rate-sensitive assets) for earning excessive profits in the environment where interest rates steadily decreased during the previous years and they were not able to adjust to the changed environment with increasing interest rates from the second half-year of 1997;
- Commercial banks absorbed heavily into non-banking business – for example, the Land Bank of Estonia (later bankrupted) owned seven subordinate establishments and related companies, which dealt with

leasing and investing, and with anything else but banking (hotels, processing agricultural products, broadcasting etc), also other banks were absorbed into risky non-banking business;

- The decision to expand to the Eastern market (Russia and other Baltic States), where the interest rates and possible profitability seemed to be higher, was also too risky and premature, especially in the framework of the Russian crisis in 1998;
- There were various disputes and conflicts of interests between the owners and management which led to wrong (mismanagement) decisions, such as the Land Bank of Estonia and the Estonian Investment Bank – for example, the shareholders of the Investment Bank intended to sell the bank to the German Schleswig-Holstein Bank in the autumn of 1997, but the top executives threatened to hand in a collective resignation and so the bank was sold to them instead.
- Sometimes there were inadvisable relations between the bank management and political powers, and corresponding political pressure – a typical "political" bank was the Land Bank of Estonia where almost all financial risks were ignored and later the Government lost its deposits in the bank amounting to more than 800 million EEK (more than 50 million Euros).

The occurrence of the second banking crisis was the starting of a market bubble burst on the Tallinn Stock Exchange in the autumn of 1997, caused partly by the impact of the financial crises in South-East Asia and supported later by the Russian crisis in the autumn of 1998. In 1998, a wave of mergers and restructuring took place in the Estonian banking sector. We may conclude that the Estonian banking sector became healthier when Swedish banks and other Nordic investors joined the circle of owners of banks, and in doing so improved the banking system's future outlook by supporting Estonian banking in order to get over the second banking crisis in 1998-1999.

The authors are of the opinion that the currency board arrangement helped in Estonia to resolve the banking crises rapidly and, for the most part, effectively without remarkable rehabilitation costs. The main instruments when anticipating and dealing with banking crises are the tightening of prudential requirements and the strengthening of banking supervision. Recent changes in the operational framework for monetary policy and banks' prudential ratios in Estonia were aimed at enhancing financial stability and increasing the liquidity buffers of the financial system. The currency board arrangement supported and strengthened the discipline and responsibility of the main actors – banks, the central bank, depositors, and the Government. A stable currency and the presence of a respective financial safety net compensated the absence of classical lender-of-last resort facility and ensured, in general, the development of a reliable banking sector.

1.3. Structural Developments

The structure of the Estonian banking sector has changed fundamentally during these last years. Today, the banking system is highly concentrated and two Swedish-owned banks dominate the market (see also Table 1). The consolidation process continued throughout the second banking crisis in 1998-1999 resulting in fundamental bank reorganizations. We can also notice all three worldwide trends in the financial consolidation process in the Estonian market: domestic consolidation, foreign entry and cross-border consolidation, and the formation of financial conglomerates and bank insurances. Some characteristics of the development of the Estonian financial market structure are presented in Table 2.

Some interesting conclusions from Table 2:

- The banking market concentration (the share of three largest banks' assets in total banks' assets) already achieved more than 90% in 1998; it was 90.4% at the end of 2002;
- foreign banks' share in total assets of Estonian commercial banks increased dramatically and was 97.5% at the end of 2002;
- the Estonian financial sector is clearly bank-oriented – the bank assets to GDP ratio was 75.6% and the banks assets share in total financial assets was 45.2% at the end of 2002;
- private credits by banks and other financial institutions increased considerably during the analyzed period – private credits by banks to GDP ratio was 46.2% and overall private credits to GDP ratio was 62% in 2002;
- Leasing and factoring portfolios have grown relatively rapidly (about four times during 1997-2002) and stock market capitalization (about 5.5 times); total financial assets ratio to GDP has risen to 167% at the end of 2002.

Table 2.

Some Indicators of the Estonian Banking and Financial Sector Development, 1997-2002

Indicator	1997	1998	1999	2000	2001	2002	02/97
Number of commercial banks	11	6	7	7	7	7	0.636
Number of private banks	11	5	6	7	7	7	0.636
Number of foreign banks	1	2	2	4	4	4	4.000
Concentration index C3, %	69.7	93.0	92.4	91.1	91.1	90.4	1.297
Concentration index C5, %	83.4	99.4	98.9	98.8	98.9	99.1	1.188
Total assets, EUR m	2594	2620	3008	3695	4372	5221	2.013
Total assets/GDP, %	63.4	55.7	61.7	67.7	71.8	75.6	1.192
Foreign ownership in share capital, %	44.2	60.7	61.6	83.6	85.4	86.7	1.962
Major foreign ownership in total assets, %	2.3	90.2	89.8	97.4	97.5	97.5	42.39
Private credit by banks, EUR m	1362	1527	1704	2189	2601	3193	2.344
Private credit by banks/GDP, %	33.2	32.6	35.4	40.1	42.7	46.2	1.392
Leasing and factoring portfolio, EUR m	315	399	433	644	893	1232	3.911
Leasing and factoring/GDP, %	8	8	9	12	15	18	2.250
Debt market capitalization, EUR m	258	235	204	231	279	211	0.818
Debt market capitalization/GDP, %	6	5	4	4	5	3	0.500
Stock market capitalization, EUR m	837	531	1913	2095	1999	4570	5.460
Stock market capitalization/GDP, %	20	11	39.8	38.4	32.8	66.2	3.310
Insurance gross collected premiums, EUR m	70	81	83	98	112	134	1.914
Gross collected premiums/GDP, %	1.7	1.7	1.7	1.8	1.8	1.9	1.118
Investment funds’ assets, EUR m	97	23	73	95	193	280	1.887
Investment funds’ assets/GDP, %	2.4	0.5	1.5	1.7	3.2	4.1	1.708

Table 2 continued

Indicator	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**02/97**
Total financial assets, EUR m	2458	2912	5550	6727	7748	11551	4.699
Total financial assets/GDP, %	60	62	115	123	127	167	2.783
Total private credit, EUR m	n.a.	1902	2106	2777	3395	4308	2.265
Total private credit/GDP, %	n.a.	40	43	50	55	62	1.550
GDP, EUR m	4110	4685	4813	5458	6089	6904	1.680
GDP real growth, %	10.6	4.7	-1.1	6.4	5.3	4.7	n.a.

Source: Bank of Estonia

Notes: (1) Total financial assets consist of the assets of the central bank and other financial institutions, debt securities market, stock market, leasing and factoring portfolio, and insurance gross premiums; (2) Foreign banks consist of foreign banks' branches in Estonia and the banks majority owned by foreign banks.

The ownership structure of Estonian banks is presented in Table 3. The dependence of the Estonian banking system on the developments in international financial markets and on foreign investors' preferences deepened from year to year. In the course of the restructuring process, foreign banks increased their share in equity capital from 10.3% in 1996 to 79% at the end of 2002. The total share of non-resident owners has risen to 86.7% at the end of 2002.

Table 3.

Ownership Structure of Estonian Banks, %

Year	Estonian Owners				Non-Resident Owners			
	Public Sector	Legal Persons	Individ uals	Total	Banks	Legal Persons	Individ uals	Total
1996	12.0	NA	NA	62.8	10.3	NA	NA	37.2
1997	4.2	41.6	11.3	57.1	22.7	19.6	0.6	42.9
1998	13.6	22.3	8.6	44.5	45.5	9.5	0.5	55.5
1999	11.6	15.2	11.0	37.6	52.6	8.9	0.7	62.2
2000	0.0	6.8	9.3	16.1	67.0	16.7	0.2	83.9
2001	0.0	5.6	8.5	14.1	63.3	22.3	0.3	85.9
2002	0.0	5.2	8.1	13.3	79.0	7.6	0.1	86.7

Source: Bank of Estonia, Annual Reports

Equity investments by Swedish banks in the two largest Estonian banks (*Hansapank* and Union bank of Estonia) in 1998 and by Finnish insurance company *Sampo Group* in *Optiva Pank* in 2000, increased the share of all non-resident owners from 37.2% to 85.9% during 1996-2001. The public sector (mostly the Bank of Estonia) share in the ownership structure increased in 1998 due to the rescue operation of two smaller banks (the central bank was the core shareholder of the newly established *Optiva Pank*), and decreased to zero already at the end of 2000 due to the sale of *Optiva Pank* to *Sampo Group.*

2. Methodology of Malmquist Productivity Indexes

2.1. Output Distance Function

To define an output distance function, consider a sample of K firms using $x^t \in \Re_+^N$ inputs in the production of $y^t \in \Re_+^M$ outputs in time period $t = 1,\ldots,T$. A multiple inputs and multiple outputs production technology may be defined using the output set, P, which represents the set of all outputs vectors, $y' = (y^t_1,\ldots,y^t_m)$, which can be produced using the input vector, $x^t = (x^t_1,\ldots, x^t_n)$ in time period $t = 1,\ldots,T$. That is

$$P^t(x^t) = \{y^t : x^t \text{ can produce } y^t \text{ at time t}\} \qquad t=1...T.$$

In an output-based approach, the production technology is completely characterized by the *output distance function* (see Shephard 1970), defined on the output set $P^t(x^t)$ as

$$D^t(y, x) = \min\{\delta \in (0,1] : (y/\delta) \in P^t(x)\} \qquad t=1...T.$$

The distance function is less than, or equal to one (i.e. $D(y, x) \leq 1$), if and only if output y belongs to the production possibility set of x (i.e. $y \in P(x)$). Note that distance function is equal to unit (i.e. $D(y, x) = 1$) if y belongs to the "frontier" of the production possibility set. A firm is considered as technically efficient if the distance function equals one.

2.2. Productivity Indices

Productivity indices explain the role of index numbers in measuring growth in outputs (output-oriented approach) that is net of inputs' growth. One way to measure the change in productivity is to see how much more output has been produced, using a given level of inputs and the present state of technology, relative to what could be produced under a given reference technology using the same level of inputs. An alternative is to measure change in productivity by examining the reduction in input use, which is feasible given the need to produce a given level of output under a reference technology. These two approaches are referred to as the output-oriented and input-oriented measures of change in productivity (see Coelli, Rao and Battase (1998)). There are several papers by Caves et al. (1982), Färe et al. (1997), Førsund (1997), Balk (1997) and Coelli et al. (1998) that provided a theoretical framework for measurement of productivity.

2.3. The Malmquist Productivity Index

In order to identify productivity differences between two firms, or one firm over two time periods, the Malmquist productivity index can be used (see Malmquist, 1953 and Caves et al., 1982). Malmquist index numbers can be defined using either the output-oriented approach or the input-oriented approach. For the moment there is concentrated on one firm over two periods output-oriented Malmquist productivity index. The output-orientated productivity measures focus on the maximum level of outputs that could be produced using a given input vector and a given production technology relative to the observed level of outputs. This is achieved using the output distance functions and Caves et al. (1982) showed how distance function can be used to define Malmquist indices of productivity change.

Caves et al. (1982) proposed, that output-based Malmquist productivity index between time periods *t* and *(t + 1)* can be defined as:

$$M_{t,t+1}\left(y^t, y^{t+1}, x^t, x^{t+1}\right) = \left[\frac{D^t(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)} \times \frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^{t+1}(y^t, x^t)}\right]^{1/2}, \tag{1}$$

where the notation *D* represents the distance function and a value of *M* is the Malmquist productivity index. The first ratio represents the period *t* Malmquist index. It measures productivity change from period *t* to period *(t+1)* using period *t* technology as a benchmark. The second ratio is the period *(t + 1)* Malmquist index and measures productivity change from period *t* to period *(t* + 1) using period *(t* + 1) technology as a benchmark. A value of *M* greater then one (i.e. $M > 1$) denotes productivity growth, while a value less than one ($M < 1$) indicates productivity decline, and $M = 1$ corresponds to stagnation.

Färe et al. (1989) showed that the Malmquist productivity index can be decomposed into two components, which is an equivalent way of index (1), as:

$$M_{t,t+1}\left(y^t, y^{t+1}, x^t, x^{t+1}\right) = \underbrace{\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)}}_{CU_{t,t+1}} \underbrace{\left[\frac{D^t(y^t, x^t)}{D^{t+1}(y^t, x^t)} \times \frac{D^t(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t+1}, x^{t+1})}\right]^{1/2}}_{TC_{t,t+1}} \tag{2}$$

In this equation the term outside the brackets ($CU_{t,t+1}$) is a ratio of two distance functions, which measures the change in the output-oriented measure of the Farell technical efficiency between period *t* and *t+1* as a "catching-up to the frontier" effect. The square root term ($TC_{t,t+1}$) in equation (2) is a measure of the technical change in the production technology. It is the geometric mean of the shift in technology between the two periods, evaluated at x^t and also at x^{t+1}.

The term ($CU_{t,t+1}$) is greater than, equal to, or less than 1 if the producer is moving closer to, unchanging, or diverging from the production frontier. The square root term ($TC_{t,t+1}$) is greater than, equal to, or less than 1 when the technological best practice is improving, unchanged, or deteriorating, respectively.

The Malmquist productivity index can be interpreted as a measure of total factor productivity (TFP) growth. Improvement in productivity, as well as improvement in efficiency and technology, is indicated by values greater than one, whereas values less than one indicate regress. The Malmquist productivity index *M* and its two components are local indices. This feature allows considerable flexibility in explaining the considered model of productivity change, both across producers and over time.

Calculation and decomposition of the adjacent period version of the Malmquist index in (2) includes four different distance functions, $D^t(y^t, x^t)$, $D^t(y^{t+1}, x^{t+1})$, $D^{t+1}(y^t, x^t)$ and $D^{t+1}(y^{t+1}, x^{t+1})$, which are the reciprocal of the Farrel technical efficiency indicators. In this study the DEA-like methods to estimate the frontier functions was used and a data envelopment analysis computer program DEAP was used for calculating Malmquist TFP indexes.

3. Data and Results of Using Malmquist Indexes

We contemplated the banking firm as a multi-product organization that produces three outputs (loans, deposits and other banking services) with two different inputs (labor and offices). A variable definition is a serious problem in banking studies. The final solution depends upon the concept of what banks do, on the stated problem, and on the availability of data. We use the inter-mediation approach, and variables are defined as follows. For outputs, y_1 are loans (loans to clients, net provisions), y_2 are deposits (deposits from clients) and y_3 are other bank services (net commissions received). For inputs, x_1 are number of employees and x_2 are number of offices.

For this study we used data from the banks' annual balance sheets and income statements for 1999 to 2002. The sample includes all 6 domestic commercial banks operating in Estonia during this period. Table 4 contains some information on the variables used. The columns of Table 4 show the maximum, minimum, average, standard deviation and coefficient of variation (CV) over four years for banks. The data in Table 4 allows an increase in productivity, while the value of bank products (loans, deposits and other banking services) has increased more than the bank inputs (labor and offices number). Reputedly this could be the result of technical efficiency or technological progress.

Table 4.

Summary Information on the Output and Input Variables

	12/99	12/00	12/01	12/02
*(y_1) Loans**				
Max	13770.5	20608.2	23210.2	28183.6
Min	19.6	57.4	68.8	79.1
Average	4052.9	5294.7	6244.0	7493.3
Standard deviation	5753.17	8173.59	9237.00	11168.21
CV	142%	154%	148%	149%
*(y_2) Deposits**				
Max	15396.7	20616.7	24653.3	27514.4
Min	15.9	53.5	91.7	52
Average	4208.3	5492.2	6737.8	7646.9
Standard deviation	6239.11	8238.68	9810.15	10967.26
CV	148%	150%	146%	143%
*(y_3) Other bank services**				
Max	346.7	424.8	457.8	551.7
Min	0.6	0.9	4.2	1
Average	74.6	115.4	126.6	141.3
Standard deviation	134.92	170.87	182.58	219.87
CV	181%	148%	144%	156%
(x_1) Number of employees				
Max	1898	1949	2076	2021
Min	15	14	14	15
Average	604.5	589.5	628.7	631.3
Standard deviation	768.79	764.94	809.83	790.00
CV	127%	130%	129%	125%
(x_2) Number of offices				
Max	129	113	107	92
Min	1	1	1	1
Average	39.5	35.0	33.8	31.3
Standard deviation	53.95	45.80	42.63	37.68
CV	137%	131%	126%	120%

*Note: * denotes millions of Estonian crowns (EEK) at original prices.*
Source: Author's calculations.

Table 5 shows the correlation between the output and input variables. The strongest correlation is among outputs variables – loans (y_1), deposits (y_2) and other bank services (y_3). The correlation between loans and deposits is 0.9977. The lowest correlation in Table 5 is between other bank services (y_3) and number of bank offices (x_2).

Table 5.

Correlation matrix for the output and input variables

	y_1	y_2	Y_3	x_1	x_2
y_1					
y_2	0.9977				
y_3	0.9824	0.9871			
x_1	0.9637	0.9705	0.9522		
x_2	0.8945	0.9079	0.8868	0.9772	

Source: Author's calculations.

Table 6 summarizes productivity change results, that is, the evolution of the Malmquist index (*M*), as well as its catching-up (*CU*) and technological change (*TC*) components. The results suggest that Estonian banks experienced on average a 25.6 percent annual productivity growth rate (that is *M-1*) during 1999-2002, a total of 105.4 percent for the period. Productivity increase is mainly the result of a 17.4 percent per year technological progress (68.0 percent for the period). The average catching-up effect, while positive, is low at only 6.9 percent per year (22.3 percent for the period). The behaviour of the catching-up effect is mainly due to the poor results of the catching-up effect from 2001 to 2002 – CU decreased 14.3 percent. There was also a productivity decrease of 2.5 percent for the period 2001-2002. The highest productivity growth rate was from 1999 to 2000, when the productivity increase for all Estonians banks was 62.4 percent for this period.

Table 6.

Productivity Change Indexes

Years	Number of Banks	Malmquist Index (M)	Catching Up (CU)	Technological Change (TC)
1999-2000	6	1.624	1.223	1.327
2000-2001	6	1.251	1.167	1.072
2001-2002	6	0.975	0.857	1.138
Geometric Average		1.256	1.069	1.174
1999 & 2002	*6*	*2.054*	*1.223*	*1.680*
1999 & 2001	*6*	*2.055*	*1.428*	*1.440*
1999 & 2000	*6*	*1.624*	*1.223*	*1.327*

Note: All indexes are geometric averages.
Source: Author's calculations.

Table 7 shows productivity scores by different banks. All banks in Estonia show positive productivity growth *(M* > 1) regardless of bank size. That is the result of technological progress *(TC* > 1). For three banks catching up with the best practice is more or equal than 1 (with the slight exception of three banks – Eesti Ühispank, Sampo Pank, Tallinna Äripanga AS, where *CU<1*). Although Eesti Ühispank, Tallinna Äripanga AS and Sampo Pank were relatively similarly able to get closer to the efficient production frontier *(CU* < 1), at the same time Tallinna Äripanga AS and Sampo Pank show lower levels of technological change and have therefore experienced lower levels of productivity change.

Table 7.

Malmquist index summary of bank means (1999-2002)

Bank	Malmquist Index (M)	Catching Up (CU)	Technological Change (TC)
Eesti Krediidipank	1,371	1,146	1,196
Eesti Ühispank	1,161	0,972	1,195
Hansapank	1,251	1,000	1,251
Sampo Pank	1,071	0,971	1,103
Preatoni Pank	**1,631**	**1,423**	**1,146**
Tallinna Äripanga AS	1,127	0,972	1,160
Geometric Average	1,256	1,069	1,174

Note: All indexes are geometric averages.
Source: Author's calculations

Eesti Krediidipank and Preatoni Pank were able to experience the highest productivity (M > geometric average M) and trying to catch up with the best practices (CU > geometric average CU). Hansapank has the best technological change, with a 25.1 percent average annual technological change, for the period 1999-2002. For Eesti Krediidipank it is surprising the evenly high level of technological change (TC > geometric average TC), as it catches up with the best practices (CU > geometric average CU), therefore obtaining a high level of productivity change. The newest and smallest bank in Estonia – Preatoni Pank exhibits better scores in most indicators for the period 1999-2002. This could be partly explained by the fact that the new institution was attractive to the public in Estonia and this bank started to work by rationalizing their input usage and so getting closer to best practices. Maybe the reason, that the two largest banks – Hansapank and Eesti Ühispank have high technological change but not the highest productivity, is a result of a strategy aimed at establishing themselves as credible competitors in the market and so they loose the dependence of clients in the market war. In short, we may conclude that Estonian banks have been able to experience technological progress and some large banks are quicker at improving their production technologies. We cannot say that higher productivity is the clear signal for success, since Hansapank, Eesti Ühispank and Sampo Pank are the three largest banks in Estonia, but the obtained levels of productivity change scores are fairly different.

4. DuPont Financial Ratio Analysis: Methodology

The starting point of the bank performance analysis is to calculate the book rate of return on equity, ROE:

$$ROE = \frac{\text{Earnings After Taxes, } EAT}{\text{Book Value of Equity, } BVE}\ , \tag{3}$$

which consists of three components:

- pull-through, U

$$U = \frac{\text{Earnings After Taxes, } EAT}{\text{Earnings Before Taxes, } EBT} \tag{4}$$

- financial leverage, LEV

$$LEV = \frac{\text{Total Assets, } TA}{\text{Book Value of Equity, } BVE} \tag{5}$$

- return on total assets, ROA

$$ROA = \frac{\text{Earnings Before Taxes, } EBT}{\text{Total Assets, } TA} \tag{6}$$

These financial ratios (3-6) form the multiple factor system:

$$ROE = \frac{EAT}{EBT} \times \frac{TA}{BVE} \times \frac{EBT}{TA} = \frac{EAT}{BVE} \tag{7}$$

All these financial ratios are widely used for a bank performance analysis. Pull-through (U) shows success of the bank tax management policy as it may be interpreted as one minus the average corporate tax rate. The financial leverage ratio (LEV) measures how many Estonian crowns (EEK) of assets the bank has per EEK of equity and may be interpreted as a bank's "gearing". Return on total assets (ROA) is one of the most frequently used financial ratios by financial analysts. ROA measures the ability of bank management to generate income after all financial and non-financial costs and expenses for owners.

Changes in ROA are usually the cause of the most important changes in a bank's performance and need a more detailed analysis. The other financial ratios such as components of ROE, pull-through (U) and financial leverage (LEV), reflect tax treatment and capitalization rate, and they usually change less. ROA may be divided into the following components:

- bank burden, B

$$B = \frac{\text{Net Non - Interest Revenue, } NNIR}{\text{Total Assets, } TA} = \frac{NIR - NIE}{TA}\ , \tag{8}$$

where NIR – non-interest revenue;
NIE – non-interest expense;

- earning assets ratio, EAR

$$EAR = \frac{\text{Earning Assets, } EA}{\text{Total Assets, } TA} \tag{9}$$

- net interest margin, NIM

$$NIM = \frac{\text{Net Interest Revenue, } NIR}{\text{Earning Assets, } EA} = \frac{IR - IE}{EA}\ , \tag{10}$$

where IR – interest revenue;
IE – interest expense,

Financial ratios (8-10) form a factor system:

$$ROA = \frac{NNIR}{TA} + \frac{EA}{TA} \times \frac{NIR}{EA} = \frac{NNIR + NIR}{TA} = \frac{EBT}{TA} \tag{11}$$

Burden (B) measures a bank management's control of operating expenses. The burden for banks is negative to show the fact that non-interest revenue (fees, earned commissions, other operating income) does not cover labor and other administrative or non-interest expenses. Earning assets ratio (EAR) is usually not an important factor of changes in ROA but it may be interesting to make comparisons between various banks because EAR characterizes different development strategies. Net interest margin (NIM) is a more important and widely used financial ratio in the factor system (11). NIM reflects the interest spread between assets and liabilities, it focuses on the net earnings from investing through borrowed funds and is the major source of profitability for the bank.

For a more detailed analysis, NIM may be divided into the three following components:

- return on earning assets, REA

$$REA = \frac{\text{Interest Revenue, } IR}{\text{Earning Assets, } EA} \qquad (12)$$

- cost of liabilities, COL

$$COL = \frac{\text{Interest Expense, } IE}{\text{Liabilities, } L} \qquad (13)$$

- liabilities to earning assets ratio, LEA

$$\text{LEA} = \frac{\text{Liabilities, L}}{\text{Earning Assets, EA}}, \qquad (14)$$

which form (12-16) the factor system

$$NIM = \frac{IR}{EA} - \frac{IE}{L} \times \frac{L}{EA} = \frac{IR - IE}{EA} = \frac{NIR}{EA} \qquad (15)$$

Return on earning assets (REA) connects directly to earning assets and interest revenue generated by them. Thus, REA characterizes the average rate of lent funds and earned dividends. The cost of liabilities (COL) may be interpreted as the average price of borrowed capital. Liabilities to earning assets ratio (LEA) measure the intensity of bank investment activity.

5. Banking Sector Performance and Profitability (DuPont Analysis)

It is argued that internationalization, adoption of new banking technologies, deregulation, banking market consolidation and other recent trends in financial intermediation should result in increasing efficiency. On the other hand, since banks are no longer the monopoly suppliers of financial services and products and markets are more contestable (increased competition between banks and new competition from non-bank financial institutions and markets), intermediation margins, net interest income and other income should result in decreasing profitability and efficiency. In any case, elimination of inefficiencies and reducing costs would be a challenge for a banks' survival in the rapidly changing market environment. Initial financial information for Estonian banking sector performance analysis is presented in Table 8 on the basis of aggregated consolidated financial statements published by the Bank of Estonia.

Table 8

Simplified Consolidated Financial Statements of the Estonian Banking System

Items	1994	1997	2000	2001	2002	02/94	02/01
Income Statement Data							
Interest Revenue, IR	943.6	2658.5	3744.2	4308.1	4253.5	4.508	0.987
Interest Expense, IE	312.8	1217.5	1811.9	2125.7	1883.0	6.020	0.886
Net Interest Revenue, NIR = IR – IE	630.8	1444.1	1932.3	2182.4	2370.5	3.758	1.086
Non-Interest Revenue, NOIR	457.0	3272.0	2065.6	2895.1	2613.4	5.719	0.903
Non-Interest Expense, NOIE	1019.8	3644.4	3384.8	3373.7	3769.1	3.696	1.117
Net Non-Interest Revenue, NNIR = NOIR – NOIE	-562.8	-372.4	-1319.2	-478.6	-1155.7	2.053	2.415
Earnings Before Taxes, EBT = NIR + NNIR	68.0	1068.9	613.1	1703.8	1214.8	17.86	0.713
Earnings After Taxes, EAT	40.9	963.1	613.1	1683.4	1153.2	28.20	0.685
Balance Sheet Data							
Cash and Reserves, R	1527,8	3203.8	6578.0	6212.3	5166.2	3.381	0.832
Earning Assets, EA	6117.8	25817.0	42019.6	53544.0	66827.5	10.92	1.248
Fixed and Other Assets, FA	742.9	2743.1	3847.3	3358.7	3054.9	4.112	0.910
Total Assets, TA = R+EA+FA	8388.5	31763.9	52444.9	63115.0	75048.6	8.947	1.189
Liabilities, L	7667.3	28562.7	45164.2	54936.0	65549.2	8.549	1.193
Book Value of Equity, BVE	721.2	3201.2	7280.7	8179.0	9499.4	13.17	1.161

Source: Bank of Estonia, Annual Reports.

The Estonian banking system has grown rapidly in nominal terms. The respective growth rates are also presented for 2002/1994 and 2002/2001 in Tables 8. In general, we can see high growth rates in almost all of the balance sheet and income statement items during the period 1994-2002. A financial ratio analysis is needed for analyzing profitability and efficiency changes in the banking system, using a modified version of DuPont financial ratio analysis technique (see Dietrich, 1996). Using initial data from Table 8 (the balance sheet data are averaged), results of DuPont financial ratio analysis are presented in Table 9.

These results need some comments, focusing on the growth rates of 2002/1994.

- The book rate of return on equity (ROE), which is the most widely used and popular measure of bank performance results, from the viewpoint of owners/investors, increased during the analyzed period from 5.67% in 1994 to 12.14% in 2002, i.e. more than two times. We can also mention very high volatility of profitability ratios (both ROE and ROA) during the analyzed period. Banks after-tax earnings to earnings before taxes ratio (pull-through, U), which characterizes the banks tax management policy efficiency, because (1 - U) = *t* (*t* – the average tax rate), also increased during this period. Banks were more skilful at finding various "tax shelters" in 1997 compared with 1994 and later. Banks' financial leverage ratio (LEV) decreased substantially due to the central bank's new equity requirements, which forced banks to raise equity or to merge. Financial leverage rose again in 2001 and 2002. The main factor of ROE change is the increase of the return on total assets (ROTA), which needs a more detailed analysis.
- ROTA rose from 0.81% to 1.62% between 1994 and 2002, this was caused by the significant decrease of the Estonian banks' burden (B) due to the improvement of the banks' cost control and services pricing, and due to the substantial increase in the share of interest-earning assets in total assets. However, the net interest margin level (NIM), which reflects the interest rate spread between assets and liabilities for deposit-taking financial institutions and is the major source for the profitability of banks, has decreased substantially, from 10.31% to 3.55 %, i.e. about three times. This phenomenon also needs further analysis.
- We may draw some important and interesting conclusions from the component analysis of the substantial decrease of the NIM level:

  (a) The average return on earning assets (REA) has fallen substantially over the recent years due to the overall falling of interest rates in the Estonian banking market, the average cost of liabilities (COL) increased slightly and fell in 2001 and in 2002 compared with 2000;
  (b) REA has fallen much faster than COL, i.e. the interest spread decreased considerably over the analyzed period ((15.42%- 4.08%) - (6.37%- 2.87%) = 11.34%- 3.50% = 7.84%), – this change reflects the sharpened competition between banks themselves and with other financial institutions, for example insurance and investment funds;
  (c) Liabilities to the earning assets ratio (LEA) has also fallen substantially, i.e. Estonian commercial banks intensified their lending and investment activities, and almost all available resources (in 2002, also a part of the equity) have been invested in the earning assets.

Table 9.

Financial Ratio Analysis of Estonian Commercial Banks (1994-2002)

Financial Ratio	1994	1997	2000	2001	2002	02/94	02/01
Book Rate of Return, %, ROE = EAT/BVE	5.671	30.09	8.59	20.58	12.14	2.141	0.590
Components of ROE, ROE = U×LEV×ROTA							
Pull-through, %, U = EAT/EBT	60.15	90.10	100.0	98.80	94.93	1.578	0.961
Financial Leverage, LEV = TA/BE	11.63	9.92	7.203	7.717	7.90	0.679	1.024
Return on Total Assets, ROTA = EBT/TA	0.811	3.365	1.192	2.700	1.619	1.996	0.600
Components of ROTA, ROTA = B + EAR×NIM							
Burden, %, B = NNIR/TA	-6.709	-1.172	-2.493	-0.755	-1.540	0.230	2.040
Earning Assets Ratio, %, EAR = EA/TA	72.93	81.28	80.12	84.84	89.05	1.221	1.050
Net Interest Margin, %, NIM = NIR/EA	10.31	5.594	4.599	4.076	3.547	0.344	0.870
Components of NIM, NIM = REA – COL×LEA							
Return on Earning Assets, REA = IR/EA	15.42	10.30	8.921	8.046	6.365	0.413	0.791
Cost of Liabilities, %, COL = IE/L	4.080	4.263	4.012	3.869	2.873	0.704	0.743
Liabilities to Earning Assets Ratio, LEA = L/EA	1.253	1.106	1.075	1.026	0.981	0.783	0.956

Source: Authors' calculations

6. Concluding Remarks

The development of the Estonian banking sector can be described by a quite rapid nominal growth of total assets, loan portfolios, net income and other quantitative financial indicators. Although the Estonian banking market was already quite concentrated, the consolidation process continued. The capitalization of Estonian banks improved, and the share of non-residents in the share capital increased significantly during the analyzed period.

This analysis has measured productivity differences between 6 Estonian domestic commercial banks by Malmquist productivity index and its catching-up and technological change components. The data used in this study covers the period from 1999 to 2002. Looking at individual years, the highest productivity growth rate over all Estonian banks was observed from 1999 to 2000. There was also the productivity decrease of 2.5 percent for the period from 2001 to 2002. The results suggest that Estonian banks experienced a 25.6 percent average annual productivity growth rate during 1999-2002, that was mainly the result of technological progress, while the average catching-up effect was relatively low.

Comparing the banks over the period of 1999-2002, it is found that Preatoni Bank has experienced the highest productivity growth and the highest catching up with the best practices, but lower levels of technological change. Eesti Ühispank, Sampo Pank and Tallinna Äripanga AS had obtained lower levels of productivity change that is mainly the result of the low catching up of best practices. For Eesti Krediidipank the high level of technological change was surprising, due to the high catching up with the best practices and causing the high level of productivity change. Hansabank has experienced strong productivity growth and the highest technological change levels, suggesting that the largest Estonian bank has more possibilities investigating in technology. Generally, Estonian banks have increased productivity as a result of technological progress during 1999 to 2002.

As the Estonian banking system is developing rapidly, both input and output quantitative financial indicators have increased substantially during the analyzed years. There was an overall falling of the market-determined interest rates in the Estonian banking market, the interest spread decreased substantially, which influenced the dynamics of various discussed financial ratios. The rise of the Estonian commercial banking system performance efficiency, which is revealed in the increase of the rate of return indicators such as *return on assets* (ROA) and *return on equity* (ROE), was caused mainly by the changes in the proportions between output indicators (for example, the banks' burden has decreased substantially). The traditional output/input-type efficiency ratios (interest or income on assets or on equity ratios) however, decreased substantially during the analyzed period.

7. Endnote

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Stabilisation Period and Malmquist Index of Productivity Change: An Empirical Study of Estonian Banks

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Abstract

The problem of banking and financial system soundness has become more important in all countries over the last years. In transition countries, the weakness of the banking system is the major factor of delaying expected economic growth. Rapid financial sector reforms and drastic restructuring has been characteristic for all Central and Eastern European transition countries.

In the current study the productivity change in Estonian banking is estimated using the Malmquist productivity index and received results are compared with standard measures of performance used by banks. The data used in this study covers the period from 1999 to 2003, during which there was a steady development of financial institutions and stabilization in the Estonian banking market. The present study shows that Estonian banks experienced an average of more than 25 percent annual productivity growth rate (production approach), during 1999-2003, due to technical progress. The comparison of correlation between Malmquist indexes and standard measures of performance (Return on Shareholders' Equity, Net Interest Margin, Cost to Income ratio) gives a result that proves that there is a weak correlation between these values.

Introduction

The Estonian banking market is small and the history of Estonian commercial banking is short. The history of the Estonian banking industry begins in the year 1988; when, a sanction for the establishment of commercial banks was first granted in the Soviet Union. The financial sector has been developing and growing, in close connection with the whole economy, very fast. At present there are six domestic commercial banks operating in Estonia. These banks are universal banks. The Estonian banking market offers a wide variety of contemporary banking services, including high-level Internet and mobile phone banking services. Commercial banks and their customers are quite innovative in Estonia. They are in the process of intensively introducing new technology-based products and services.

Special banks' analyses are interesting from the viewpoint of different audiences: owners, regulators, customers and management. It is visible that financial sector development study and performance analysis is needed. Every new analysis can provide an additional picture of the banking sector. The main objective of this study is to examine productivity change in the Estonian banking industry during the development stabilization period and compare the results with some standard measures of performance used by Estonian banks.

There are two basic approaches to the measurement of productivity change: the econometric estimation of a production, cost, or some other function, and the construction of index numbers using non-parametric methods. Pastor (1995) refers to the advantages and disadvantages of both methods. Berger, Humphrey and Mester review applications of this literature to banking (Berger and Humphrey (1997), Berger and Mester (1997)). The construction of index numbers using non-parametric methods is adopted for the reason that it does not require the imposition of a possibly unwarranted functional form on the structure of production technology[15]. The Malmquist total factor productivity (TFP) index is used to examine productivity change in the banking industry. Malmquist firm-specific productivity indexes were introduced by Caves, Christensen and Divert (1982). They named these indexes after Malmquist, who had earlier proposed constructing input quantity indexes as ratios of distance functions (Malmquist (1953)).

There are output-oriented and input-oriented measures of change in productivity (Coelli, Rao and Battase (1998)). This study concentrated on the output-oriented Malmquist productivity index, where the output-oriented productivity measures focus on the maximum level of outputs that could be produced using a given input vector and a given production technology relative to the observed level of outputs.

Different indexes can be used for productivity measurements – these are the Fischer, Törnqvist and Malmquist indexes. According to Grifell-Tatjé and Lovell (1996), the Malmquist index has few advantages relative to the Fischer

[15] This is required by the econometric approach.

and Tornqvist indexes. First, it does not require the profit maximization, or expense minimization, assumption and information on the input and output prices. Also, it allows the decomposition of productivity changes into two components (technical efficiency change and technological change). Malmquist index's main disadvantage is the necessity to compute distance functions[16]. However, the data envelopment analysis (DEA) technique can be used to solve this problem.

There are many different methods that could be used to measure the distance function that make up the Malmquist TFP index. One of the more popular methods has been the DEA-like linear programming methods suggested by Färe et al. (1994b). To construct Malmquist TFP indexes using DEA-like methods the DEAP computer program is used (Coelli, Rao and Battase (1998)). DEAP is a data envelopment analysis computer program (Coelli (1996)).

There have been few studies on banking productivity analysis using Malmquist productivity index for Europe – banks of Nordic countries (Berg, Forsund and Jansen (1992), Berg et al. (1993), Bukh, Forsund and Berg (1995) and Mlima (1999)), Portuguese banks (Rebelo and Mendes (2000)) and Turkish banks (Isik and Hassan (2003)). The current study is the second productivity analysis of Estonian banks, using the Malmquist productivity index. The first analysis was made in the end of year 2003 (Kirikal, Sõrg and Vensel (2004)). This work raises two questions for Estonian banks:

- Do Malmquist indexes of productivity change and do their components provide similar values for an intermediation model and a production model?
- Are Malmquist indexes of productivity change scores correlated with standard measures of performance used by banks?

The current study is structured as follows. The next section gives a review of the Estonian banking industry. The third section describes the Malmquist productivity index and its decomposition. The fourth section presents the models and the data. Section five contains the empirical results. The final section provides a conclusion.

1. Review of The Estonian banking industry

The Estonian position has been unique due to the late start, which has enabled Estonia to learn from the mistakes made by countries with historically strong banking traditions. Today's situation in banking is the result of rapid development since the monetary reform and introduction of the Estonian kroon on June 20, 1992. By the end of 1992, there were 41 commercial banks in Estonia. Rapid changes were followed by a crises in the financial sector that

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[16] The Malmquist index does not permit statistical analysis. This problem has been partly solved using bootstrapping techniques to construct confidence intervals (Simar and Wilson (1996), Lothgren (1997)).

lead to the mergers and bankruptcy of banks. Estonia has experienced two serious banking crises during the first 12-year period, in 1992-1994 and in 1998-1999.

Today the institutional division of the Estonian banking market has remained stable and is divided between two large banking groups, four small banks and a branch of a foreign bank (see Figure 1). Regardless of the certain level of maturity achieved in market coverage and balance stroke between market participants, competition still shows signs of becoming increasingly fierce. Since 2002 clear features – rapidly declining loan margins and luring away clients – have indicated certain market saturation. The fastest-growing segment of the banking portfolio is housing loans, where annual growth is more than 50 percent. The service fee alongside interest income is very important for the banks. Service fees have grown consistently during the last years. Apart from the fees charged for issuing loans and redrawing loan contracts (about a third of the overall service fee income) incomes have also been supported by the cash flow generated through increased utilization of fee-charging electronic channels (primarily fees from card payments). The latter are important for the banks since they generate non-interest sensitive income (Bank of Estonia (2003)).

Figure 1 shows that Hansapank controls 57%, Eesti Ühispank controls 25%, Estonian Branch of Nordea Bank Finland[17] 8%, Sampo Pank (Sampo Bank) 7% and other banks only 3% of the total banking assets. Therefore today there are two major banks in Estonia – Hansabank and Eesti Ühispank. Hansapank, whose majority owner is Swedbank (Sweden), controls the market, followed by Eesti Ühispank, whose largest shareholder is Skandinaviska Enskilda Banken (Sweden). The third and fourth largest are Finnish-owned banks – Nordea Bank Finland and Sampo Pank. Banking markets in different countries are becoming increasingly integrated, especially those within the European Community. Due to the opening of financial markets, the share of foreign capital in the banks' total share capital is about 97 percent in Estonia. This means that currently Scandinavian-owned banks control the Estonian banking market.

[17] Nordea Bank Finland Plc Estonian Branch is a branch of Nordea Bank Finland, which is one part of Nordea AB, the largest financial group in the Nordic Region.

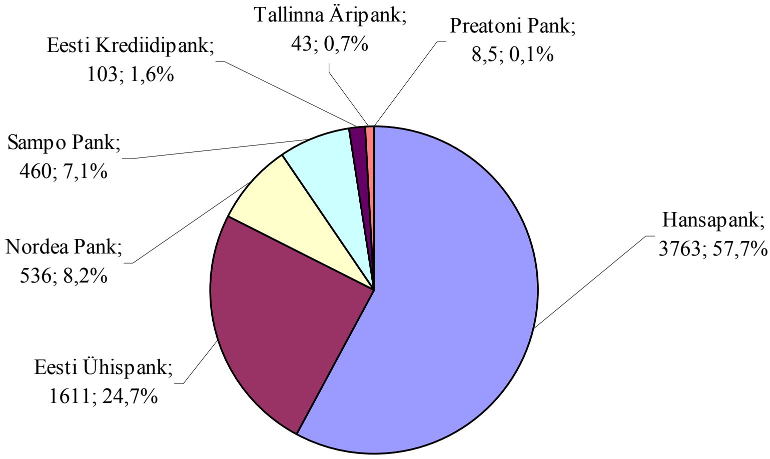

Figure 1. Market Share of Estonian Banks by Total Assets (In percentages of millions of Euros as of December 31, 2003; Source: Estonian Banking Association homepage)

The data used in this study covers the period from 1999 to 2003, during which there was a steady development of financial institutions and stabilization in the banking market. This data is from the quarterly data of the banks' annual balance sheets and income statements. The example includes all six commercial banks operating in Estonia (Estonian Branch of Nordea Bank Finland excluded) during this period - Eesti Krediidipank (Estonian Credit Bank), Preatoni Pank[18], Hansapank, Eesti Ühispank, Sampo Pank and Tallinna Äripank (Tallinn Business Bank).

The period from 1999 to 2003 is also interesting for the current study because it was the pre-European Union-membership period for Estonia. From the 1st of May 2004 Estonia became an official member of the European Union.

2. The Malmquist Productivity Index

The Malmquist productivity index can be used to identify productivity differences between two firms, or one firm over two-time periods (Malmquist (1953), Caves Christensen and Diewert (1982)). For estimation of the technical efficiency change and technological changes over the studied time period, we used a decomposed Malmquist productivity index based on ratios of output distance functions.

[18] The Council of the Bank of Estonia gave a banking license to Preatoni Pank on 28 September 1999. Preatoni Pank has focused on intermediation of foreign capital into Estonian economy, real estate financing and asset management.

Caves, Christensen and Divert (1982) proposed, that output based Malmquist productivity index between time periods *t* and *(t + 1)* can be defined as:[19]

$$M_{t,t+1}\left(y^t, y^{t+1}, x^t, x^{t+1}\right) = \left[\frac{D^t(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)} \times \frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^{t+1}(y^t, x^t)}\right]^{1/2}, \qquad (1)$$

where the notation *D* represents the distance function and the value of *M* is the Malmquist productivity index. The first ratio represents the period *t* Malmquist index. It measures productivity change from period t to period *(t+1)* using period *t* technology as a benchmark. The second ratio is the period *(t + 1)* Malmquist index and measures productivity change from period *t* to period *(t + 1)* using period *(t + 1)* technology as a benchmark. A value of M greater than one (i.e. $M > 1$) denotes productivity improvement, while a value less than one ($M < 1$) indicates productivity deterioration, and $M = 1$ indicates no productivity change.

Färe et al. (1989) showed that the Malmquist productivity index can be decomposed into two components, that is an equivalent way of index (1), as:

$$M_{t,t+1}\left(y^t, y^{t+1}, x^t, x^{t+1}\right) = \underbrace{\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)}}_{\text{EFFCH}} \underbrace{\left[\frac{D^t(y^t, x^t)}{D^{t+1}(y^t, x^t)} \times \frac{D^t(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t+1}, x^{t+1})}\right]^{1/2}}_{\text{TECHCH}} \qquad (2)$$

In this equation the term outside the brackets (EFFCH) is a ratio of two distance functions, which measures the change in the output-oriented measure of Farell technical efficiency between period *t* and *t+1*. The square root term (TECHCH) in equation (2) is a measure of the technical change in the production technology. It is an indicator of the distance covered by the efficient frontier from one period to another and thus a measure of technological improvements between the periods.

The term (EFFCH) is greater than, equal to, or less than one if the producer is moving closer to, unchanging, or diverging from the production frontier. The square root term (TECHCH) is greater than, equal to, or less than one when the technological best practice is improving, unchanged, or deteriorating, respectively.

Calculation of the adjacent period version of the Malmquist index includes four different distance functions – $D^t(y^t, x^t)$, $D^t(y^{t+1}, x^{t+1})$, $D^{t+1}(y^t, x^t)$ *and* $D^{t+1}(y^{t+1}, x^{t+1})$. These functions are the equivalent of the Farrel technical efficiency indicators (Farrel (1957)). In this study the DEA-like methods to

[19] See, for example: Färe et al. (1994), Coelli (1996), Grifell-Tatjé and Lovell (1996, 1997).

estimate the frontier functions is used and a data envelopment analysis computer program DEAP for calculation Malmquist TFP indexes is used.

3. Model and Data

The exact definition of input and output variables in banking is a disputable issue (Berger and Humphrey (1997)). The majority of published banking studies can be categorized as users of the intermediation model or users of the production model. An intermediation model characterizes banks as financial intermediaries whose function is to collect funds in the form of deposits and other loanable funds, and to lend them out as loans or other assets earning an income. A production model treats banks as institutions providing fee based products and services to customers using various resources. Products and services such as loans and deposits are outputs in this model and the resources consumed such as labor, capital and operating expenses are inputs.

I use the intermediation approach for Model A and the production approach for Model B. The variables are defined as follows.

Model A: For outputs – y_1 are loans (loans to clients, net of provisions) and y_2 are other bank services (commissions received plus net profit from financial operations). For inputs – x_1 is number of employees, x_2 is physical capital (the book value of tangible assets) and x_3 are deposits (deposits from clients).
Model B: For outputs – y_1 are loans (loans to clients, net of provisions), y_2 are other bank services (commissions received plus net profit from financial operations) and y_3 are deposits (deposits from clients). For inputs – x_1 is number of employees and x_2 is physical capital (the book value of tangible assets).

All variables, with the exception of labour, are reported in millions of Euros and corrected to the 1999 price level using the consumer price index. Labour is measured in numbers of staff. The quarterly data are from the banks' annual balance sheets and income statements from 1999 to 2003. The sample includes all six domestic commercial banks operating in Estonia during this period.

Table 1 contains some information on the variables used. The columns of Table 1 show the average and median of the banks output and input variables for five years. The average and medians for loans, number of employees and deposits consistently increase between 1999 and 2003. The commissions received also attend the prior description – except median for last year. The only measure that does not follow this pattern is physical capital for which the 2003 average and median are approximately twice as low as in 1999. The data in Table 1 allows an increase in productivity, while the value of bank outputs (loans and commissions received) has increased more than the bank inputs (number of employees and physical capital). Reputedly this could be the result of technical efficiency or technological progress.

Table 1.

Summary Information on the Output and Input Variables

	31.12.99	31.12.00	31.12.01	31.12.02	31.12.03
(Y_1) Loans to clients, net of provisions*					
Average	259.02	322.12	364.57	426.02	576.49
Median	64.39	74.88	100.33	117.83	160.53
(Y_2) Commissions received plus net profit from financial operations*					
Average	2.02	3.35	3.14	3.27	3.38
Median	1.06	1.42	1.16	2.84	1.10
(X_1) Physical capital*					
Average	14.43	12.15	10.12	9.42	7.26
Median	2.93	2.73	2.63	6.49	7.44
(X_2) Number of employees					
Average	604.50	589.50	628.67	631.33	686.50
Median	300.00	315.00	363.00	412.00	477.00
(X_3 for model A and Y_3 for model B) Deposits from clients*					
Average	268.96	334.13	393.40	434.82	474.02
Median	95.04	120.35	181.81	202.32	227.28
Consumer price index by years					
	100.00	105.05	109.46	112.40	113.60

*Note: * denotes millions of Euros, corrected to the 1999 price level using the consumer price index.*
Source: Author's calculations.

4. Empirical Results

In this section the empirical findings are presented. Table 2 summarizes productivity change results, that is, the evolution of the Malmquist TFP index (M), as well as its technical efficiency change (EFFCH) and technological change (TECHCH) components.

The results suggest that Estonian banks experienced an average of 3.2 percent quarterly productivity change by intermediation approach (model A) and 6.4 percent quarterly productivity change by production approach (model B) during 1999-2003. Therefore the average annual productivity growth rate for intermediation approach is 12.8 percent and for production approach is more than 25 percent.

Table 2.

Productivity Change Indexes for model A and B (quarterly)

Quarters	Malmquist TFP Index (M)		Technical Efficiency Change (EFFCH)		Technological Change (TECHCH)	
	A	B	A	B	A	B
1999 Q4 - 2000 Q1	1.426	1.460	0.992	1.395	1.438	1.046
2000 Q1- Q2	0.782	0.881	1.041	0.838	0.751	1.052
2000 Q2- Q3	1.084	1.211	1.051	1.118	1.032	1.083
2000 Q3 - Q4	1.185	1.284	0.907	0.984	1.307	1.304
2000 Q4 - 2001 Q1	0.774	0.886	1.022	1.054	0.757	0.840
2001 Q1- Q2	1.198	1.165	1.059	1.011	1.132	1.152
2001 Q2- Q3	0.986	0.865	0.836	0.902	1.179	0.960
2001 Q3 - Q4	1.041	1.265	1.197	1.129	0.870	1.121
2001 Q4 - 2002 Q1	0.935	0.889	0.944	0.946	0.990	0.939
2002 Q1- Q2	1.051	1.294	0.925	1.195	1.137	1.083
2002 Q2- Q3	0.967	0.747	1.064	0.766	0.909	0.976
2002 Q3 - Q4	1.182	1.399	0.989	1.221	1.195	1.146
2002 Q4 - 2003 Q1	0.974	0.876	1.012	0.863	0.962	1.014
2003 Q1- Q2	1.021	0.967	0.984	1.016	1.038	0.952
2003 Q2- Q3	1.140	1.153	1.020	1.145	1.118	1.007
2003 Q3 - Q4	0.957	1.011	0.965	1.008	0.991	1.003
Geometric Average	**1.032**	**1.064**	**0.997**	**1.025**	**1.035**	**1.037**
Geometric Average from 1999 Q4 to …						
2000 Q2	1.056	1.134	1.016	1.081	1.039	1.049
2000 Q4	1.094	1.189	0.996	1.065	1.099	1.117
2001 Q2	1.048	1.128	1.011	1.054	1.038	1.070
2001 Q4	1.040	1.107	1.008	1.043	1.031	1.062
2002 Q2	1.030	1.100	0.993	1.047	1.037	1.051
2002 Q4	1.036	1.087	0.998	1.033	1.038	1.052
2003 Q2	1.030	1.061	0.998	1.019	1.032	1.042
2003 Q4	1.032	1.064	0.997	1.025	1.035	1.037

Notes: All indexes are geometric averages.

The average productivity increase is mainly the result of technological progress – 3.5 percent and 3.7 percent for the model A and B respectively. The average technical efficiency change is negative for model A (-0.3% per quarter) and only 2.5 percent per quarter for model B. The highest productivity growth rate was from the forth quarter of 1999 to the first quarter of 2000, when the average productivity increase of Estonian banks was more than 40 percent. This could be explained by the effect of a Russian crisis in 1998-1999, that also influenced the Estonian banking system and decreased banking net income during this period. The quarterly productivity increase and decrease was similar for both models over the period of 1999-2003. There was positive productivity growth ($M > 1$) for nine periods out of sixteen. The factor for increase or decrease of Malmquist TFP index is the technological change component (TECHCH) for model A and the technical efficiency change component (EFFCH) for model B. Therefore there is a noticeable difference in results of Malmquist index components, where the deposits are inputs or outputs in the model.

For the two models, A and B, the correlation coefficient of Malmquist indexes is 0.8 but the correlation coefficients of their components (technical efficiency change and technological change) are only 0.06 and 0.49 respectively. Therefore the Malmquist indexes of productivity change give quite similar results but their components give relatively different results for the intermediation model and the production model.

The cumulative geometric average change indexes are listed in the last eight rows of Table 2. All indexes indicate growth during the period 1999-2003, except technical efficiency change indexes for model A. There is a decrease from 2002 to 2003. The Malmquist TFP indexes and the technical efficiency change indexes refer to the retardation in the changes. The productivity change regress of these years is mainly due to fierce competition in the banking market, especially in the loan-market. The stable values of technological change denote that Estonian banks have been able to experience technological progress.

Table 3.

Correlation coefficients for the Malmquist indexes, their components and standard measures of performance (ROE, NIM, CTI)

	Malmquist TFP Index (M)		Technical Efficiency Change (EFFCH)		Technological Change (TECHCH)	
	Model A	Model B	Model A	Model B	Model A	Model B
ROE	-0.281	-0.180	0.120	0.142	-0.309	**-0.555**
NIM	**0.554**	0.353	-0.093	**0.515**	**0.531**	-0.072
CTI	0.325	0.301	**-0.499**	0.151	**0.515**	0.348

Source: Author's calculations

Table 3 shows correlations between the Malmquist TFP indexes (M) and three standard measures of performance: the *Return on Shareholders' Equity* (ROE, defined as net income after taxes divided by shareholders' equity), the *Net Interest Margin* (NIM, defined as net interest income divided by total assets), the *Cost to Income ratio* (CTI, defined as total expenses divided by total income). The first step was to calculate the ROE, NIM and CTI ratios of banks for the entire period, and the second step was making the correlation test with the Malmquist indexes and their components.

The strongest inversely proportional correlation (-0.555) appeared between ROE and technological change components for the model B. Remarkably, also related were the Malmquist index and its component part TECHCH with values NIM for model A. Correlation was weak with ROE variables. Therefore, there is a weak correlation between Malmquist indexes and standard measures of performance. This means that all the calculated ratios and indexes characterise Estonian banking from different aspects.

5. Concluding Remarks

This analysis has measured productivity change for six Estonian domestic commercial banks by the Malmquist TFP productivity index and its technical efficiency change and technological change components. There were two models in this study – the intermediation approach for the first model and the production approach for the second model. Also the correlation between Malmquist indexes of productivity change scores and standard measures of performance used by banks was calculated. The quarterly data used in this study covers the period from 1999 to 2003.

Looking at individual periods (quarters) the author found that the highest productivity growth rate over all Estonian domestic banks was in the first quarter of 2000. This could be explained by the effect of a Russian crisis in 1998-1999, which also influenced the Estonian banking system and decreased banking net income in this period. The results suggest that Estonian banks experienced an average of 3.2 percent quarterly productivity change by the intermediation approach and 6.4 percent quarterly productivity change by the production approach during 1999-2003. The factor for the increase or decrease of the Malmquist TFP index was the technological change component for the model where deposits were inputs and the technical efficiency change component for the model where deposits were outputs in the model. Also found was that both researched models gave highly correlated measures for the Malmquist TFP indices, but their components (technical efficiency change and technological change) gave less correlated measures. The cumulative geometric average of the Malmquist TFP indexes indicated retardation in the changes during the 4-year period, which was the result of the fierce competition in banking market.

To analyse correlations between Malmquist TFP indexes and three standard measures of performance, the *Return on Shareholders' Equity* (ROE), the *Net Interest Margin* (NIM) and the *Cost to Income ratio* (CTI) were calculated for six Estonian banks. The strongest inversely proportional correlation (-0.555) appeared between ROE and Malmquist indexes technological change components for model B. Correlation was weak with the ROE variables. Thus, there was weak correlation between the Malmquist indexes and standard measures of performance.

Therefore, the productivity increase was mainly the result of introducing innovative possibilities by Estonian banks and their customers. The average productivity increase may indicate a strong competition in the Estonian banking market, allowing the potential success for Estonian banks in the integrated European Union banking market.

Essay No: 3.

Productivity, the Malmquist Index and the Empirical Study of Banks in Estonia[20]

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Abstract

The problem of soundness in banking and financial systems has become increasingly important in all countries in recent years. Therefore it is not surprising that it is also relevant in Estonia, where the financial sector has been developing and growing rapidly in step with the whole economy. It is because of this that the monitoring, analysis and regulation of the performance of banks requires special attention from different viewpoints – that of owners, regulators and customers as well as management.

The Estonian banking market offers a wide variety of contemporary banking services. The commercial banks, and their customers, are quite innovative, having progressively introduced new technology-based products and services. All banks produce similarly extensive outputs using a range of inputs, therefore the basic income-expenditure model may not be the best method for trend analysis. Different versions of financial ratio analysis are therefore used to analyse bank performance. However each new ratio or index will characterise Estonian banking from a different viewpoint. Productivity is a measure of how efficiently the economy transforms its labour, capital and materials into goods and services. The main objective of this study is to introduce the importance of productivity management and to present the Malmquist productivity change index.

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Introduction

The Estonian banking position is unique due to a late start, which has enabled Estonia to learn from the mistakes made by countries with historically strong banking traditions. Today's situation in banking is the result of rapid development since the 1990s. A period of rapid change was followed by crisis in the financial sector that led to mergers and bankruptcy in the banking sector. Today the institutional division of the Estonian banking market has achieved stability – being divided between the two largest banking groups, four small banks and the branch of one foreign bank. Hansapank and Eesti Ühispank together control the largest portion of the Estonian banking market. Due to the opening of the financial markets, the percentage of foreign capital in the total share capital of Estonian banks is about 97 percent.

Over recent years, bank performance analysis has received increasing attention in Estonia. The most widely applied measures for evaluating banks include different financial ratio measures, which provide the tools for managing information in order to analyse the financial condition and performance of a bank. The traditional financial ratios, such as Return on Shareholders' Equity (ROE), Return on Assets (ROA), Profit Margin (PM), Net Interest Margin (NIM), Cost to Income ratio (CTI) and Earnings per Share (EPS), are used to characterize the performance of the banks. While the banks' performance represents the complexity of many outputs and inputs, there are some limitations to financial ratios as performance measures. The fundamental limitation of traditional ratio analysis is that the choice of a single ratio does not provide enough information about the various dimensions of the performance of a bank. To exceed the single-ratio problem in financial analysis, alternative techniques to measure performance have been developed. The methods of performance measurement discussed in this paper can be applied to different units. These units might be countries, industries, banks, departments or people. In this paper the term "firm" or "company" is used to describe different economic entities (e.g. states, companies, bank branches, divisions, people). In some of the literature the term "decision making unit" (DMU) is used when the term "firm" or "company" may not be agreeable.

Productivity is one important component of the monitoring, analysis and supervision of company performance. The term productivity was probably first mentioned by the French mathematician Quesnay in an article in 1766 (Sumanth 1998). In 1950, the Organization for European Economic Cooperation (OEEC), one of the oldest organizations espousing productivity enhancement, particularly in Europe, issued a formal definition (OEEC 1950):

> Productivity is the quotient obtained by dividing output by one of the factors of production. In this way it is possible to speak of the productivity of capital, investment, or raw materials, according to whether output is being considered in relation to capital, investment, or raw materials etc.

Different financial ratios can provide a description of the productivity of a firm and its productivity change over time or between firms. This study will present the classical productivity measures as well as a newer method for measuring productivity change – the Malmquist productivity change index. The current study raises four questions:

- What is productivity?
- What is the Malmquist productivity index?
- What are the empirical results from productivity analysis of Estonian banks?
- Do the Malmquist indices correlate with the indices from standard measures of performance used by banks?

The structure of the paper is as follows. The next section provides a review of productivity. The second section presents how to calculate the productivity ratios and indices. The third section describes the Malmquist productivity index and its decomposition. Section four contains some empirical results about productivity in Estonian banks. The final section provides a conclusion and ideas for future research.

1. Concept of Productivity

1.1. Importance of Productivity

The performance of a firm, converting inputs into outputs, can be defined in many ways. One possible measure of performance is a productivity ratio. By defining the productivity of a firm as the ratio of outputs that it produces to the inputs used, the larger values of this ratio are associated with better performance. Productivity is a relative concept. Therefore, the productivity of a company in the present year could be measured relative to its productivity last year, or it could be measured relative to the productivity of another company in the same year. It is even possible to compare the productivity of an industry over time or across countries.

Our real income and living standards critically depend upon our ability to raise productivity, and as a nation, our objective should be to maximize increases in living standards (broadly defined). Therefore, productivity should always be something that we want to increase as much as possible (O'Neill, Egelton, Hogue 1999). Changes in productivity are of great importance at all levels – national, industrial, company and personal (Kendrick 1993):

- At the *national* level, productivity is a major element of economic growth and progress.
- At the *industrial* level, above-average productivity growth leads to relative declines in costs and prices. On both domestic and international

markets, this increases the competitiveness of firms in progressive industries, which consequently tend to grow faster than average.

- At the *company* level, productivity is fundamental to profitability and survival. Companies with higher productivity than the industry average tend to have higher profit margins. Moreover, if productivity is growing faster than that of the competitors, the margins will rise.
- At the *personal* level, increasing productivity in all of one's activities is an important aspect of self-fulfilment. The individual serves as a key to advancement since it helps increase the productivity of the organisation.

On a global scale, improved productivity is essential to eliminate hunger, disease and poverty. Having established what "productivity" means, it is appropriate to list those subcomponents that determine relative increases in wealth or well-being: (1) new technologies and methodologies; (2) energy utilization; (3) investment; and (4) attitudes (Smith 1993). Therefore, the first element in improving productivity is to develop new ideas and new processes – to do things in a new and better way. The next important component is improved energy utilization. Energy refers to all sources of power, whether from the earth, from the sun, the seas, from animals or people, and most importantly, from the human mind. Investments in new technology, energy-reducing or labour-saving equipment are necessary components for raising the level of prosperity. The attitudes of managers and employees are fundamental components in improving productivity. The managers must make sure that people and jobs match because employees have the skills and understanding necessary to achieve both the objectives of the company and their own personal goals. In sum, it is possible to increase productivity by managing these four well-being elements.

1.2. Productivity Management

Productivity is one of the major responsibilities of management. By attaining productivity increases, several other management goals are automatically achieved. An increase in the productivity of a firm results in improved product quality and service, decreased production costs as well as improved market share and profit. In the effort to achieve productivity goals, however, management must not lose sight of the other important management responsibilities – ensuring service quality, timeliness, accomplishing the mission and customer satisfaction. Indicators of the performance of these management responsibilities should also be tracked and emphasized by management. It is important to point out that stressing excellence in relation to all these management responsibilities does not present conflicting, but complementary goals (Soniat and Raaum 1993). There are several books by Christopher, W. F. ed. (1993), Sumanth, D. J. (1998), Belasco, K. S. (1990) that provide a methodology for successful application of productivity management.

Success in any productivity enhancement program depends on the leadership, participation and the ongoing support of every manager. So the first activity should be a top-level evaluation of management structure and style (Eppolito 2002). Increases in productivity represent one of the key competitive advantages of a company. Unfortunately, companies seldom manage their productivity. The main point of productivity management is to identify areas of potential productivity improvement. In order to manage productivity in the true sense of the term, four phases must be linked together (Sumanth 1998):

- Measurement;
- Evaluation;
- Planning;
- Improvement.

These four phases form a continuous productivity process or cycle. The first phase of the productivity cycle is measurement. The present productivity level of the firm must be compared with the target level. This evaluation will provide a vision of the new productivity level for the following period. Depending on the planned level of productivity, improvement must arrive in the subsequent periods. Productivity improvement marks the end of the first productivity cycle, but productivity must be measured again in the next period and this then becomes the beginning of the next new productivity cycle.

The following sections of this study focus on productivity measurement. On the whole, it is not easy to measure productivity due to the following important aspects. Productivity information must be understandable. The results, and also the data collection and analysis system, should be easy to interpret and at the disposal of the decision maker at the appropriate time. Only then will productivity information have predictive value in the planning phase and feedback value to aid monitoring and supervisory activities. Finally, productivity data must also include all those aspects of production that are important to management and that actually represent the activity.

2. Productivity Measures

2.1. Productivity Ratios

The concept of "productivity" has been in existence for many years. The classic measure of productivity is the ratio of output produced per unit of input expended and the formula is (Soniat and Raaum 1993):

$$\text{productivity} = \frac{\text{Output}}{\text{Input}}$$

Productivity is efficiency in the use of resources measured as output in relation to input. Input refers to the resources (e.g. labour, capital, materials and energy) going into the production of the output. Figure 1 represents the input-output transformation, where “process” is the value-added work. As a result of work, we get an output that can be in the form of a product, a service or information for the customer. The customer is the user of the product and/or service produced, and may be external or internal.

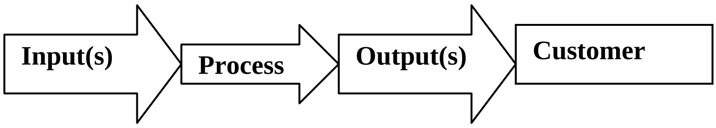

Figure 1. Input-Output transformation map (Source: Author’s compositions)

To calculate any of the desired productivity ratios we need to know the input and output variables. The individual inputs are labour (e.g. the number of hours, the labour costs or the number of workers), capital (e.g. physical capital, financial capital or inventories in monetary value), energy (e.g. electricity, diesel, oil) and materials (e.g. materials utilized in the production cycle in money value). The output, gross or net output, would be available in physical terms and in current dollars.

Productivity measures may be classified into several major groups, where none of the measures or groups is considered to be the best. The most commonly used productivity ratio groups are (Christopher, W. F. ed. (1993), Sumanth, D. J. (1998)):

- Partial productivity (PP);
- Total factor (labour plus capital) productivity (TFP);
- Total productivity (TP).

The formulas for partial productivity (1), total factor productivity (2) and total productivity (3) are presented below.

$$PP = \frac{O}{L \quad (\text{or } M, C, E, m)} \tag{1}$$

$$TFP = \frac{O}{L + C} \tag{2}$$

$$TP = \frac{O}{L + M + C + E + m}, \tag{3}$$

where O – output;
L – labour;
M – material;
C – capital;
E – energy;
m – other inputs.

Partial productivity measures look at the ratio (1) of output to a single input. These include labour productivity (e.g. output per hour worked or per employee), materials productivity (e.g. output per unit of material used), capital productivity (e.g. output per unit of capital invested) and energy productivity (e.g. output per unit of energy consumed). Therefore, this single input can either be labour, materials, capital, energy or some other input. The weakness of partial productivity measures is that they tend to overstate increases in productivity. The advantage of partial productivity measures is that they are much easier to understand and to measure.

The most widely used measure of productivity is labour productivity. It essentially consists of output per employee. This partial productivity measure is used in the following example. A bank invests in a new type of printer that speeds up the process of cash withdrawals from the bank office by 40 percent. Will the labour productivity ratio also increase by 40 percent? In this case, the faster printer is necessary for employees to pay the same amount of cash from the bank office and therefore output per employee will not change. But, the bank now requires less employees to process cash withdrawals and so they can increase the labour productivity ratio. The labour productivity ratio could rise as a result of greater labour productivity or a more intensive use of other inputs such as capital, materials and/or energy. But the labour productivity measure does not consider the effect of the other factors of production such as capital. Therefore, labour productivity is really a partial productivity measure and does not provide a comprehensive evaluation of the overall productivity of all production inputs.

A broader and theoretically more pertinent concept that also incorporates the effect of capital is total factor productivity. Total factor productivity (TFP) takes the ratio of output to capital and labour services (2). The advantage of total factor productivity is that it accounts for capital-labour substitution. The disadvantages are that it is a more difficult ratio to understand and measure.

Total productivity (TP) is the ratio of output to all combined inputs including labour, materials, capital, energy and others inputs (3). Total productivity is a more accurate productivity measure than total factor productivity, and its weaknesses are similar to those of total factor productivity.

2.2. Productivity Indices

Productivity measurement is usually conducted from two perspectives – according to the level of productivity and trends in the productivity. The productivity ratio refers to the productivity level at a given point in time expressed as output units delivered per unit of input resources expended. Trends are defined by looking at productivity development over time. Productivity trend ratios are commonly converted into an index. Indices make it possible to show the input, output and productivity rates on the same graph. So productivity indices can provide us with some information on the causes of changes to productivity – whether they are attributable to the input or the output dimension.

For example, processing 20 housing loan applications per employee would be one labour productivity level, while comparing that productivity level over three years (20 applications per employee this year, 18 last year and 16 the year before) would show an upward trend in labour productivity of about 10 percent per year. Next the labour productivity index will be introduced. All indices are computed based on labour productivity in the first year. The base year index value is one. The labour productivity index for the next year is 1.125 (18 divided by 16) and the cumulative index for the present year is 1.25 (20 divided by 16). Labour productivity indices over these three years are represented in Figure 2. To obtain information about input and output data, it is possible to show input and output indices on the same figure.

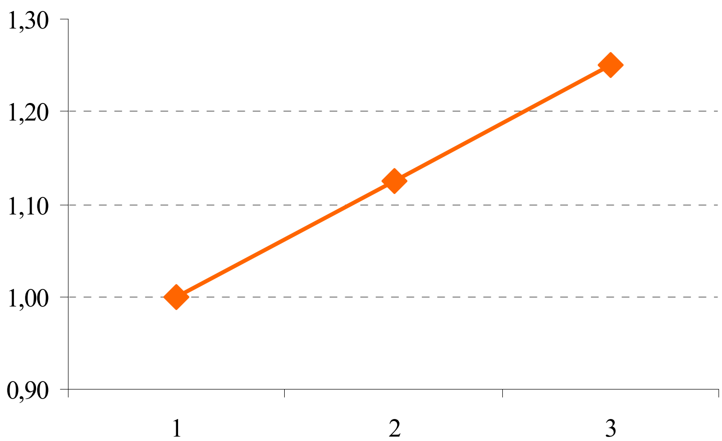

Figure 2. Labour productivity index (Source: Author's calculations)

These two measurement dimensions have different uses. Productivity level data can be useful in determining budget requirements and identifying opportunities for improvement by comparing an entity's productivity levels with that of other entities delivering the same or similar services. Productivity trend data can be useful in identifying opportunities for improvement by comparing current productivity with that of previous periods, and providing a scorekeeping device on management accountability for improving productivity (Soniat and Raaum 1993).

3. Malmquist Productivity Index and its decomposition

Calculating the productivity level or index can be very easy when a single output is produced from a single input (partial productivity). But companies usually produce many outputs from many inputs. How is it possible then to calculate the productivity change index? Enter the Malmquist productivity change index – one method for measuring productivity change over time or between firms.

In 1953, Sten Malmquist, a Swedish economist and statistician, published in *Trabajos de Estadistica* (Malmquist 1953) a quantity index for use in consumption analysis. Later Caves, Christensen and Divert (1982) adapted Malmquist's idea for production analysis and they named their productivity change indices after Sten Malmquist. According to Grifell-Tatjé and Lovell (1996), the Malmquist index has some advantages relative to other productivity indices. For example, it does not require input prices or output prices, which makes it particularly useful in situations where prices are misrepresented or non-existent. The Malmquist index does not require the profit maximization or cost minimization assumption. This makes it useful in situations where the objectives of producers differ, are unknown or not achieved. An attractive feature of the Malmquist productivity index is that it decomposes. Färe et al. (1989) showed that the Malmquist productivity index can be decomposed into two components – technical efficiency change and technical change. The value of this decomposition is that it provides insight into the sources of productivity change. The main disadvantage of the Malmquist index is the necessity to compute distance functions. There are many different methods that could be used to measure the distance function, which makes up the Malmquist productivity index. One of the more popular methods has been the DEA-like linear programming method suggested by Färe et al. (1994b).

Productivity indices explain the role of index figures in measuring growth in outputs (output oriented approach) that are net of input growth. One way to measure a change in productivity is to see how much more output has been produced, using a given input level and the present state of technology, relative to what could be produced under a given reference technology using the same input level. An alternative is to measure the change in productivity by examining the reduction in input use, which is feasible given the need to produce a given level of output under a reference technology. These two approaches are referred to as the output-oriented and input-oriented measures of change in productivity (Coelli, Rao and Battase (1998)). The current study concentrated on the output-oriented Malmquist productivity index.

3.1. Output Distance Function

To define an output distance function, consider a sample of K firms using $x^t \in \Re_+^N$ inputs in the production of $y^t \in \Re_+^M$ outputs in the time period t = 1,...,T. Multiple inputs and multiple outputs production technology may be defined using the output set, P, which represents the set of all output vectors, $y' = (y^t_1, \ldots, y^t_m)$, which can be produced using the input vector, $x^t = (x^t_1, \ldots, x^t_n)$ in the time period t = 1,...,T. That is:

$$P^t(x^t) = \{y^t : x^t \text{ can produce } y^t \text{ at time t}\} \qquad t=1\ldots T.$$

In an output-based approach, the production technology is completely characterized by the output distance function (Shephard, 1970), defined on the output set $P^t(x^t)$ as:

$$D^t(y,x) = \min\{\delta \in (0,1] : (y/\delta) \in P^t(x)\} \qquad t=1\ldots T.$$

The distance function is less than or equal to one (i.e. $D(y,x) \le 1$), if and only if output y belongs to the production possibility set of x (i.e. $y \in P(x)$). Note that the distance function is equal to the unit (i.e. $D(y,x) = 1$) if y belongs to the "frontier" of the production possibility set. A firm is considered technically efficient if the distance function equals one.

3.2. Malmquist Productivity Index

The Malmquist productivity index can be used to identify productivity differences between two firms or one firm over two-time periods. To estimate technical efficiency changes and technological changes over the period in question, we used a decomposed Malmquist productivity index based on ratios of output distance functions.

Färe et al. (1989) showed that the output-based Malmquist productivity index between time periods t and $(t + 1)$ can be decomposed into two components, as[21]:

$$M_{t,t+1}(y^t, y^{t+1}, x^t, x^{t+1}) = \underbrace{\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D^t(y^t, x^t)}}_{\text{EFFCH}} \underbrace{\left[\frac{D^t(y^t, x^t)}{D^{t+1}(y^t, x^t)} \times \frac{D^t(y^{t+1}, x^{t+1})}{D^{t+1}(y^{t+1}, x^{t+1})}\right]^{1/2}}_{\text{TECHCH}}, \quad (4)$$

[21] See, for example: Färe et al. (1994), Coelli (1996), Grifell-Tatjé and Lovell (1996, 1997).

where the notation D represents the distance function and the value of M is the Malmquist productivity index. A value of M greater than one (i.e. $M > 1$) denotes productivity growth, while a value less than one ($M < 1$) indicates productivity decline, and $M = 1$ indicates no productivity change.

In equation (4) the term outside the brackets (*EFFCH*) is a ratio of two distance functions, which measures the change in the output-oriented measure of the Farell technical efficiency between period t and $t+1$. The square root term (*TECHCH*) is a measure of the technical change in the production technology. It is an indicator of the distance covered by the efficient frontier from one period to another and thus a measure of technological improvements between the periods. The term (*EFFCH*) is greater than, equal to or less than one if the producer is moving closer to, unchanging or diverging from the production frontier. The square root term (*TECHCH*) is greater than, equal to or less than one when the technological best practice is improving, unchanged, or deteriorating, respectively.

Calculation of the Malmquist index for adjacent periods includes four different distance functions – $D^t(y^t, x^t)$, $D^t(y^{t+1}, x^{t+1})$, $D^{t+1}(y^t, x^t)$ *and* $D^{t+1}(y^{t+1}, x^{t+1})$. There are many different methods that could be used to measure the distance function, which makes up the Malmquist productivity index. In the empirical part of this study (see section five) will be used the DEAP computer program to construct Malmquist indices using DEA-like methods (Coelli, Rao and Battase, 1998). DEAP is a data envelopment analysis computer program (Coelli, 1996).

4. Measuring Productivity in Estonian Banks

The data used in this part of the study covers the period from 1999 to 2003, during which there was the steady development of financial institutions and stabilization in the Estonian banking market. The period from 1999 to 2003 is also interesting because it was the pre-EU-membership period for Estonia. Since the 1st of May 2004 Estonia has been an official member of the European Union. This data is from annual balance sheets and income statements of the banks involved. All variables, with the exception of labour and offices, are reported in millions of Euros and corrected to the 1999 price level using the consumer price index (except in case 5.1. in the present study). The example includes all six domestic commercial banks operating in Estonia (the Estonian Branch of Nordea Bank Finland was excluded) during this period – Eesti Krediidipank (Estonian Credit Bank), Preatoni Pank[22], Hansapank, Eesti Ühispank, Sampo Pank and Tallinna Äripank (Tallinn Business Bank).

[22] The Supervisory Board of Eesti Pank extended a banking license to Preatoni Pank on 28 September 1999. Preatoni Pank has focused on the intermediation of foreign capital into the Estonian economy, real estate financing and asset management. Since the 18th of June 2004, the new business name of Preatoni Pank is SBM Pank.

When analyzing a bank's income statement, four major categories need to be analyzed –interest income and expenses, non-interest income and expenses. These categories represent the primary source of revenues and expenses generated by a bank. According to data from Estonian banks, income and expenses as a percentage of total income are presented in Table 1.

Table 1.

Interest and non-interest income/expense sharing in Estonian banks on the 31st of December 2003

Category name	… income as a percent of total income	… expenses as a percent of total expenses
Interest	62%	36%
Non-interest	38%	64%
Total	100%	100%

Source: Author's calculations.

Table 1 shows that the primary revenue for Estonian banks is generated by interest income. In the expenses category, non-interest expenses (64%) are higher than interest expenses (36%). Interest expenses are generally a function of the market, so they are difficult to truly control and/or reduce. With non-interest expenses as a significant portion of total expenses, there is a better chance of the bank themselves controlling them.

Table 2 contains information on the sharing of non-interest income and expenses among Estonian banks, where commission income is 52 percent of non-interest income. This is approximately 20 percent of total income. Therefore, the service fee in addition to interest income is very important for the banks. To achieve more commission income it is essential to continue introducing fee-based banking products and services. The administrative expenses are 53 percent of non-interest expenses. Almost half of the administrative expenses are wages and salaries, in other words, 24 percent of non-interest expenses. This figure of 24 percent is certainly a significant cost to the organization and certainly an expense that merits controlling.

Table 2.

Non-interest income and expense sharing in Estonian banks on the 31st of December 2003

Category name	… income as a percent of non-interest income	… expenses as a percent of non-interest expenses
Commission	52%	10%
Administrative (incl. wages and salaries)		53%
Wages and salaries		24%

Source: Author's calculations.

If the goal is short-term savings, then it is immediately possible to cut wages and salaries as well as reduce the number of people on staff. To monitor and reduce non-interest expenses (including administrative expenses, wages and salaries) in the long-term, banks need to increase their productivity. This means that banks must get better results with the same or reduced inputs (e.g. staff, capital). Consequently, banks must have an understanding of the elements of productivity – what is important to measure and how does productivity improve.

The following three productivity cases describe Estonian banks and are calculated on the basis of non-interest income and expense data, since the banks themselves monitor this data on a large scale.

4.1. First Case: Productivity Levels and Productivity Indices in Estonian Banks

In the first case, partial productivity levels and indices are computed for Estonian banks. Labour productivity is a well-known and widely used measure of partial productivity and is easy to measure. All the necessary data is presented in Table 3, where output is shown as total loans to clients (net provision) and input as the number of employees.

Table 3

Loans to clients (net provision) and number of employees in Estonian banks

Estonian banks	**1999**	**2000**	**2001**	**2002**	**2003**
Output: Loans to clients (net provision), million Euros*	1,554.14	1,932.69	2,187.42	2,556.14	3,458.93
Input: Number of employees	3,627	3,537	3,772	3,788	4,119

** Corrected to the 1999 price level using the consumer price index.*
Source: Author's calculations.

From Table 3, we can see that loans to clients (net provision) have more than doubled and the number of employees risen by more than 10 percent in Estonian banks over the four-year period. Based on this data, it is possible to calculate labour productivity, defined as loans per employee. As trend ratios give more information, labour productivity indices are calculated based on this data from Table 3. In Figure 3 the input, output and labour productivity indices are shown graphically. From the graph, you can immediately see that output increased more than input, giving rise to a productivity increase. Labour productivity in Estonian banks has increased by 96 percent over the four years in question.

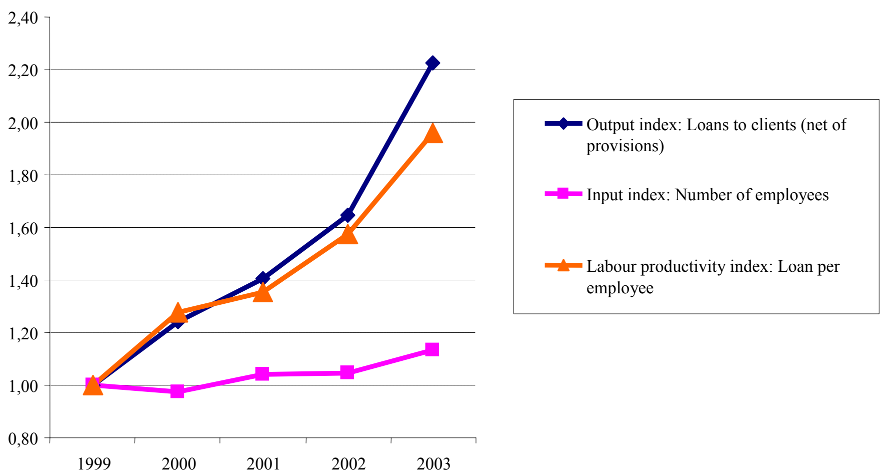

Figure 3. Output, input and labour productivity indices (loans per employee) for Estonian banks (Source: Author's calculations)

Productivity trend data provides us with valuable information on a unit's performance over time. Also, the trend experienced by various units can be compared in order to determine which is performing best. However, comparing productivity trends alone can be misleading, because it is important to know the productivity level of the base year.

Table 4.

Labour productivity levels and indices for Estonian banks

Labour productivity = Loans per employee	**1999**	**2000**	**2001**	**2002**	**2003**
Labour productivity levels for Estonian banks	0.43	0.55	0.58	0.67	0.84
Labour productivity index for Estonian banks	1.00	1.28	1.35	1.57	1.96
Labour productivity levels					
Eesti Krediidipank	0.09	0.11	0.13	0.15	0.18
Eesti Ühispank	**0.45**	0.50	0.57	0.64	**0.99**
Hansapank	**0.46**	0.64	0.65	0.79	**0.89**
Sampo Pank	**0.38**	0.42	0.49	0.50	**0.60**
Preatoni Pank	0.08	0.25	0.29	0.30	0.28
Tallinna Äripank	0.13	0.15	0.17	0.24	0.20
Labour productivity index					
Eesti Krediidipank	1.00	1.25	1.48	1.78	**2.08**
Eesti Ühispank	1.00	1.10	1.26	1.41	**2.19**
Hansapank	1.00	1.39	1.41	1.71	1.91
Sampo Pank	1.00	1.11	1.30	1.33	1.61
Preatoni Pank	1.00	2.98	3.43	3.58	**3.29**
Tallinna Äripank	1.00	1.17	1.33	1.86	1.58

Source: Author's calculations.

Table 4 contains information about the labour productivity levels and indices of Estonian banks over a period of five years. All banks in Estonia have shown positive productivity growth (*Productivity index > 1*) regardless of their size. For three of the banks, Eesti Krediidipank, Eesti Ühispank and Preatoni Pank, the labour productivity index is greater than 2. Are these three banks the best in Estonia? To answer that, it is important to know the base year productivity level for these banks. The base year labour productivity level for Eesti Ühispank is 0.45, but for Eesti Krediidipank and Preatoni Pank it is only 0.09 and 0.08, respectively. Based on results in Table 4, the information suggests that Eesti Ühispank was the best.

The previous discussion shows how easy the construction of productivity ratios and indices can be when a single output is produced. However, in most cases there are a number of outputs. The mix of these outputs can change over time and the amount of input used in delivering each output may differ. In these cases the productivity change can be computed using the Malmquist productivity index.

4.2. Second Case: the Malmquist Index for Estonian Banks

The following case is a short review of the first productivity analysis of Estonian banks using the Malmquist productivity index completed in 2004 (Kirikal, Sõrg, Vensel (2004)). There have also been some empirical studies of banking productivity using the Malmquist productivity index in Europe – banks of the Nordic countries (Berg, Forsund, Jansen (1992), Berg et al. (1993), Bukh, Forsund, Berg (1995), Mlima (1999)); Portuguese banks (Rebelo, Mendes (2000)); Turkish banks (Isik, Hassan (2003)); German banks (Chu-Fen (2004)) – as well as the studies in Estonia (Kirikal, Sõrg, Vensel (2004), Kirikal (2004)).

The exact definition of input and output variables in banking is a disputable issue (Berger and Humphrey 1997). The majority of banking studies can be categorized as users of the intermediation model or of the production model. An intermediation model characterizes banks as financial intermediaries whose function is to collect funds in the form of deposits and other lendable funds and to offer them as loans or other assets that earn income. A production model, on the other hand, treats banks as institutions providing fee based products and services to customers using various resources. Products and services such as loans and deposits are outputs in this model, and the resources consumed such as labour, capital and operating expenses are inputs. The final choice of model depends upon the concept of what banks do, the stated problem and the availability of data.

In the second empirical case, Estonian banks are considered as multi-product organizations that produce three outputs (loans, deposits and other banking services) with two different inputs (employees and offices). The production approach is used and the variables are defined as follows. For the outputs, y_1 are loans (loans to clients, net provisions), y_2 are deposits (deposits from clients) and y_3 are other bank services (commissions received). For the inputs, x_1 is the number of employees and x_2 is the number of offices. The data comes from the published annual balance sheets and income statements for 1999 to 2002. All variables, with the exception of labour and offices, are in millions of Estonian kroons at original prices. The sample includes all six domestic commercial banks operating in Estonia during this period.

Table 5.

The Malmquist index summary of bank means (1999–2002)

Bank	Malmquist Index (M)	Technical Efficiency Change (EFFCH)	Technological Change (TECHCH)
Eesti Krediidipank	**1.371**	**1.146**	**1.196**
Eesti Ühispank	1.161	0.972	**1.195**
Hansapank	1.251	1.000	**1.251**
Sampo Pank	1.071	0.971	1.103
Preatoni Pank	**1.631**	**1.423**	1.146
Tallinna Äripank	1.127	0.972	1.160
Geometric Average	1.256	1.069	1.174

Note: All indices are geometric averages.
Source: Author's calculations.

Table 5 shows productivity scores from different banks, in other words, the evolution of the Malmquist TFP index (*M*), as well as its technical efficiency change (*EFFCH*) and technological change (*TECHCH*) components. The results suggest that Estonian banks experienced an average annual productivity change of 25.6 percent during 1999–2002. These productivity increases are mainly the result of a technological change. An average technological change is 17.4 percent per year, but the average technical efficiency change, while positive, is low at only 6.9 percent per year.

All banks in Estonia show positive productivity growth *(M* > 1) regardless of their size. That is the result of technological progress *(TECHCH > 1).* Sampo Pank, Tallinna Äripank and Eesti Ühispank show lower levels of technical efficiency change and have therefore experienced lower levels of productivity change. Eesti Krediidipank and Preatoni Pank were able to experience the highest productivity change (*M > geometric average M*) and technical efficiency change (*EFFCH > geometric average EFFCH*). These two banks also attained a high labour productivity index in the previous case. Hansapank experienced the best technological change (25.1 percent average annual technological change) for the period of 1999–2002. The newest and smallest bank in Estonia – Preatoni Pank – exhibited the best scores for the two indicators during the period of 1999–2002. This could be partly explained by the fact that the new institution started to rationalize their input usage and therefore became closer to best practice.

In short, it can be conclude that Estonian banks have been able to experience technological progress and the two largest banks – Hansapank and Eesti Ühispank – are quicker at improving their production technologies. Hansapank, Eesti Ühispank and Sampo Pank have obtained fairly different levels of productivity change and by no means represent the highest scores in Estonia. It is important that productivity levels for these banks be ascertained for the base period, therefore as a result it cannot yet be said that a higher productivity change is a sure sign of success.

4.3. Third Case: the Malmquist Indices and Standard Measures of Performance

In the third empirical case the Malmquist indices of productivity change and their components for the intermediation model and for the production model will be researched. Also the correlation between the Malmquist indices of productivity change and the standard measures of performance change used by the banks will be computed. This case is a short survey of the productivity analysis completed by the author in the summer of 2004 (Kirikal 2004).

The intermediation approach is used for Model A, and the production approach is used for Model B. The variables are defined as follows.

Model A: For outputs, y_1 represents loans (loans to clients, net provisions) and y_2 represents other bank services (commissions received plus net profit from financial operations). For inputs, x_1 is the number of employees, x_2 is physical capital (the book value of tangible assets) and x_3 represents deposits (deposits from clients).

Model B: For outputs, y_1 represents loans (loans to clients, net provisions), y_2 represents other bank services (commissions received plus net profit from financial operations) and y_3 represents deposits (deposits from clients). For inputs, x_1 is the number of employees and x_2 is physical capital (the book value of tangible assets).

All variables, with the exception of labour, are corrected to the 1999 price level using the consumer price index. Labour is measured in number of staff. The quarterly data are from the annual balance sheets and income statements from 1999 to 2003. The sample includes all six domestic commercial banks operating in Estonia during this period.

Table 6.

Cumulative Malmquist productivity indices for model A and B (quarterly)

Quarters	Malmquist TFP Index (M)		Technical Efficiency Change (EFFCH)		Technological Change (TECHCH)	
	A	**B**	**A**	**B**	**A**	**B**
Geometric Average from 1999 Q4 to …						
2000 Q2	1.056	1.134	1.016	1.081	1.039	1.049
2000 Q4	1.094	1.189	0.996	1.065	1.099	1.117
2001 Q2	1.048	1.128	1.011	1.054	1.038	1.070
2001 Q4	1.040	1.107	1.008	1.043	1.031	1.062
2002 Q2	1.030	1.100	0.993	1.047	1.037	1.051
2002 Q4	1.036	1.087	0.998	1.033	1.038	1.052
2003 Q2	1.030	1.061	0.998	1.019	1.032	1.042
2003 Q4	**1.032**	**1.064**	**0.997**	**1.025**	**1.035**	**1.037**

Note: All indices are geometric averages.
Source: Author's calculations.

Table 6 summarizes the cumulative geometric average productivity indices, listing the quarterly productivity change results – the Malmquist TFP index (*M*), technical efficiency change (*EFFCH*) and technological change (*TECHCH*). All indices indicate growth during the period 1999–2003 except the technical efficiency change indices for model A where there is a decrease from 1999 to 2003. The results denote that Estonian banks show an average of 3.2 percent quarterly productivity change using the intermediation approach (model A) and 6.4 percent quarterly productivity change using the production approach (model B) in the period 1999-2003. Therefore the average annual productivity growth rate for the intermediation approach is 12.8 percent and for the production approach more than 25 percent. The quarterly average productivity increase is mainly the result of technological progress – 3.5 percent and 3.7 percent for models A and B respectively. The average technical efficiency change is negative for model A (-0.3% per quarter) and only 2.5 percent per quarter for model B. Therefore, there is a noticeable difference in the results of the Malmquist index and its components, where the deposits are inputs or outputs in the model.

The Malmquist TFP indices and the technical efficiency change indices refer to retardation in the changes. The productivity regression during these years is mainly due to the fierce competition in the banking market, especially in the loans market. The stable values for technological change denote that Estonian banks have been able to make technological progress.

Table 7.

Correlation coefficients for the Malmquist indices, their components and standard measures of performance (ROE, NIM, CTI)

	Malmquist TFP Index (M)		Technical Efficiency Change (EFFCH)		Technological Change (TECHCH)	
	Model A	Model B	Model A	Model B	Model A	Model B
ROE	-0.281	-0.180	0.120	0.142	-0.309	**-0.555**
NIM	**0.554**	0.353	-0.093	**0.515**	**0.531**	-0.072
CTI	0.325	0.301	**-0.499**	0.151	**0.515**	0.348

Source: Author's calculations.

Table 7 shows the correlations between the Malmquist TFP indices (*M*) and three standard measures of performance indices: *Return on Shareholders' Equity* (ROE, defined as net income after taxes divided by shareholders' equity), *Net Interest Margin* (NIM, defined as net interest income divided by total assets) and *Cost to Income ratio* (CTI, defined as total expenses divided by total income). The first step was to calculate the ROE, NIM and CTI ratios for the banks for the entire period, and the second step was to conduct the correlation test with the Malmquist indices and their components.

The strongest inversely proportional correlation (-0.555) appeared between ROE and the technological change components for model B. The Malmquist index and its component part, TECHCH, also showed a remarkable correlation with value NIM for model A. Correlation with the ROE variables was weak. Therefore, in conclusion it could be said that the correlation is weak between the Malmquist indices and the standard measures of performance indices. This means that all the calculated ratios and indices characterise Estonian banking from different aspects and the Malmquist productivity index provides information that complements the traditional performance measures. The Malmquist index components made it possible to examine the causes of productivity change. Therefore, it is possible to see whether the banks have improved their productivity through a more efficient use of existing technology or through technological progress.

5. Conclusion and Ideas for Future Research

Special banks' analyses are interesting from the viewpoint of different audiences: owners, regulators, customers and management. The performance of the financial institution is crucial for the well being of the whole economy, and it has attracted the attention of many researchers. The experts have identified objectives that a company should strive to follow. One of several appointed goals was productivity. Therefore, the main objective of this study was to provide a review of productivity, introduce productivity ratios and to present some empirical cases involving Estonian banks.

Changes in productivity are of great importance at all levels – national, industrial, company and personal (Kendrick 1993). The ever popular "Come in early, stay late and work through lunch" is the old-school instruction for increasing productivity. Today there are several books that provide a methodology for the successful application of productivity management and increasing productivity. In an effort to achieve productivity goals, it is important to remember that people are the key to any productivity increase.

The construction of productivity ratios and indices may be easy when a single output is produced using a single input. However, in most cases there are a number of outputs and inputs and productivity can only be estimated as a ratio of aggregate output to the sum of inputs. The classical productivity ratios are partial productivity (PP), total factor (labour plus capital) productivity (TFP) and total productivity (TP). Since the mix of outputs can change over time and the amount of input may differ, the classical productivity models are not the best for performance analysis. In these cases, productivity change can be computed using a newer method to measure productivity change – the Malmquist productivity change index.

The last part of the current study has included three cases of productivity analysis. These analyses have measured productivity change in each of the six Estonian domestic commercial banks over the period 1999–2003. The classical productivity measure was used in the first case and the Malmquist TFP productivity index in the other cases.

The first case shows that when analysing the productivity index it is also important to know the productivity level in the base year. Based on labour productivity levels and indices, it can be said that Eesti Ühispank performed the best for the period 1999–2003. The main objective of the second case was to introduce productivity change in the Estonian banking industry using the Malmquist productivity index, and present the results of the first productivity analysis of Estonian banks using the Malmquist index, which was completed by the author in the spring of 2004. The results suggest that Estonian banks experienced an average of 25.6 percent annual productivity change in the period 1999–2002, when the production approach was used. Therefore, all Estonian banks have increased productivity mainly due to technological progress. In the third case correlations were calculated between the Malmquist TFP indices and three standard measures of performance indices, *Return on Shareholders' Equity* (ROE), *Net Interest Margin* (NIM) and *Cost to Income ratio* (CTI), for six Estonian banks. Since there was only a weak correlation between the Malmquist indices and the standard measures of performance indices, it can be said that each of the calculated ratios and indices characterise different aspects of Estonian banking. In short, the author can conclude that productivity increases in Estonian banking are based directly on investments, where investments in technology and people are clearly the most essential factor.

Hopefully the results presented in this paper will provide a useful basis for future research in the field of productivity, efficiency, the financial market and banking. The goal of future work is to more thoroughly research the relationship between the Malmquist productivity index, standard measures of performance and management decisions.

Abstract

Productivity, the Malmquist Index and the Empirical Study of Banks in Estonia

The present thesis consists of six chapters and three essays. The thesis investigates the productivity change of the Estonian banking industry during 1999-2003. This study was motivated due to the banking sector's importance to the whole economy, and from the need to research productivity change of banks after the rapid development of the Estonian banking industry since1992. The main contribution of this thesis is to provide relevant and useful information of productivity change differences in Estonian banking. All three essays include the application of the Malmquist productivity index on a cross section dataset of banks in Estonia. The analyses in the current thesis are the first productivity analyses of Estonian banks using the Malmquist productivity index.

The present thesis has four goals contributing towards productivity analysis and the examination of banks' productivity.

- The first goal is to analyse the productivity change of banks in Estonia using the Malmquist productivity index.
- Secondly to research the causes of productivity change using the Malmquist productivity index components.
- The third goal of the present thesis is the comparison of the Malmquist productivity index with the standard measures of performance used by banks.
- The fourth goal is to analyse the partial productivity of banks in Estonia.

The first essay (Kirikal, Sõrg, Vensel 2004) addresses the productivity change of banks in Estonia by applying the Malmquist productivity index. The data used in this study covers the period from 1999 to 2002. One purpose of this research is to present the Malmquist productivity index, which is first such usage for productivity analysis of Estonian banks. The present study shows that Estonian banks experienced an average of 25.6 percent annual productivity growth rate during 1999-2002, which was the result of technological progress. Generally, all Estonian banks had increased productivity as a result of technological progress during this period. Also some historical notes on the development of the Estonian banking system and the capital structure of banks are presented in this essay. Different versions of financial ratio analysis are used for the bank performance analysis using financial statement items as initial data sources. The usage of a modified version of DuPont financial ratio analysis is also discussed in the first essay and empirical results of performance analysis of the Estonian commercial banking system are presented (1994-2002).

In the second essay productivity change in Estonian banking is estimated using the Malmquist productivity index and received results are compared with standard measures of performance used by banks. The data used in this study

covers the period from 1999 to 2003, during which there was a steady development of financial institutions and stabilization in the Estonian banking market. The present study shows that Estonian banks experienced an average of more than 25 percent annual productivity growth rate (production approach) during 1999-2003 due to technical progress. The description of productivity change using the Malmquist indexes and standard measures of performance (Return on Shareholders' Equity, Net Interest Margin, Cost to Income ratio) is remarkably different, as shown by the correlation analysis between these values.

The third essay is initiated from the need to describe the classical productivity measures (such as partial productivity) next to the Malmquist productivity index and to provide a short review of the importance of productivity. In this essay the partial productivity (labour productivity) level and index are calculated on data from banks in Estonia. Based on labour productivity levels and indices, it can be said that Eesti Ühispank performed the best for the period 1999–2003. The classical productivity change indexes and the Malmquist productivity change index characterise productivity change of banks from a different viewpoint and therefore, all these indexes are important for performance analysis of banks in Estonia. The importance of productivity in management is also considered in the third essay.

Kokkuvõte

Tootlikkus ja Malmquisti indeks Eesti pankade näitel

Käesolev doktoriväitekiri koosneb kuuest peatükist ja kolmest esseest. Töös uuritakse tootlikkuse muutust Eesti panganduses aastatel 1999-2003. Uurimisteema valiku peamiseks ajendiks oli pangandussektori kui kogu majanduse seisukohalt tähtsa sektori uurimise olulisus ja vajadus leida tootlikkuse muutus pankades peale Eesti panganduse kiiret arengut aastast 1992. Doktoritöö peamine eesmärk on anda asjakohast ja kasulikku informatsiooni tootlikkuse muutusest Eesti pankades. Kõigis kolmes essees on kasutatud Eesti pankade tootlikkuse muutuse mõõtmiseks Malmquisti indeksit. Käesolevas töös esitatud Eesti pankade tootlikkuse muutuse analüüsid on esimesed, kus analüüsimiseks on kasutatud Malmquisti indeksit.

Doktoritöö panus tootlikkuse analüüsi ja pankade tootlikkuse uurimisse on esitatud alljärgnevalt nelja eesmärgina:

- Esimene eesmärk on analüüsida Eesti pankade tootlikkuse muutust kasutades Malmquisti indeksit.
- Teiseks eesmärgiks on Malmquisti indeksi komponentide analüüsimisega uurida tootlikkuse muutuse põhjuseid Eesti pankades.
- Kolmandaks eesmärgiks on Malmquisti indeksi ja igapäevaselt pankade tegevuse analüüsimiseks kasutatavate hinnangute omavaheline võrdlemine.
- Töö neljandaks eesmärgiks on analüüsida Eesti pankade osatootlikkust.

Esimeses essees (Kirikal, Sõrg, Vensel 2004) kasutatakse Eesti pankade tootlikkuse muutuse uurimisel Malmquisti tootlikkuse muutuse indeksit. Töö empiirilises osas on kasutatud Eesti pankade andmeid aastate 1999-2002 kohta. Uurimuse uudsuseks on asjaolu, et esmakordselt on Eesti pankade tootlikkuse muutuse analüüsimiseks kasutatud Malmquisti indeksit. Läbiviidud analüüs näitab, et Eesti kommertspankade keskmine aastane tootlikkuse muutus perioodil 1999 kuni 2002 oli 25,6 protsenti, mis on põhjustatud peamiselt tehnoloogilisest progressist. Kokkuvõtlikult võib öelda, et vaadeldaval perioodil kogesid kõik Eesti kommertspangad tehnoloogilise arendustegevuse tulemusena tootlikkuse tõusu. Esimeses essees on ka ülevaade olulisematest ajaloolistest momentidest Eesti panganduse arengus, uuritud pankade kapitali struktuuri ja analüüsitud teisendatud DuPonti finantssuhtarvude meetodiga Eesti kommertspankade tegevust perioodil 1994 kuni 2002.

Teises essees on Eesti pankade tootlikkuse muutus leitud Malmquisti indeksiga ja saadud tulemusi võrreldakse igapäevaselt pankade tegevuse analüüsimiseks kasutatavate hinnangutega. Töö empiirilises osas kasutatud andmed on aastatest 1999-2003. Vaadeldavat perioodi võib nimetada stabiliseerumise perioodiks Eesti panganduse arengus. Uurimus näitab, et Eesti kommertspankade keskmine tootlikkuse muutus on tootmiskesksel lähenemisel (*production approach*) enam kui 25 protsenti aastas ning põhjustatud innovatiivsete, uuel tehnoloogial põhinevate toodete ja teenuste kasutuselevõtust. Korrelatsioonianalüüs kinnitab, et Eesti pankade tootlikkuse muutuse leidmine Malmquisti indeksiga ja igapäevaselt pankade tegevuse analüüsimiseks kasutatavate hinnangutega (omakapitali tulukus, puhas intressimarginaal, kulu-tulu suhe) annavad tootlikkuse muutuse kohta Eesti kommertspankades märkimisväärselt erinevad tulemused.

Kolmanda essee eesmärgiks on tutvustada Malmquisti tootlikkuse muutuse indeksi kõrval ka klassikalisi tootlikkuse hinnanguid (näiteks osatootlikkus), anda ülevaade tootlikkuse olulisusest nii globaalsel kui ka isiklikul tasasandil ja rõhutada tootlikkuse olulisust juhtimise seisukohalt. Osatootlikkuse (tööjõu tootlikkus) analüüs essee empiirilises osas näitas, et perioodil 1999-2003 saavutas Eesti pankadest kõrgeima osatootlikkuse taseme Eesti Ühispank. Tulemustest lähtuvalt võib öelda, et klassikalised tootlikkuse muutuse indeksid ja Malmquisti tootlikkuse muutuse indeks iseloomustavad pankade tootlikkuse muutust erinevatest vaatenurkadest ning seega on Eesti pankade tegevuse analüüsimise seisukohast olulised kõik leitud suurused.

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