THE NEW BANKING ERA

THE EFFECTS OF THE DIGITALIZATION ON THE EFFICIENCY OF SWEDISH BANKS

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Abstract:

In this thesis, the impact on the efficiency from the digitization of Swedish banks is investigated. Using two separate models, first the impact of digital development on the relative efficiency of the banks in the sample is evaluated. A set of input variables and output variables are used to measure the relative efficiency. Then the impact of digitization on the absolute efficiency is analyzed. The following variables related to digitization are included in the regression analysis: number of branches, number of employees, total assets, and dummy variables for the level of digitization. The results from the DEA model show that banks that have employed a digital strategy, and/or appointed a Chief Digital Officer or equivalent, are more efficient relative to other banks in the sample. The regression model results imply that digitization has a positive impact on the efficiency of Swedish banks. The conclusion is that the effects of the digitalization is positive on the efficiency of Swedish banks.

Keywords:

Absolute efficiency, Bank, Data Envelopment Analysis, DEA, Digitalization, Regression, Relative efficiency

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1. Introduction

Over the last couple of years, the digitalization has affected multiple industries. The nature of banking is changing, which makes it interesting to evaluate the efficiency of banks considering the effects of digitalization. We aim to investigate the efficiency of Swedish banks for the years 2005-2017.

In this thesis, we first apply the non-parametric frontier model *Data Envelopment Analysis* (DEA) to compute relative efficiency scores of Swedish banking corporations. We employ two input variables and four output variables in our DEA model, to determine the *relative efficiency* of each observation for the banks in the sample.

We then employ five explanatory variables to our model and perform a regression analysis, in order to explain differences in the *absolute efficiency* of the observations in the sample. Based on the results from these two analyzes, we evaluate the impact of digitization on the banking efficiency.

The models are separate, and should therefore not be confused. The first model calculates a relative efficiency score, called DEA score. The second model runs a regression to determine the impact of different independent variables on the absolute efficiency of each observation.

The DEA model requires the determination of what is considered input, and what is output, in the banking business model. Used as inputs are in this case the expenses: *interest expenses* and *non-interest expenses*. The resulting outputs are *loans*, *deposits*, *interest income*, and *non-interest income*. We analyze the DEA score using dummy variables that indicate digital transformation; a *digitalization dummy* and a *Chief Digital Officer (CDO) dummy*.

To determine the impact of different independent variables on the efficiency of the banks in the sample, we employ explanatory variables related to digitization. These are: *number of employees*, *number of branches*, *total assets*, and the same dummy variables as in the DEA model analysis.

Number of employees is expected to be negatively related to digitization. A more digitized business is expected to result in fewer employees, and thus having more digitized operations should result in a higher efficiency, because of a decreased employee cost. Hence, number of employees is expected to have a negative coefficient for the efficiency.

The rationale for including the number of branches is the same as for the number of employees. The more digital the bank, the fewer branches it is expected to have, as a larger share of the operations is conducted digitally. Fewer branches should result in cost savings, and hence, all else equal, number of branches is expected to have a negative coefficient for the efficiency.

The dummy variables are included to reflect the digital engagement of different banks in the sample. A dummy variable value of 1 indicates that the bank has a clearly defined digital strategy, and an appointed CDO or equivalent, respectively. Both dummy variables are expected to have a positive coefficient for the efficiency, as we expect digitization to enhance the efficiency of banks, through cost savings and similar.

Total assets for each observation is also included in our regression model as a proxy for firm size. We also include a time fixed effect, as well as a company fixed effect. This is in order for us to control for the impact of fixed effects in our model.

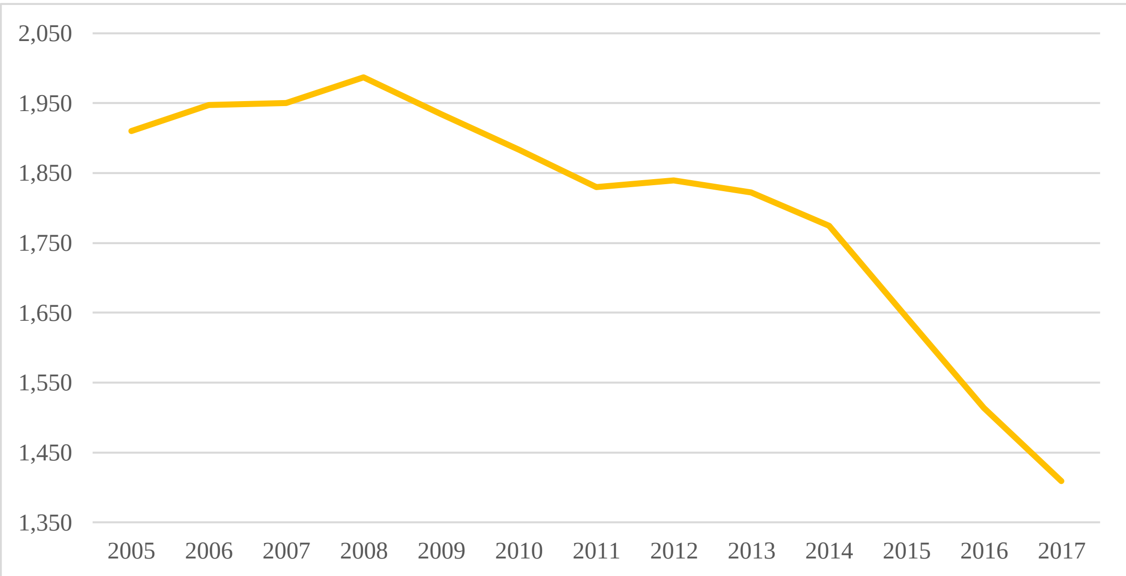
2. Background

2.1. Banking in Sweden

The financial sector in Sweden has three primary tasks to fulfill: transform savings into investments, provide efficient payment options, and manage risk. This task is shared among the banks, credit institutions, and insurance companies, among others. These companies contribute to both growth and employment. In 2017, 4.1 percent of the Swedish GDP was derived from the financial sector. 90,000 people were employed in the sector, which is equal to two percent of the total labor force in Sweden. In 2018, the combined total assets for the banking corporations, foreign banks' branches in Sweden, and savings banks, amounted to 9,272 billion SEK. Furthermore, eleven percent of the government income from corporate tax was derived from the financial sector. Other important actors in the market are hedge funds, venture capitals, fintech companies, and pension funds (Swedish Bankers, 2017).

In our thesis, we will focus on Swedish banking corporations, and thus our study excludes the other actors in the market. This is because we limit the scope to include banks that face the same market conditions, employing similar inputs to produce similar outputs.

Graph 1. Number of branches in Sweden



There is currently a great pressure on firms in the financial sector to develop and adapt to new conditions, coming from new companies, both in Sweden and abroad. As shown in graph 1, the number of branches in Sweden has declined steadily over the last decade. This indicates the decreasing need for traditional services from the banks, as the services are instead conducted using the banks' digital channels.

Also, the changing logistics of payments and online banking has contributed to the development of new services being provided from both banks and other types of companies (Swedish Bankers, 2017).

In 2017, 119 banks divided into four categories – banking corporations, foreign banks, savings banks, and member banks – were operating in Sweden. The number of Swedish banking corporations increased by 54 percent between 2005 and 2017, mainly as a result of Swedish credit market companies transforming into banking corporations. The decreasing number of savings banks is mostly a result of their consolidation and transformation into banking corporations (Swedish Bankers, 2017).

Table 1. Categories and number of banks in Sweden

	2005 (Dec)	2017 (Dec)
Swedish banking corporations	26	40
Foreign banking corporations	4	1
Foreign bank branches	24	29
Savings banks	71	47
Member banks	2	2
Total	127	119

Source: Swedish Bankers

The Swedish banking market is dominated by four large banks, that have a joint market share of above 70 percent.[1] Three out of these four banks have, since the beginning of 2010, continuously been losing market share on the credit market. The concentration on the market is considered as normal compared to similar countries, and is hence not showing signs of insufficient competition. In an international perspective, 61 percent of the Swedish population indicated that they were happy with their bank, compared to 57 percent in comparable countries (Copenhagen Economics, 2018).

Copenhagen Economics has measured the competition and efficiency among the banks in Sweden. One measurement presented is the cost efficiency in Sweden, which seems to be high. There is no sign of low competition that could enable inefficient banks to operate in the market. The operating costs are among the lowest in Europe, and there is evidence that these low operating costs are reflected on the price that the customers pay. Furthermore, the lending margins are among the lowest in Europe. The interest margin is correlated with the low cost, thus driven by the operating costs. This is what to expect when the competition is healthy (Copenhagen Economics, 2018).

Low mobility among customers can be a sign of either low competition and/or satisfied customers. Between the years 2010-2012, four percent of the population switched banks, a number in parity with other countries in Europe. On the other hand, ten percent were switching bank during the years 2014-2016 (Copenhagen Economics, 2018). Low

[1] Nordea, SEB, Svenska Handelsbanken and Swedbank

switching costs in Sweden, where the customer usually does not pay any fees to open or close accounts, could be a factor that enables this development to continue.

Our belief is that this can be considered a sign of the large banks not fulfilling all the modern needs of the Swedish banking customers. The banking industry is built upon trust and as shown by the switch, the challengers are earning this to a larger extent.

2.2. Digitalization

Today, digitization of organizations is one of the most prominent trends in the global economy. One explanation is the belief that digitization will result in higher organizational performance, as well as a stronger competitive advantage. Various industries prove that investments in digitalization have positive effects, as digital leaders outperform their peers (Kotarba, 2017).

Already in 2015, Deloitte published an article in which they state that the difficulty for banks is to understand the digital impact on their business, what should be the drivers for transformation, and how to adapt to the digitalization. A required development in line with the digitalization is the creation of new functions and roles. Appointing a *Chief Digital Officer* (CDO) and *Chief Innovation Officer* (CInO) could be beneficial for implementing new operating models (Deloitte, 2015).

Measuring the level of digitization is complex and prone to subjectivity. Our aim is to measure the digital engagement of banks through tangible variables that are equally measurable for all banks in the sample. We use several proxies for the level of digitization of the banks, including number of branches, number of employees, and total assets. We also employ two dummy variables that indicate the digital engagement of the banks: *digital dummy* and *CDO dummy*.

2.3. Research Question

The Swedish financial industry is, and historically has been, well ahead in the technical development, being ranked number four in the "Digital Banking Readiness Index" worldwide already in 2013 (A.T. Kearney, 2013). However, few studies have been made on the effects of the digitalization on Swedish banks. By employing a DEA model, we can determine the relative efficiency score of the observations in the sample. This is later analyzed to evaluate the impact of digitization. In our regression model, we include factors related to digitization, in order to evaluate their effect on the absolute efficiency of the banks in the sample.

In this thesis, we aim to answer the following research question:

Does digitization have an impact on the efficiency of Swedish banking corporations?

To answer the research question, we employ two different methodologies to evaluate the efficiency of banks, considering the impact of digitization. The first model assesses the *relative efficiency* of the banks, while the second model considers the *absolute efficiency* of each bank. Thus, the sub questions to the research question can be formulated as follows:

1. *Does adaption to the digitalization have an impact on the relative efficiency of the banks in Sweden?*
2. *Does the digitization of the banks in Sweden have an impact on their absolute efficiency?*

As previous literature has not considered the impact of digitization on the efficiency of Swedish banks using these methods, we hope to contribute to this field of study, and provide insight into how the adaption to the digitalization might affect the efficiency of banking.

2.4. Limitations

Our data is limited to covering only Swedish banking corporations. Because our research question concerns banks in Sweden, the data is thus adequate for our study. However, the results may not be applicable to other countries, because the banking sector and business of banks might differ substantially. Also, this industry is constantly changing due to digitalization, business cycles, and regulations.

The entire sample consists of companies operating in the same market, and that are thus affected quite similarly by macroeconomic elements and regulations. Therefore, we have chosen not to focus on such externalities in this thesis. Neither governmental rates nor inflation is studied, following our assumption that these are affecting the banks in a similar way.

3. Data and Variables

In this section, the data and variables used are presented. The data is collected from the branch organization Swedish Bankers, as well as the banks' annual reports. The data sample consists of Swedish banking corporations over the period 2005-2017.

In order to obtain a fair and reasonable data set to use in the analysis, the data was cleaned according to the following three steps: From the complete set of data, only Swedish banking corporations were included, thus excluding other categories of banks. In the second step, the observations for which annual reports were missing were excluded, e.g. for banks that have ceased to exist or that have been acquired by other corporations. Lastly, banks with no reported data in the statistics from Swedish Bankers were removed. The complete sample consists of 1,546 observations, and the number of observations in the final sample amount to 814. After the last step, 310 observations from 40 different banks remain. A more detailed presentation of the sample cleaning can be found in appendix 1. The full list of bank observations included is found in appendix 2.

3.1. Sources

The analysis in this report is essentially built on harmonized data from the branch organization Swedish Bankers, as well as data gathered from the company-specific annual reports over the period 2005-2017. The sources used are further described below.

3.1.1. Swedish Bankers' Association

Swedish Bankers is a branch organization for banks and foreign branches operating in Sweden. Their mission is to act as an association that represents the banks towards authorities and organizations, both in Sweden, and internationally. Every year, Swedish Bankers publish financial statistics and reports about the banks. From them, we have acquired data for the variables: number of branches, number of employees, loans, deposits, and total assets.

3.1.2. Annual Reports and Webpage

To construct the data set, official numbers from the companies for the specified years were used. Their annual reports were used to gather data for the following variables: interest expense, non-interest expense, interest income, and non-interest income. The dummy variables, digital dummy and CDO dummy, were also determined using information from the annual reports. To determine the value of the CDO dummy, other sources were also used, such as press releases and similar announcements.

3.1.3. The Swedish Riksbank's Exchange Rate

In order to convert financial statements in other currencies into SEK, the Swedish Riksbank's yearly average exchange rates for the declaration were used. The exchange rate used when converting to SEK was taken from each year. See appendix 3 for exact rates for each year.

3.2. Definitions

To determine and define the variables used in our analysis, we initially define the objectives of a bank, as well as specify its input and output. There is disagreement about what a bank produces and what constitutes banking output, as well as how to measure the output (Grigorian and Manole, 2002).

Several approaches have been developed to define the input-output relationship in financial institution behavior. Grigorian and Manole (2002) present three approaches to bank production: asset approach, user-cost approach, and value-added approach. First, the *asset approach* considers banks only as financial intermediaries between liability holders and debtors. The bank's output consists of its loans and other assets, while the input to the intermediation process are its deposits and other liabilities.

Secondly, the *user-cost approach* uses the net revenue generated by a particular asset or liability to determine whether that financial product is an input or an output. Hancock (1991) was one of the first to apply this approach to banking, and stated that if the financial returns of an asset does not exceed the opportunity cost of funds, the financial instrument is considered an input. If not, the financial instrument is considered an output.

Finally, according to the *value-added approach*, both assets and liabilities have some output characteristics. However, only items that have substantial value are considered as outputs, while others are considered as inputs or intermediate products.

The core business of Swedish banks is to receive deposits and issue loans, which essentially means that they convert savings into investments (Swedish Bankers, 2017). Deposits are resource-consuming, and accordingly, we consider deposits as output, which corresponds to the value-added approach. Remaining output consists of income and loans. Other than that, we define the input as the expenses of the bank.

3.3. Variables

3.3.1. DEA Model Variables

Our DEA model includes two input variables: total interest expense *(IE)* and total non-interest expense *(NIE)*. We also include four output variables: total loans *(L)*, total deposits *(D)*, total interest income *(II)* and total non-interest income *(NII)*, using data for the stated years. See tables below for sample statistics and variable definitions.

Table 2. Sample statistics for DEA variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ID1	310			1001	1311
ID2				3002	3056
IE	310	-6781.37	16150.84	-112000.13	-3.83
NIE	310	-4806.45	10263.18	-49145.53	-34.39
L	310	106230	243084.8	167	1503532
D	310	103691	223344	150	1734783
II	310	11752.93	25884.67	31.06	160920.94
NII	310	4194.97	9447.981	-738.80	49246.08

Table 3. Variable definitions

ID 1	Observation-specific ID: Used for identification and separation of the observations in the sample.
ID 2	Company-specific ID: Used to cluster the observations by company to capture the company fixed effects in the regression model. That is, the within-subject effects.
Year	Year for which the data was gathered, used to capture the time fixed effects in the regression model.

Table 4. Definitions of input variables (all in MSEK)

IE	Total interest expense: Interest paid for the loans assigned to the public, group level.
NIE	Total non-interest expense: Total costs before credit losses to the public, group level.

Table 5. Definitions of output variables (all in MSEK)

L	Loans: Total loans to the Swedish and foreign public (households, corporations, municipalities, etc.).
D	Deposits: Total deposits and borrowing from the Swedish and foreign public (households, corporations, municipalities, etc.).
II	Total interest income: Income from lending to the Swedish and foreign public (households, corporations, municipalities, etc.).
NII	Total non-interest income: Total income minus net interest income.

3.3.2. Regression Model Variables

We aim to investigate variables that we believe, as an effect of the digitalization, might have an impact on the absolute efficiency of banks. As dependent variable in the regression, the log-transformed *efficiency* of each bank observation is used. The efficiency is defined as the sum of output divided by the sum of input for every observation, as seen in the formula below. This measure differs from the DEA score, as the efficiencies are now absolute, instead of relative.

$$\text{Efficiency} = \frac{Loans + Deposits + Interest\ income + Non\ interest\ income}{Interest\ expenses + Non\ interest\ expenses} \quad (1)$$

The variables used in the regression model are defined according to the following:

Table 6. Definition of the dependent variable used in the regression model

ln_E	Efficiency: Log-transformed value of the ratio of output to input for each observation.

Table 7. Definitions of the independent variables used in the regression model

ln_NB	Number of branches: Log-transformed value of number of branches for each observation. A branch is defined as an independent office. Banks operating solely through internet or phone obtains a value of 1.
ln_NE	Number of employees: Log-transformed value of number of employees for each observation. Average number of employees in Sweden each year.
ln_TA	Total assets: Log-transformed value of total assets of each bank. Used as a proxy for bank size.
DD	Digital dummy: Dummy variable, takes on the value of 1 if the bank has a clearly defined digital strategy.
DCDO	CDO dummy: Dummy variable, takes on the value of 1 if the bank has an appointed Chief Digital Officer or equivalent.

Descriptive statistics for the variables are presented in table 8 below.

Table 8. Regression model variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ID1	310			1001	1311
ID2				3002	3056
E	310	37.89312	34.14143	1.691	332.4
NB	310	62.29355	124.1308	1	477
NE	310	1418.603	2699.642	15	9058
TA	310	272957.2	592474.9	300	4110200
DD	310	0.370968	0.483845	0	1
DCDO	310	0.125807	0.332167	0	1

Number of branches *(NB)*, as well as number of employees *(NE)*, are included to capture the effects of digitization on the operative efficiency of banks. We assume that a more digitized bank is able to decrease NB and NE, because of more digital operations. This is assumed to have a positive effect on the efficiency as, all else equal, fewer branches and employees should result in lower non-interest expenses. The conclusion is that NB and NE are expected to have negative coefficients for the efficiency.

$$\text{More digitization} \uparrow = \text{Fewer branches and/or employees} \downarrow = \text{Higher efficiency} \uparrow$$

Total assets are included as a proxy for bank size. This is mainly to monitor the effect of firm size on the efficiency, in order to determine whether this has an impact, and thus to avoid omitted variable bias. We expect this variable to have a positive coefficient, as we believe that larger banks have more resources to put into the adaption to digitalization, and are therefore more efficient than smaller ones.

The dummy variables DD and DCDO are included to reflect the digital engagement of the banks in the sample. We expect digitization to enhance the efficiency of banks for several reasons, including cost savings, and similar. Thus, both dummy variables are expected to have a positive coefficient for the efficiency. The dummy variables are created manually, but tested using the Cohen's Kappa coefficient to determine the inter-rater agreement. See appendix 4 a-d. for further specification of the test results.

Omitted variable bias might occur if relevant variables are left out of the model. We have tried to eliminate biases by controlling for company-specific effects. The inclusion of TA is also a way of avoiding omitted variable bias.

3.4. Critical Discussion

The uncleaned sample consists of a complete collection of all the registered banking corporations in Sweden according to Swedish Bankers for the given year, and no banking corporation is excluded due to firm characteristics. Therefore, the sample should be free from any biases before the cleaning. The risk for sample bias increases when the data from annual reports is collected, as some reports are missing. Furthermore, to obtain an as accurate as possible view of the Swedish banking market for the given year, banks are included even though they ceased to exist in a later period.

Since some of the data is not taken from harmonized templates, differences in how companies have chosen to calculate and present numbers can occur. However, potential errors are estimated to be insignificant due to Swedish accounting legislation, as all limited companies ("*Aktiebolag*") in Sweden are required to follow *Aktiebolagslagen* (2005:551) and *Årsredovisningslagen* (1995:1554).

Furthermore, the human factor could affect the parts of the data collected manually. To limit the human mistakes in the gathering process, the observations are verified and cross-checked. Spot checks have been made as part of the process, to control for mistakes in the data set.

Another factor to take into consideration is the timing effect and potential lag of our dummy variables. We have chosen to appoint the variable with a value of 1 the year the company shows a change in strategy; either when they start presenting a clearly defined digital strategy, or when they appoint their CDO or equivalent. However, since the effect of these efforts might be shifted to take place in a later period, this might result in a slight misjudgment embedded in these variables.

Initially, we aimed to include data for the banks' investments in digital transformation, as well as the digital engagement of their customers. However, this data was not available for collection in an adequate and corresponding way for all banks, and thus these variables were left out of the model. It would also have been interesting to include whether the banks' digital engagement arises from in-house development, outsourcing of digital services, or acquisitions of fintech companies. Although omitting these variables might not result in a severely biased model, it would have been interesting to investigate if the impact on the efficiency of banks would differ considering these variables.

4. Methodology

In this section, we describe our methodology. First, we describe the non-parametric approach used to evaluate the relative efficiency of the banks, and then the regression model used to analyze which factors, related to the digitization, have an impact on the absolute efficiency.

4.1. Efficiency Measurement Methodologies

Historically, the most common performance measure of banks has been Return on Equity (ROE). A good level of ROE may reflect either a good level of profitability, or more limited equity capital (European Central Bank, 2010). As a result of the consequences of the financial crisis, there has been a debate on what performance measure to appoint to banks. For most banks providing a ROE of 20 percent, this has proven to be unsustainable, which justifies a more comprehensive assessment of the performance of banks. The European Central Bank clearly states that ROE as performance measure must be redefined. There are several alternative approaches for measuring banks' performance, as the key drivers of performance are earnings, efficiency, risk-taking, and leverage (European Central Bank, 2010).

Throughout this thesis, we will use *efficiency* as the performance measure of banks. We will first evaluate the technical efficiency of Swedish banking corporations by employing the non-parametric Data Envelopment Analysis model, further explained in the coming sections. In this method, we use the *relative efficiency* measure, from now on referred to as the *DEA score*.

We will then turn to the regression model, in which we instead employ the *absolute efficiency* measure as our dependent variable. This is henceforth referred to as *efficiency*. To make the dependent variable more normally distributed, we log-transform it. We can then run a linear regression model to test the impact of different independent variables on the efficiency.

The rationale behind the separate measures of efficiency is the desire to both investigate the impact of digitization on the relative, as well as on the absolute efficiency of banks. The nature of the DEA score, being a number in the interval 0 to 1, results in a skewed variable, which prevents us from running an ordinary linear regression using the DEA score as the dependent variable. Instead, we employ the absolute efficiency as the dependent variable in the regression model.

4.1.1. Previous Literature

Data Envelopment Analysis (DEA) has proven to be an effective way of measuring the relative efficiency of banks, and several studies have applied DEA in this field of study. Charnes et al. (1978) introduced the DEA model, based on the work of Farrell (1957).

Some studies that have applied DEA to their research are Grabowski et al. (1994), who use DEA to evaluate the effect of deregulation on the relative efficiency of banks in the US in the 80's. Miller and Noulas (1994) use DEA to investigate the relative technical efficiency of large bank production, and Berg et al. (1991, 1993) study Nordic banks using DEA. Fukuyama (1993) measures efficiency in Japanese banks using DEA, and Zaim (1995) studies the effect of financial liberalization on the relative efficiency of Turkish commercial banks using DEA. Jackson and Fethi (2000) use DEA to evaluate the efficiency of Turkish commercial banks, and then use a Tobit regression model to investigate the determinants of efficiency.

Yue (1992) shows the usefulness of DEA using data for 60 commercial banks in Missouri during 1984-1990. Sherman and Gold (1985) measure and evaluate the operating efficiency of bank branches using DEA, concluding that DEA is a beneficial complement to other techniques for improving bank branch efficiency. Parkan (1987) discusses the application of DEA to bank branches to identify operational inefficiencies. Ferrier and Lovell (1990) compare econometric estimation of cost frontier to linear program production frontier (DEA) in measuring efficiency in banking. They state that the linear program production frontier is sufficient to accommodate many variables. Oral and Yolalan (1990) discuss the methodology of DEA and conclude that this approach is not only complementary to other traditionally used financial ratios, but also useful for bank management in reallocating resources between branches to achieve higher efficiencies.

More recently, Feng and Wang (2018) use a DEA decomposition approach to examine why European banks are less profitable than U.S. banks, while Chen et al. (2018) investigate the efficiency of Chinese banks during the financial crisis by applying a DEA model under a stochastic environment.

4.2. DEA Model

Data Envelopment Analysis (DEA) is a non-parametric technique used to construct empirical production frontiers, to empirically measure the productive efficiency of decision-making units (DMUs). An important feature for the usage of DEA is its ability to manage the characteristics of a bank; using multiple inputs to produce multiple outputs (Jackson and Fethi, 2000). DEA can be used both to compare the efficiency across DMUs within an organization, as well as to compare the efficiency across firms operating in the same sector.

DEA has previously been applied in studies that evaluate the efficiency of banks. Using a production function, one can show the maximum output that can be achieved with any possible combination of inputs. In other words, a production technology frontier can be constructed. DEA is an empirical application of this principle that overcomes the problem that one can never observe all the possible combinations of input and output in reality.

To examine the relative efficiency of a particular DMU, compared to the other DMUs in the sample, DEA employs the principles of linear programming theory. DEA provides a benchmark for best practice technology based on the banks in the sample, however, it is important to note that it does not necessarily provide a benchmark for the most efficient technology available (Miller and Noulas, 1994).

A DEA model can either be constructed to minimize inputs (input-oriented), reducing the input amounts as much as possible while holding output constant, or to maximize output (output-oriented), maximizing output levels without increasing the use of input (Cooper et al. 2000).

Based on the data in the sample, DEA constructs a frontier: banks on the frontier are efficient, while banks inside the frontier are inefficient. Efficiency is measured by the ratio of weighted output to weighted input, a ratio that lies between 0 and 1. The bank is relatively efficient if the ratio equals 1, and is inefficient if the ratio is less than 1. It is important to note that a bank that is efficient not necessarily produces the absolute maximum level of output given the level of input, but rather produces the best practice output level for the banks in the sample. As stated in the introduction, the Swedish banking sector is considered healthy and thus limit inefficient banks to operate. The DEA scores are relative, and even though a bank gets a low score, it could still have a high absolute efficiency. The DEA model allows each bank to maximize its own best possible efficiency compared to the other banks, by adopting its own set of weights.

The DEA model can be derived according to the following:

The DEA Model

$$\max E_c = \sum_{r=1}^{s} \frac{u_r y_{rc}}{v_i x_{ic}}$$

$$\text{subject to} \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \qquad (2.1)$$

$$u_r, v_i \geq 1$$

$$r = 1, \dots, s; i = 1, \dots, m; and\ j = 1, \dots, n$$

where

c = a specific bank to be evaluated

y_{rj} = the amount of output r produced by bank j

x_{ij} = the amount of input i used by bank j

u_r = output r weight

v_i = input i weight

n = number of banks

s = the number of outputs

m = the number of inputs

The objective function aims to maximize the efficiency of the bank: The ratio of weighted output to weighted input of the bank, subject to the constraint that any other bank in the sample cannot exceed unit efficiency by using the same weights. To compute the weights and the efficiency score, the optimization is performed separately for each unit.

Linear program version of fractional program

The objective function described above is a fractional model formulation that, by restricting the denominator of the objective function equal to one and adding this as a constraint to the problem, can be simplified and converted into a linear program problem that is expressed as follows:

Primal

$$\max E_c = \sum_{r=1}^{s} u_r y_{rc}$$

$$\text{subject to} \sum_{i=1}^{m} v_i x_{ic} = 1$$

$$\sum_{r=1}^{s} u_{rc} y_{rj} - \sum_{i=1}^{m} v_{ic} x_{ij} \leq 0 \qquad (2.2)$$

$$u_r, v_i \geq 0$$

$$r = 1, \dots, s; i = 1, \dots, m; and\ j = 1, \dots, n$$

To solve this linear problem, it can be replaced by the dual program that follows:

Dual

$$
\begin{aligned}
&\min E_c = \theta_c \\
&\text{subject to} \sum_{j=1}^{n} \lambda_j y_{rj} \; - s_i^{+} = y_{rc} \\
&\sum_{j=1}^{n} \lambda_j x_{ij} - \; s_i^{-} = \theta_c x_{ic} \qquad (2.3) \\
&\lambda_{j,} s_i^{-}, s_i^{+} \geq 0 \\
&j = 1, \dots, n
\end{aligned}
$$

θ_c = input weights of bank c

λ_j = input and output weights of other banks in the sample

To determine if the banks are operating in a technically efficient way, the DEA efficiency scores are used as performance indicators. Banks with an efficiency score of 1 are considered efficient, that is, if optimal values of the variables in the dual are $\theta_c = 1$, with $s_i^{-} = s_i^{+} = 0$, for all values of c and j. Banks with a DEA score of less than 1 are considered inefficient relative to the one operating at the efficiency frontier. The linear maximization program in (2.3) assumes constant returns to scale technologies. However, the inclusion of the constraint of $\sum_{j=1}^{n} \lambda_j = 1$ to the problem allows for variable returns to scale (VRS) in the production, which is used in our model.

In our model, VRS is used to determine the individual efficiencies for all observations. VRS is a type of frontier scale used in DEA models to estimate whether differences in input and output result in increasing, decreasing or constant returns to scale (Cooper et al. 2011).

In our method, we run one DEA test for each year included in the sample, that is, for the years 2005 to 2017. Thus, in total we run 13 DEA tests to determine the relative efficiency of each observation in the sample.

4.2.1. Analyzing DEA

From the results of the DEA model, we analyze the relative efficiency scores obtained. Other than examining the spread in the scores, we look at the difference between the banks that have implemented digital transformation work, and the banks that have not.

Our assumption is that the spread between the most and the least efficient bank increases over the period 2005-2017, due to the varying degree of adapting to the digitalization.

Increased digitization is assumed to result in an increased spread, because of more digitized banks being more efficient than the banks not adopting digital strategies.

We also investigate if there is a pattern in when the effects of the digitalization seem to have taken place, as well as what impact the digitization variables have on the relative efficiency of banks.

4.3. Regression model

In the following section, we present our regression model. Using panel data, we first run a Hausman test to confirm whether to use random effects or fixed effects regression. The result implies that the fixed effects regression should be used.

In our data set, we include a company-specific ID to exclude company-fixed effects. We also include a time-fixed effect, and run the regression accordingly. Because our data set comprises all Swedish banking corporations that existed each year over the period 2005-2017, the data is unbalanced because new banks arise, and some banks cease to exist during the period. However, this does not necessarily have implications for the regression results.

Table 9. Log-transformed regression variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ln_E	310	3.23673	0.962552	0.47595	5.806246
ln_NB	310	1.88181	2.133215	0	6.167517
ln_NE	310	5.67037	1.670247	2.70805	9.111403
ln_TA	310	10.1794	2.111142	5.70378	15.22898

Because our independent variables are skewed, we choose to log-transform them to make them more symmetric, and hopefully normally distributed. As earlier mentioned, the dependent variable is also a log-transformed variable.

4.3.1. Estimated Model

The estimated model is expressed in the following matter:

$$ln\_E_i = \beta_0 + \beta_1\, ln\_NB_i + \beta_2\, ln\_NE_i + \beta_3\, ln\_TA_i + \beta_4\, DD_i + \beta_5\, DCDO_i + \varepsilon_i \qquad (3)$$

where *ln_E* is the natural log of the absolute efficiency score, *ln_TA* is the bank size determined using the natural log of the total assets of the bank, *ln_NB* is the number of branches determined using the natural log of number of branches in Sweden, *ln_NE* is the number of employees determined using the natural log of number of employees in Sweden, β_0 is the constant included in the model, β_1 to β_5 are the regression coefficients, and ε is the probable error term.

4.3.2. Testing Model Assumptions

Linear regression is sensitive to outliers and has five key assumptions: linear relationship, multivariate normality, homoscedasticity, no or little multicollinearity, and no auto-correlation. We test for these assumptions, in order to adjust our model and do the modifications necessary for the assumptions to hold.

We also use the function for robust standard errors in the model. This accounts for eventual heteroscedasticity, as robust standard errors is a method for obtaining unbiased standard errors of OLS coefficients. Thus, we do not have to consider heteroscedasticity, because this adjustment is already embodied in the model. The heteroscedasticity-consistent results of this regression are used to allow the fitting of a model even though the residuals are heteroscedastic. The robust standard errors also correct for eventual auto-correlation between the variables, and hence, this does not have to be considered when running the model.

Homoscedasticity

Even though our model already includes correction for heteroscedasticity, we run a Breusch-Pagan test to test for it. The results from the test imply presence of heteroscedasticity in the error terms. We also evaluate a scatterplot of the standardized residuals versus the standardized predicted values to see if there is heteroscedasticity. Graphically, the data looks relatively homoscedastic. However, as we run a robust standard errors regression, this eliminates the effect of the heteroscedastic error terms.

Multicollinearity

Multicollinearity implies that two or more independent variables correlate to each other. If two strongly correlated variables are included in the model, the estimation of the coefficients can be uncertain, and the coefficients can receive the wrong sign or size. To eliminate any multicollinearity in our model, we calculate the Variance Inflation Factors (VIFs) of the independent variables. Because no VIF score is above ten, no severe multicollinearity is implied. Specification of the test results can be found in appendix 5.

Autocorrelation

The error term of one observation should not be correlated with the error term of another observation. Autocorrelation emerges for several reasons including omitting important variables, a functionally wrongly specified regression, and measurement errors in the dependent variable. To detect any autocorrelation, we use a Wooldridge test. The test indicates some autocorrelation in our estimated regression model. However, as we run a robust standard regression model, this accounts for the autocorrelation found.

5. Empirical Findings from DEA Model

This section covers the empirical findings from our DEA model, which is used to examine the relative efficiencies of Swedish banks. Banks with an efficiency score of 1 are considered efficient, relative to the other banks in the same year. The maximum value, i.e. the efficiency frontier, is therefore always equal to 1, even though the absolute efficiency may differ. Table 10 displays sample statistics for the DEA scores.

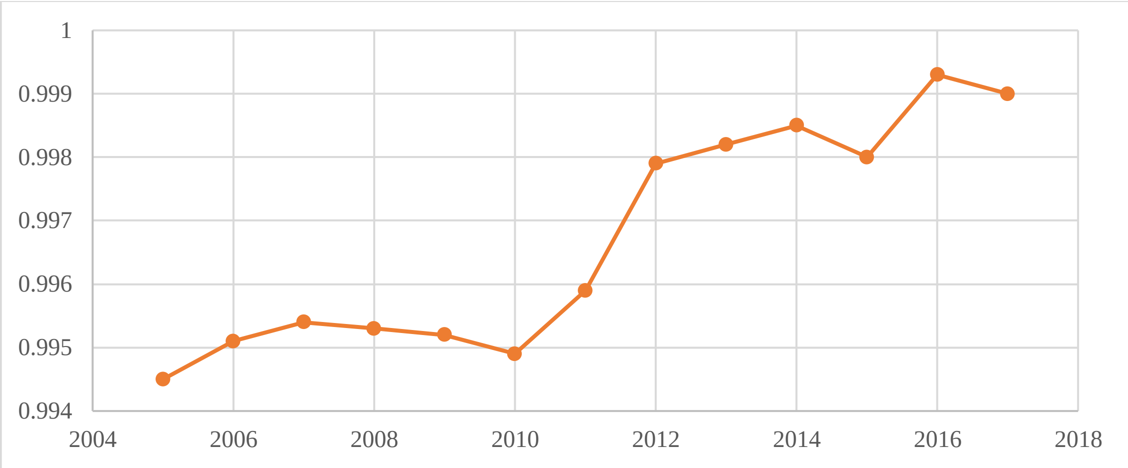
Table 10. Sample statistics for the DEA scores obtained

Year	Min	1st Qu	Median	Mean	3rd Qu	Max
2005	0.0055	0.0345	0.1273	0.3957	0.8971	1
2006	0.0049	0.0132	0.0429	0.2753	0.3424	1
2007	0.0046	0.0127	0.0207	0.3168	0.8356	1
2008	0.0047	0.0169	0.0245	0.2526	0.1028	1
2009	0.0048	0.0175	0.0293	0.2499	0.1182	1
2010	0.0051	0.0187	0.0397	0.2468	0.1122	1
2011	0.0041	0.0149	0.0369	0.2282	0.1013	1
2012	0.0021	0.0115	0.0183	0.1848	0.1104	1
2013	0.0018	0.0057	0.0195	0.1548	0.0674	1
2014	0.0015	0.0051	0.0164	0.1392	0.0599	1
2015	0.0020	0.0071	0.0179	0.1299	0.0534	1
2016	0.0007	0.0058	0.0190	0.1234	0.0544	1
2017	0.0010	0.0052	0.0146	0.0942	0.0441	1

5.1. Analysis

The assumption was that the spread in efficiency between the bank on the efficiency frontier each year, and the minimum value of relative efficiency for the given year, is increasing due to the digitization of certain banks. We believe that the banks operating a clearly defined digital strategy, and/or having an appointed CDO, will be more efficient relative to other banks.

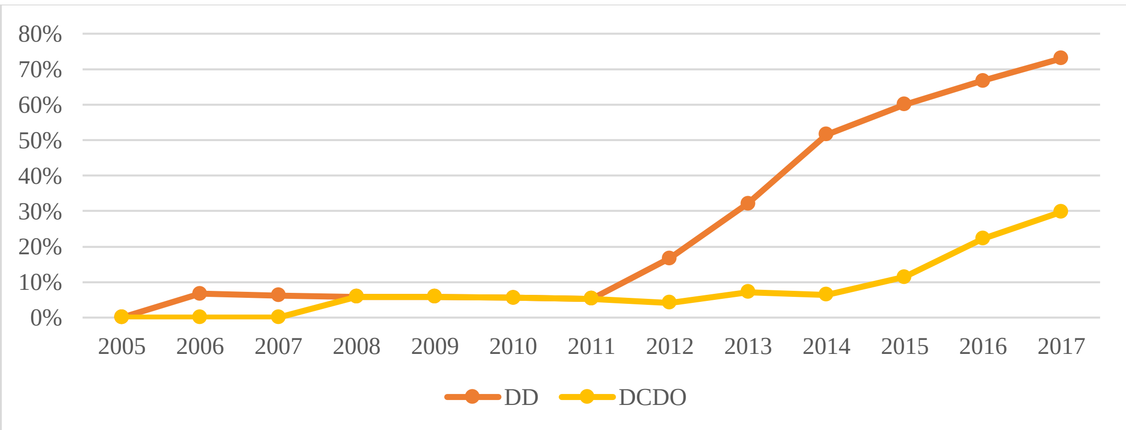
Graph 2. The spread between the efficient bank and the least efficient bank



Graph 2 shows the spread between the bank on the efficiency frontier and the score of the least efficient bank for the years 2005-2017. Clearly, the spread has been increasing over time. As previously mentioned, we assume that this is an effect of digitalization, since digitization is expected to result in higher operational performance among digitized banks.

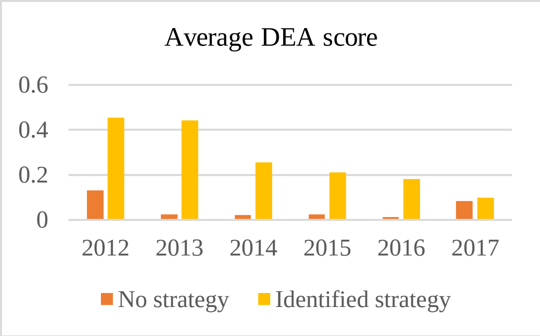
Next, the correlation between a high efficiency score, and the implementation of a defined digital strategy or the appointment of a CDO, is investigated. We find that the trend for implementing a digital strategy started in 2011, and has then continued by each year. 2011 is also the inflection point where the spread started to expand.

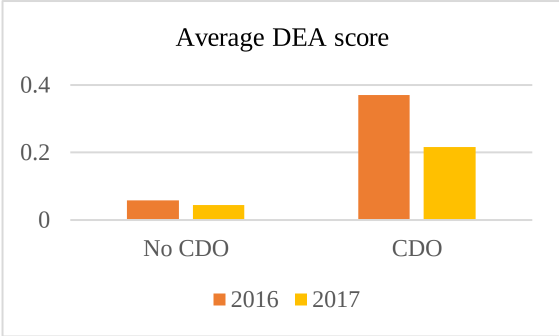
Graph 3. The development of the implementation of digital strategy and CDO



The implementation of the CDO role follows the trend of digitization and has had an upswing since 2015. CDO roles have not been implemented to the same extent as digital strategies. Graph 3 presents the share of banks each year with a clearly defined digital strategy and an appointed CDO, respectively.

Diagram 1 and 2. Differences in average DEA score related to dummy variables





As seen in diagram 1 above, there are signs of differences in the average DEA score depending on the digital dummy, starting from 2012 when digital strategies were more widely introduced. The average relative efficiency is declining, but in all years studied, the average DEA score for banks that have an implemented digital strategy is higher than the average DEA score for banks that do not. This implies that the adaption to digitalization, and the transformation work implemented accordingly, has a positive effect on the relative efficiency of Swedish banks.

The same reasoning goes for the CDO dummy, shown in diagram 2. The banks that have an appointed CDO have higher average DEA scores than the banks that do not, and thus, the adaption to digitalization again proves to have a positive effect on the relative efficiency of Swedish banks.

Of the banks that have an appointed CDO in 2017, the four largest banks in Sweden are included. The average total assets for banks with an appointed CDO is 226.3 percent above the average total assets among all banks in 2017. The banks not having a CDO have average total assets of 92.2 percent below the average. This indicates that mainly large banks have implemented a CDO role in their organizations.

6. Explaining Differences in Absolute Efficiency

In this section, we extend the analysis to explain the differences in absolute efficiency among the observations, using our multiple linear regression model. We consider the impact on efficiency of number of branches, number of employees, total assets, and level of digitization. The level of digitization is measured by employing dummy variables: The dummy variable DD takes on the value 1 if the bank has a clearly defined digital strategy, and the dummy variable DCDO takes on the value 1 if the bank has an appointed Chief Digital Officer or equivalent.

6.1. Regression Results

This part presents the regression results and discusses the assumptions concerning the coefficients. Table 11 reports the regression results. The estimated regression model was expressed as:

$$ln\_E_i = \beta_0 + \beta_1\, ln\_NB_i + \beta_2\, ln\_NE_i + \beta_3\, ln\_TA_i + \beta_4\, DD_i + \beta_5\, DCDO_i + \varepsilon_i$$

Table 11. Regression model results

OLS (2 FE)	Variables	Regression
Dependent	ln_E	
Independent	ln_NB	-0.106
		(-0.784)
	ln_NE	-0.0590
		(-0.679)
	ln_TA	0.0631
		(0.554)
	DD	-0.0142
		(-0.230)
	DCDO	0.255*
		(1.950)
		(3.348)
	Constant	2.871**
		(2.318)
	Observations	310
	Number of ID2	40
	R-squared	0.568
	Company FE	YES
	Time FE	YES

*Robust t-statistics in parentheses: *** p<0.01, ** p<0.05, * p<0.1*

The dependent variable in the regression model is the efficiency measured by the ratio of output to input. As stated in part 3.3.2 Regression Variables, the independent variables are included to capture the impact of digitization on the efficiency of banks.

Number of branches and number of employees were expected to have negative coefficients for the efficiency, while the coefficient of total assets was expected to be positive. For the dummy variables, both were expected to have positive coefficients.

As predicted, ln_NB and ln_NE have negative coefficients, and thus an increase in these variables imply a decline in efficiency. The positive coefficient for ln_TA implies an increase in efficiency for an increase in the variable.

DCDO has a large positive coefficient, which implies that appointing a CDO has a big impact on the efficiency of banks. On the other hand, DD has a small negative coefficient, which implies a slight negative impact on the efficiency when adopting a digital strategy. However, this regression coefficient is not statistically significant.

The asterisks indicate the level of statistical significance of the regression coefficients. In our regression, not all variables have a statistically significant relationship with the dependent variable. More asterisks do not mean more significance, only a more precise estimate. None of the independent variables have statistical significance on the five percent level, but DCDO is statistically significant on the ten percent level. However, the absence of more significant variables might be a result of our relatively small sample size.

6.2. Model Fit

The adjusted R-squared for our regression model is 0.568, which means that the model explains 56.8 percent of the variability in the absolute efficiency. Testing for the distribution of the error term using a Kernel density estimate, as well as a standardized normal probability plot, we find that the residuals are normally distributed.

The conclusion is that, although it shows little significance, our model has a good fit. The final estimated regression model is thus expressed as:

$$\widehat{ln\_E} = 2.871 - 0.106\widehat{ln\_NB} - 0.059\widehat{\mathrm{ln}\_NE} + 0.063\widehat{\mathrm{ln}\_TA} - 0.014\widehat{DD} + 0.255\widehat{DCDO} \quad (4)$$

6.3. Analysis

As the model explains almost 57 percent of the variability in the dependent variable, it is assumed to be reliable to use as an indication for the impact of digitization on the efficiency of Swedish banks.

The negative coefficients of ln_NB and ln_NE imply a decrease in efficiency by an increase in any of these variables. These variables were included in the model to capture how the operating efficiency of banks is affected by digitalization. The assumption was that the more digitized the bank, the more it will be able to decrease its number of branches and number of employees, because of a more digital business model. As the efficiency decreases by a higher number of branches and number of employees, the opposite relationship is also assumed to hold. A decrease in the number of branches or number of employees should, all else equal, result in increased efficiency. The implication from this is that the digitization of Swedish banks has a positive impact on their efficiency.

The positive coefficient for DCDO implies that appointing a CDO results in increased efficiency. The implication is again that digitization has a positive effect on the efficiency.

However, DD has a negative coefficient, which implies that having a clearly defined digital strategy would affect the efficiency negatively. This is opposite to our assumptions of digitization having positive effects on efficiency. As the statistical significance of this variable is very low, we choose not to appoint much weight to the results or implications of this.

Total assets were included in the model as a proxy for firm size, expected to have a positive coefficient, as a result of larger banks having more resources to put into digital transformation, and thus becoming more efficient because of the digitized business. The coefficient for ln_TA is positive, and thus the implication is that size, and thereby according to our assumption, digitization, has positive impact on the efficiency of Swedish banks.

The regression model and following analysis can be further extended to include other variables for measuring digitization: e.g. evaluating differences between digital natives and transformed digital, and similar. Our estimated model experiences some auto-correlation, which might be explained by omitted variable bias; some of these variables could have been beneficial to include in our model.

7. Conclusion

The objective of this thesis was to evaluate the impact of digitization on Swedish banks. To do so, we investigated the efficiency of the banks in the sample, using two separate methodologies. Both models show that adapting to the digitalization has implications for the efficiency of Swedish banks.

First, the non-parametric Data Envelopment Analysis model was employed, in which we computed the relative efficiencies of the observations. These were then analyzed to determine the impact of digitization on the relative efficiency of banks. In the second method, we used a multiple linear regression model, to determine the impact of different explanatory variables related to digitization on the absolute efficiency of the banks.

The results from the analysis of the DEA scores show that adapting to digitalization has a positive impact on the relative efficiency, and thus the digitization of banks results in higher relative efficiency. Considering the results from the regression model, these also imply that more digitized operations result in higher absolute efficiency.

Like previous studies, we have evaluated the effect of a certain event, namely digitization, on the relative efficiency of banks. Data Envelopment Analysis proves to be a proficient way of measuring differences in efficiency between companies or units that operate similarly and are affected by comparable external factors. Regression models have previously been applied to investigate the determinants of efficiency, and our study shows that variables related to digitization can be used to determine the level of absolute efficiency.

Consistently, the results from our analyzes show that banks that become more digitized increase their efficiency, both in relative and in absolute numbers. Implementing digital transformation work, and having more digitized operations, has a positive impact on the efficiency. The conclusion from these results is that digitization enhances the efficiency of Swedish banks. Conclusively, the digitalization has positive effects on the efficiency of Swedish banking corporations.

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9. Appendix

Appendix 1. Observations left in sample after data cleaning

Year	Total sample (Swedish Bankers)	Banking corporations (included in sample)
2005	127	53
2006	126	55
2007	126	59
2008	118	62
2009	117	61
2010	114	60
2011	114	62
2012	117	66
2013	118	65
2014	117	67
2015	116	66
2016	117	68
2017	119	70
TOTAL	1546	814

Appendix 2. Full list of banks included in the final sample

Company	Year	Company	Year
Amfa Finans	2012	SBAB Bank	2010
Avanza Bank	2006	SBAB Bank	2011
Avanza Bank	2007	SBAB Bank	2012
Avanza Bank	2008	SBAB Bank	2013
Avanza Bank	2009	SBAB Bank	2014
Avanza Bank	2010	SBAB Bank	2015
Avanza Bank	2011	SBAB Bank	2016
Avanza Bank	2012	SBAB Bank	2017
Avanza Bank	2013	SEB	2005
Avanza Bank	2014	SEB	2006
Avanza Bank	2015	SEB	2007
Avanza Bank	2016	SEB	2008
Avanza Bank	2017	SEB	2009
Bergslagens Sparbank	2013	SEB	2010
Bergslagens Sparbank	2014	SEB	2011
Bergslagens Sparbank	2015	SEB	2012
Bergslagens Sparbank	2016	SEB	2013
Bergslagens Sparbank	2017	SEB	2014
Bluestep Bank	2016	SEB	2015
Bluestep Bank	2017	SEB	2016
Carnegie Investment Bank	2005	SEB	2017
Carnegie Investment Bank	2006	Skandiabanken	2005
Carnegie Investment Bank	2007	Skandiabanken	2006
Carnegie Investment Bank	2008	Skandiabanken	2007
Carnegie Investment Bank	2009	Skandiabanken	2008

Carnegie Investment Bank	2010	Skandiabanken	2009
Carnegie Investment Bank	2011	Skandiabanken	2010
Carnegie Investment Bank	2012	Skandiabanken	2011
Carnegie Investment Bank	2013	Skandiabanken	2012
Carnegie Investment Bank	2014	Skandiabanken	2013
Carnegie Investment Bank	2015	Skandiabanken	2014
Carnegie Investment Bank	2016	Skandiabanken	2015
Carnegie Investment Bank	2017	Skandiabanken	2016
Collector Bank	2015	Skandiabanken	2017
Collector Bank	2016	Sparbanken Alingsås	2015
Collector Bank	2017	Sparbanken Alingsås	2016
Erik Penser Bank	2013	Sparbanken Alingsås	2017
Erik Penser Bank	2014	Sparbanken Eken	2008
Erik Penser Bank	2015	Sparbanken Eken	2009
Erik Penser Bank	2016	Sparbanken Eken	2010
Erik Penser Bank	2017	Sparbanken Eken	2011
Forex Bank	2006	Sparbanken Eken	2012
Forex Bank	2007	Sparbanken Eken	2013
Forex Bank	2008	Sparbanken Eken	2014
Forex Bank	2009	Sparbanken Eken	2015
Forex Bank	2010	Sparbanken Eken	2016
Forex Bank	2011	Sparbanken Eken	2017
Forex Bank	2012	Sparbanken Göinge	2015
Forex Bank	2013	Sparbanken Göinge	2016
Forex Bank	2014	Sparbanken Göinge	2017
Forex Bank	2015	Sparbanken Lidköping	2010
Forex Bank	2016	Sparbanken Lidköping	2011
Forex Bank	2017	Sparbanken Lidköping	2012
HQ Bankaktiebolag	2006	Sparbanken Lidköping	2013
HQ Bankaktiebolag	2007	Sparbanken Lidköping	2014
HQ Bankaktiebolag	2008	Sparbanken Lidköping	2015
HQ Bankaktiebolag	2009	Sparbanken Lidköping	2016
ICA Banken	2006	Sparbanken Lidköping	2017
ICA Banken	2007	Sparbanken Rekarne	2013
ICA Banken	2008	Sparbanken Rekarne	2014
ICA Banken	2009	Sparbanken Rekarne	2015
ICA Banken	2010	Sparbanken Rekarne	2016
ICA Banken	2011	Sparbanken Rekarne	2017
ICA Banken	2012	Sparbanken Sjuhärad	2017
ICA Banken	2013	Sparbanken Sjuhärad8	2012
ICA Banken	2014	Sparbanken Sjuhärad8	2013
ICA Banken	2015	Sparbanken Sjuhärad8	2014
ICA Banken	2016	Sparbanken Sjuhärad8	2015
ICA Banken	2017	Sparbanken Sjuhärad8	2016
IKANO Bank	2006	Sparbanken Skaraborg	2012
IKANO Bank	2007	Sparbanken Skaraborg	2013
IKANO Bank	2008	Sparbanken Skaraborg	2014
IKANO Bank	2009	Sparbanken Skaraborg	2015
IKANO Bank	2010	Sparbanken Skaraborg	2016
IKANO Bank	2011	Sparbanken Skaraborg	2017
IKANO Bank	2012	Sparbanken Skåne	2014

IKANO Bank	2013	Sparbanken Skåne	2015
IKANO Bank	2014	Sparbanken Skåne	2016
IKANO Bank	2015	Sparbanken Skåne	2017
IKANO Bank	2016	Stadshypotek Bank	2005
IKANO Bank	2017	Stadshypotek Bank	2006
Landshypotek Bank	2013	Svea Bank	2017
Landshypotek Bank	2014	Svenska Handelsbanken	2005
Landshypotek Bank	2015	Svenska Handelsbanken	2006
Landshypotek Bank	2016	Svenska Handelsbanken	2007
Landshypotek Bank	2017	Svenska Handelsbanken	2008
Länsförsäkringar Bank	2005	Svenska Handelsbanken	2009
Länsförsäkringar Bank	2006	Svenska Handelsbanken	2010
Länsförsäkringar Bank	2007	Svenska Handelsbanken	2011
Länsförsäkringar Bank	2008	Svenska Handelsbanken	2012
Länsförsäkringar Bank	2009	Svenska Handelsbanken	2013
Länsförsäkringar Bank	2010	Svenska Handelsbanken	2014
Länsförsäkringar Bank	2011	Svenska Handelsbanken	2015
Länsförsäkringar Bank	2012	Svenska Handelsbanken	2016
Länsförsäkringar Bank	2013	Svenska Handelsbanken	2017
Länsförsäkringar Bank	2014	Swedbank	2005
Länsförsäkringar Bank	2015	Swedbank	2006
Länsförsäkringar Bank	2016	Swedbank	2007
Länsförsäkringar Bank	2017	Swedbank	2008
Marginalen Bank	2011	Swedbank	2009
Marginalen Bank	2012	Swedbank	2010
Marginalen Bank	2013	Swedbank	2011
Marginalen Bank	2014	Swedbank	2012
Marginalen Bank	2015	Swedbank	2013
Marginalen Bank	2016	Swedbank	2014
Marginalen Bank	2017	Swedbank	2015
MedMera Bank	2013	Swedbank	2016
MedMera Bank	2014	Swedbank	2017
MedMera Bank	2015	TF Bank	2012
MedMera Bank	2016	TF Bank	2013
MedMera Bank	2017	TF Bank	2014
Nordax Bank	2014	TF Bank	2015
Nordax Bank	2015	TF Bank	2016
Nordax Bank	2016	TF Bank	2017
Nordax Bank	2017	Tjustbygdens Sparbank	2005
Nordea Bank	2005	Tjustbygdens Sparbank	2006
Nordea Bank	2006	Tjustbygdens Sparbank	2007
Nordea Bank	2007	Tjustbygdens Sparbank	2008
Nordea Bank	2008	Tjustbygdens Sparbank	2009
Nordea Bank	2009	Tjustbygdens Sparbank	2010
Nordea Bank	2010	Tjustbygdens Sparbank	2011
Nordea Bank	2011	Tjustbygdens Sparbank	2012
Nordea Bank	2012	Tjustbygdens Sparbank	2013
Nordea Bank	2013	Tjustbygdens Sparbank	2014
Nordea Bank	2014	Tjustbygdens Sparbank	2015
Nordea Bank	2015	Tjustbygdens Sparbank	2016
Nordea Bank	2016	Tjustbygdens Sparbank	2017

Nordea Bank	2017	Varbergs Sparbank	2014
Nordnet Bank	2005	Varbergs Sparbank	2015
Nordnet Bank	2006	Varbergs Sparbank	2016
Nordnet Bank	2007	Varbergs Sparbank	2017
Nordnet Bank	2008	Vimmerby Sparbank	2012
Nordnet Bank	2009	Vimmerby Sparbank	2013
Nordnet Bank	2010	Vimmerby Sparbank	2014
Nordnet Bank	2011	Vimmerby Sparbank	2015
Nordnet Bank	2012	Vimmerby Sparbank	2016
Nordnet Bank	2013	Vimmerby Sparbank	2017
Nordnet Bank	2014	Volvofinans Bank	2007
Nordnet Bank	2015	Volvofinans Bank	2008
Nordnet Bank	2016	Volvofinans Bank	2009
Nordnet Bank	2017	Volvofinans Bank	2010
OK-Q8 Bank	2015	Volvofinans Bank	2011
OK-Q8 Bank	2016	Volvofinans Bank	2012
OK-Q8 Bank	2017	Volvofinans Bank	2013
Resurs Bank	2005	Volvofinans Bank	2014
Resurs Bank	2006	Volvofinans Bank	2015
Resurs Bank	2007	Volvofinans Bank	2016
Resurs Bank	2008	Volvofinans Bank	2017
Resurs Bank	2009	Ölands Bank	2013
Resurs Bank	2010	Ölands Bank	2014
Resurs Bank	2011	Ölands Bank	2015
Resurs Bank	2012	Ölands Bank	2016
Resurs Bank	2013	Ölands Bank	2017
Resurs Bank	2014		
Resurs Bank	2015		
Resurs Bank	2016		
Resurs Bank	2017		

Appendix 3. The Swedish Riksbank's exchange rate

Year	EUR	NOK
2005	9.2849	1.176
2006	9.2549	1.150
2007	9.2481	1.155
2008	9.6055	1.171
2009	10.621	1.216
2010	9.5413	1.192
2011	9.0335	1.159
2012	8.7053	1.164
2013	8.6494	1.109
2014	9.0968	1.089
2015	9.3562	1.047
2016	9.4704	1.020
2017	9.6326	1.033

Appendix 4a. Crosstabulation DD

	ET			
		0	1	
JS	0	195	15	210
	1	8	92	100
		203	107	310

Appendix 4b. Cohen's Kappa coefficient DD

	Value	Asymptotic Std. Error[a]	Approx. T[b]	Approx. Sign.	
Measure of agreement	Kappa	0,833	0,033	14,691	0
N of Valid Cases		310			

[a] Not assuming the null hypothesis.
[b] Using the asymptotic standard error assuming the null hypothesis.

Appendix 4c. Crosstabulation DCDO

	ET			
		0	1	
JS	0	271	5	275
	1	7	28	35
		278	32	310

Appendix 4d. Cohen's Kappa coefficient DCDO

	Value	Asymptotic Std. Error[a]	Approx. T[b]	Approx. Sign.	
Measure of agreement	Kappa	0,816	0,054	14,385	0
N of Valid Cases		310			

[a] Not assuming the null hypothesis.
[b] Using the asymptotic standard error assuming the null hypothesis.

Appendix 5. Variance Inflation Factors (VIF)

Variable	VIF
ln_E	1.40
ln_NB	2.64
ln_NE	7.10
ln_TA	6.61
DD	1.53
DCDO	1.39
Mean	3.45