# ECONOMETRIC MODELS OF ESTONIAN BANKING

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**Abstract**

*Econometric models have not been widely used for thorough analysis of the statistics published by Estonian banks. So far no one except the present authors has made an attempt to use models to prognosticate the amount of total income during the following period(s).*

*The article presents the results of analyses made by the authors during the last five years. These results have been published in a number of collections of research articles and have been reported on international conferences worldwide (in Mexico, South Africa, Egypt, Poland, Check Republic, Chile, China, USA, etc.).*

*From econometric models the Cobb-Douglas production function with income-earning assets, equity, liabilities and fixed assets as inputs was selected. The time period chosen is from the first quarter of 1996 to the third quarter of 2007, that is a total of 51 periods. The secondary condition set was that the sum o f the elasticity multipliers α and β should equal 1.*

*The balance sheets and income statements published quarterly by the banks were used as the empirical base of analysis.*

*Keywords: banking, econometric models, production function.*

## Introduction: Theoretical Background and Overview of Related Literature

The history of econometric models is rich and varied. In the 1960s researchers were hypnotically fascinated by the opportunities offered by the introduction of econometric models. However, this history has suffered also less brilliant days: when in numerous countries the actual level of inflation surpassed the level prognosticated economists began to doubt the usefulness of applying econometric models. It was found that the time span over which interrelationships between economic indicators are stable is not long enough and

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therefore these indicators cannot be used for economic forecasts (Greespan, 2001). It was found that the forecasts made with the help of such models need continuous tuning and are therefore too expensive. (Gaida et al., 1998). Still, over time econometric models have been improved and are again widely used in making economic forecasts.

Economy as a whole functions like a joint organism for which banking is a very important, even vital part. No wonder that in this vital part of economy econometric models have found quite wide application. For example, in 2001 analysts of the World Bank used an econometric model to analyse the influence of deposit insurance on the development of the financial sectors of nations (Cullet al., 2001). In numerous banks economic indicators have been analysed with the help of econometric models in order to prognosticate the activities of the bank in the future. It was as early as in 1975 that the Federal Reserve Bank of Minneapolis used an econometric model to assess economic activity in the United States. In that model the total output of the economy was selected as the input variable and different components of the federal budget, indicators of employment and some other indices were used as independent variables (Supel, 1975). The latest example of the use of an econometric model in banking analysis could be the model constructed under the guidance of Timothy J. Richards, which treats the competitiveness of banks located in small towns and in rural places in the United States depending on the distances between the banks (Richards et al., 2007). The award of the 2003 Nobel Prize in Economics to Robert Engle crowned econometrics as a successful branch of economics. The Prize was awarded to Engle for research into methods of analysing economic time series with time-varying volatility (ARCH) and the application of ARCH in the evaluation of banking risks and pricing options (Engle, 2003).

In addition to US economists, econometric models have been applied for analysing banking also by researchers from Russia (Zamkova, 2002; Kraminski, 2003), Ukraine (Azarenkova, 2004), Finland (Pesola, 2005), India (Sathye, 2005), Nigeria (Balogun, 2007) and several other countries. All they set different goals and they used different models; however, the ultimate aim was analogous: prognostication of future conditions on the basis of data collected.

An econometric model used for analysis by the Central Bank of Ireland (McQuinn et al., 2005) was of special interest for the present authors. The reason was that this model was based on the Cobb-Douglas production function. We had not seen earlier the use of the production function as the basis of an econometric model. The model used in Ireland is significantly larger as compared to our model. The aim of the study is to compile such a quarterly model for each country in the EU system so that it would be possible to analyse shocks and simulations in the Eurozone. The model includes 96 variables and 89 equations have been constructed. Without going into detail, we can say that this model has been regarded as suitable for making simulations because it responds to various types of shocks and yields credible results. Thus it was concluded that the model is a suitable tool for analysing economic policies and for macroeconomic prognostications. The time period chosen for the model was 1980–1999.

This stimulated us to continue with our model although the preliminary results had not been especially encouraging.

We made our first attempts at analysing the statistics published by the Bank of Estonia with the help of econometric models already in 2003. By that time the balance sheets and income statements published by the Estonian banks formed already a sufficiently large database so that application of econometric models could be expected to give some results.

Our first task was to select the type of econometric model. As is known, a very large number of different econometric models have been used for analysis in the world and thus the first thing is to select the most suitable of them.

The authors decided to select the Cobb-Douglas production function. We set two additional conditions. The sum of elasticity coefficients $\alpha$ and $\beta$ had to equal 1 and the values of the elasticity coefficients had to be between 0 and 1. Having solved the first problem, we had to address the next one: what should we choose as variables? For the input variable we selected the total income of banks, as this is the indicator that is of greatest interest for customer groups connected with the bank. Indeed, the total income of a bank (or actually its size) is of interest in addition to the bank's own employees also to shareholders, investors, creditors and borrowers. However, it should be mentioned here that these customer groups do not constitute a very large proportion of a bank's customers because it is the depositors who make up the largest group of bank customers. Their deposits, however, are safeguarded by a relevant law valid since 1998 (RT 1998, 40,612).

Selection of independent variables required more consideration. Theoretically, these could be very different indicators. Finally, we selected four indicators: income-earning assets ( x1), equity (x2), liabilities (x3) and fixed assets (x4).

In 2003 it was possible to construct a time series of data available for public use that included information on 30 quarters (1st quarter 1995 to 2nd quarter 2002). The first tests of the suitability of the model were made using the time series of that length. Each year has added four points to the series, and by the time of writing the present paper it included already 52 points (1st quarter 1995 to 4th quarter 2007).

As a production function can simultaneously include only two independent variables, then by using the four selected variables in pairs, six different combinations can be formed. In the further processing we included only the combinations that met the preconditions that $\alpha + \beta = 1$ and that $\alpha$ and β > 0. All these suitable combinations with their coefficients of elasticity are presented in Table 1.

**Table 1. Coefficients of elasticity meeting the precondition set**

| Length of time series (points) | Elasticity coefficients | Income earning assets and equity (x1x2) | Income earning assets and liabilities (x1x3) | Income earning assets and fixed assets (x1x4) | Equity and liabilities (x2x3) | Equity and fixed assets | Liabilities and fixed assets |
|---|---|---|---|---|---|---|---|
| 30 | α | | **0,5414** | | | | |
| | β | | **0,4586** | | | | |
| 31 | α | **0,921** | | | | | |
| | β | **0,079** | | | | | |
| 32 | α | | | | | | **0,1675** |
| | β | | | | | | **0,8325** |
| 33 | α | 0,4023 | | 0,0787 | 0,4067 | | **0,1334** |
| | β | 0,5977 | | 0,9213 | 0,5933 | | **0,8666** |
| 34 | α | 0,5275 | | 0,0487 | 0,3837 | | **0,1093** |
| | β | 0,4725 | | 0,9513 | 0,6163 | | **0,8907** |
| 35 | α | | | | 0,8447 | | **0,0782** |
| | β | | | | 0,1553 | | **0,9218** |
| 36 | α | 0,8589 | | | 0,8458 | | **0,0739** |
| | β | 0,1411 | | | 0,1542 | | **0,9261** |
| 37 | α | | | | 0,8386 | | **0,0854** |
| | β | | | | 0,1614 | | **0,9146** |
| 38 | α | 0,9417 | | 0,332 | 0,1045 | | **0,3528** |
| | β | 0,0583 | | 0,668 | 0,8955 | | **0,6472** |
| 39 | α | 0,9861 | | 0,5922 | 0,0223 | 0,0605 | **0,5984** |
| | β | 0,0139 | | 0,4078 | 0,9777 | 0,9395 | **0,4016** |
| 40 | α | 0,6832 | | 0,3350 | 0,8076 | 0,1072 | **0,3404** |
| | β | 0,3168 | | 0,6650 | 0,1924 | 0,8928 | **0,6596** |
| 41 | α | 0,5263 | | 0,8019 | 0,6011 | **0,7375** | 0,5849 |
| | β | 0,4737 | | 0,1981 | 0,3989 | **0,2625** | 0,4151 |
| 42 | α | 0,1953 | | | **0,8519** | | 0,9422 |
| | β | 0,8047 | | | **0,1481** | | 0,0578 |
| 43 | α | **0,4379** | | | 0,7998 | | |
| | β | **0,5621** | | | 0,2002 | | |
| 44 | α | 0,1192 | | | 0,4401 | | 0,9545 |
| | β | 0,8808 | | | 0,5599 | | 0,0455 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 45 | α<br>β | **0,91**<br>**0,09** | | | | 0,8269<br>0,1731 | |
| 46 | α<br>β | **0,1501**<br>**0,8499** | | | | | 0,9591<br>0,0409 |
| 47 | α<br>β | | | 0,9212<br>0,0788 | | | **0,7835**<br>**0,2165** |
| 48 | α<br>β | **0,8965**<br>**0,1035** | | | 0,0324<br>0,9676 | 0,4116<br>0,5884 | 0,9392<br>0,0608 |
| 49 | α<br>β | | | 0,8742<br>0,1258 | | | **0,8988**<br>**0,1012** |
| 50 | α<br>β | | | | | | **0,823**<br>**0,177** |
| 51 | α<br>β | **0,0597**<br>**0,9403** | | | | | |
| 52 | α<br>β | | | **0,6909**<br>**0,3091** | 0,0623<br>0,9377 | 0,4656<br>0,5344 | 0,6881<br>0,3119 |

Source: Authors calculations

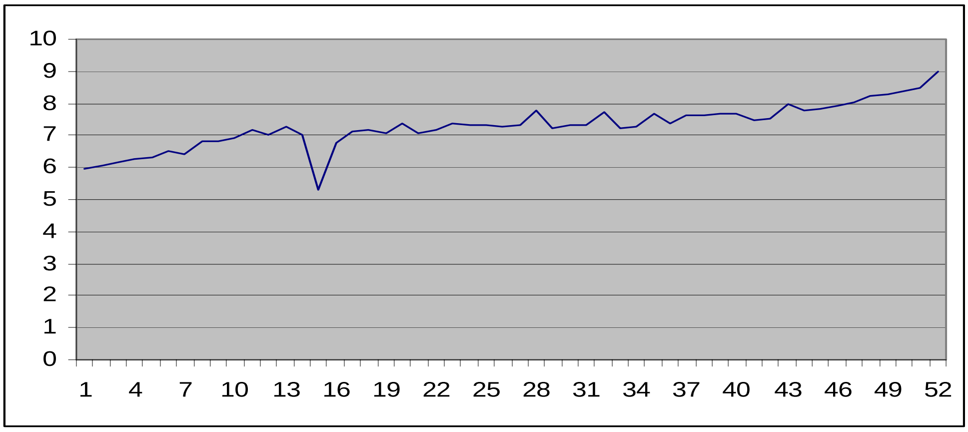
It is possible to get quite a lot of information from this table:

The column where the pair of independent variables consists of income-earning assets and liabilities is quite empty. This is caused by the fact that after the calculation of the random component of the time series we checked correlations between different indicators and we always found multicolinearity between the indicators ‘income-earning assets’ and ‘liabilities’. Therefore this pair was excluded from analysis.

In each row one pair of the coefficients of elasticity is written in boldface. This designates the pair for which the coefficient of elasticity r is the largest, and consequently the model constructed on the basis of this pair is the most suitable and trustworthy.

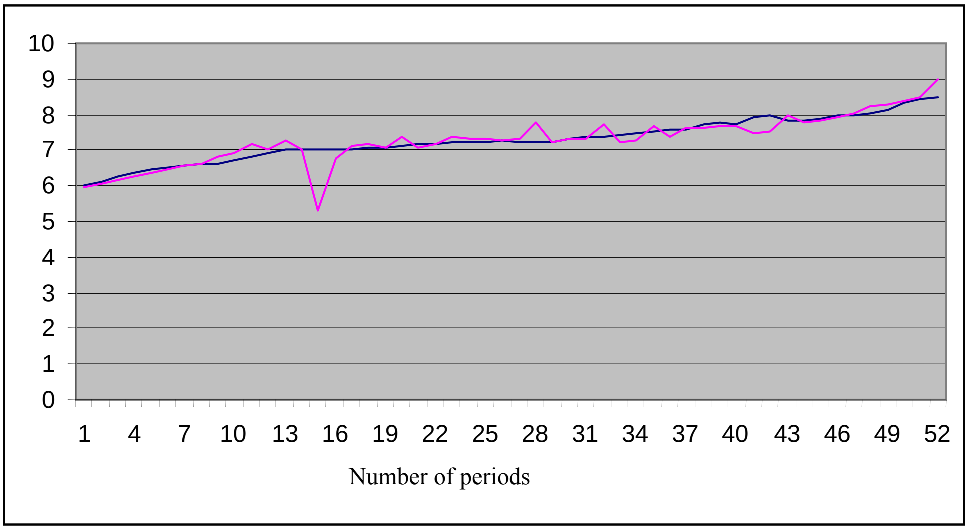
Figure 1 shows the dynamics of the total income of Estonian banks from the 1st quarter of 1995 to the end of 2007. The time series includes a total of 52 points.

Figure 1. Dynamics of the total income of Estonian banks, 1995–2007 (52 points, semilogarithmic scale)




The production function calculated for this period gave four suitable pairs of indicators meeting the preconditions (see Table 1). The most suitable among them was the pair 'income-earning assets' and 'fixed assets' (see Figure 2).

Figure 2. Total income of Estonian banks and the suitability of the graphs constructed on the basis of the pair of indicators 'income-earning assets' and 'fixed assets' (semilogarithmic scale)



The model constructed on the basis of this pair of indicators

$Lny = -2{,}517 - 0{,}0071t + 0{,}0945\cos\alpha + 0{,}0021\sin\alpha + 0{,}0083\cos2\alpha + 0{,}0442\sin2\alpha + 0{,}0155\cos3\alpha + 0{,}0812\sin3\alpha + 0{,}6909\ln x_1 + 0{,}3091\ln x_4$ has the coefficient of elasticity r = 0,89112. The other pairs of indicators meeting the preconditions have a smaller coefficient of elasticity and thus also their suitability is lower.

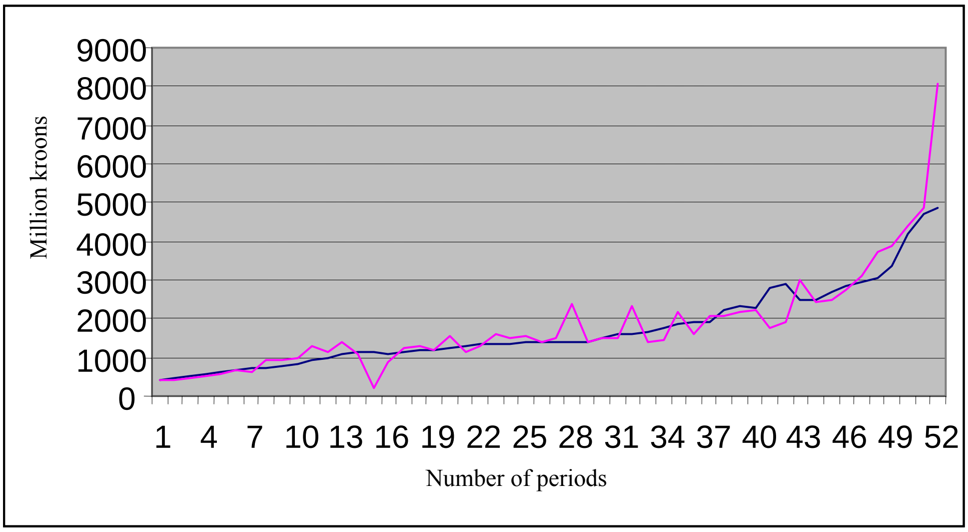
It can be deducted from the model that if income-earning assets increase by 1%, the total income will increase by 0,6909% and if the fixed assets increase by 1%, the total income will increase by 0,3091%.

Table 1 suggests that the combination of the indicators ‘liabilities’ and ‘fixed assets’ was most often the best one. With certain reservation, this can be regarded as a logical outcome. Liabilities form the base of earning an income by a bank and fixed assets create conditions for earning this income.

As the two graphs in Figure 2 are quite close, we can conclude that the methodology used – application of the production function to prognosticate the future – seems to be promising. However, for this the time series should become still longer because the correlation coefficients calculated already for the time series of all different lengths show a tendency towards increasing, which refers to increasing credibility of the model with lengthening time series.

In Figure 3 the data analysed are presented as real data.

Figure 3. Total income of Estonian banks and suitability of the graph of the model constructed on the basis of the pair of indicators ‘income-earning assets’ and ‘fixed assets (real data)



Also this figure proves close agreement of real data and the model constructed with the help of the production function.

## Conclusions

1. The Cobb-Douglas production function is a suitable modelling tool for revealing relationships between different indicators of banking.
2. The suitability of the production function increases with increasing length of the time series.
3. The production function may prove to be a suitable basis for modelling with the aim of forecasting future values of banking indicators.

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